

Study Team Response
to comments and recommendations of the
NWRI Final Report of the February Meeting of the
Independent Advisory Panel for the
LOTT Reclaimed Water Infiltration Study
(dated August 11, 2014)

Introduction

The LOTT Clean Water Alliance (LOTT) is completing a scientific study of reclaimed water and groundwater recharge called the Reclaimed Water Infiltration Scientific Study (RWIS). A project proposal including a detailed scope and budget was developed by a team including HDR Engineering, Inc. (HDR), Intertox, Windward Environmental, Peter Fox (of Arizona State University), and Jordan Clark (of the University of California Santa Barbara). The initial draft scope document was titled “*LOTT Clean Water Alliance Reclaimed Water Infiltration Study, Phase III Study Implementation Scope of Services*”, dated January 28, 2014. This document is referred to as “the scope”.

LOTT contracted with the National Water Research Institute (NWRI) to convene an expert panel to perform a scientific third-party peer review of the proposed RWIS scope. The NWRI peer review panel issued a report dated August 11, 2014, titled “*Final Report of the February 18-19 Meeting of the Independent Advisory Panel for the LOTT Clean Water Alliance Reclaimed Water Infiltration Study*”. The report presents the comments and recommendations from the peer review panel.

The HDR Study Team has reviewed the peer review panel report. This document presents a response to the comments and recommendations contained within the report. Study team responses are provided in [blue text](#). The numbering of comments/recommendations was not included in the NWRI panel report; it was added by the Study Team, to aid in reviewing and referencing this response document.

3. Findings and Recommendations

3.1 General Comments

1. LOTT and the communities it serves are to be commended for their care of the environment, water conservation efforts, and significant efforts in addressing wastewater management.
2. LOTT is to be commended for adopting a scientific approach to investigating the fate of reclaimed water following aquifer recharge, and for working to ensure that the scientific investigation is credible, objective, and transparent.
3. It was clear to the Panel that LOTT's outreach program is an integrated element in the wastewater treatment operation and is important to the public and others in the communities that LOTT serves.
4. The Panel commends LOTT and its consultants for excellent work with meeting preparation, presentations, and the site tour.
5. A site assessment is needed at the Henderson site.
 - a. The Henderson site was characterized as having permeable sand lenses and gravels, as well as fractured flow with no appreciable soil development. The depth of the vadose zone at the Henderson site is less than that at the Hawks Prairie site. Contaminant attenuation may be different at the Henderson site than at the Hawks Prairie site, and waters reintroduced at the Henderson site are closer to potential downgradient supply wells and the Deschutes River.
 - b. The reclaimed water infiltrated at the Henderson site would be from a different wastewater treatment plant (WWTP) than that used for infiltration at the Hawks Prairie site; thus, it may contain different constituents of concern.
 - c. Because the site characteristics at the Henderson site may differ from those at the Hawks Prairie site, one cannot extrapolate the conditions from the Hawks Prairie site to the Henderson site.
 - d. Initial studies aimed at understanding a site's ability to accept infiltrated water is needed, but it is important to know if contaminants are able to transport more rapidly to downgradient wells at the Henderson site due to sediment/soil characteristics and aquifer properties.

Study Team Response

We agree that further hydrogeological characterization and assessment is needed at the Henderson site, or whatever site is ultimately selected by LOTT to serve as the "second study site" that is referenced in the scope of work. An initial hydrogeologic feasibility assessment of the Henderson site is planned to occur concurrent to the beginning of Phase 3 of the RWIS, under a separate contract. Then, a more detailed hydrogeologic site characterization will be conducted. Also, background groundwater quality sampling will be conducted in the vicinity of the second study site using area residential and public supply wells.

Once the hydrogeologic assessment of the "second study site" is completed, an evaluation will be conducted to evaluate the fate and transport of reclaimed water constituents through

groundwater to downgradient receptors (i.e., wells and surface water) and to evaluate the human health and ecological risk factors. The fate and transport method will be based on the hydrogeologic and geochemical information identified at the site, the background groundwater quality monitoring and the types of residual chemicals identified during sampling of the reclaimed water. Work plans will be prepared and submitted to the panel for comment on the characterization approach for the second site as well as the fate and transport methodology prior to conducting these investigations and analyses.

6. If the goal of LOTT's studies is to determine the risk associated with using reclaimed wastewater for groundwater recharge, it is important to establish whether the aquifer system at a proposed site is contaminated by septic system discharges or other sources prior to the introduction of LOTT reclaimed wastewater.

Study Team Response

We cannot sample existing groundwater quality prior to introduction of reclaimed water at the existing infiltration facility, because the Hawks Prairie Reclaimed Water Ponds and Recharge Basins have been operating since 2006. However, the information needed to evaluate the comparative risks to ecological receptors and human health will be collected using the following method. The existing groundwater quality will be determined by sampling public supply and residential wells over a relatively large area in the vicinity of the Hawks Prairie facility. Some of this area will have already been influenced by reclaimed water infiltration from the Recharge Basins and some of the areas will be outside of the groundwater flow path or far downgradient. Also, detailed sampling of reclaimed water will be conducted to determine residual chemical type and concentrations being infiltrated. And a detailed study of residual chemical degradation at the Hawks Prairie site will be conducted. Then a fate and transport method will be developed that evaluates the concentrations of residual chemicals resulting from reclaimed water infiltration. The regional groundwater quality information combined with the site specific estimates of additional reclaimed water residual chemicals added to groundwater will be the basis for the comparative risk assessment evaluation. Using this approach, it is possible to still answer the study questions without having full and detailed information on the groundwater quality prior to LOTT introducing reclaimed water at the Hawks Prairie site.

7. The Panel suggests that LOTT encourage its academic partners to publish peer-reviewed scientific papers of results from the Reclaimed Water Infiltration Study. The study goals included ensuring that the process is "credible, objective, and transparent." Because the study appears to be planned with sufficient attention to scientific protocols and questions and represents a significant scientific opportunity, peer-reviewed publication of some of the results should be possible. Publication will increase the transparency and credibility of the study and is likely to increase public trust.

Study Team Response

LOTT will plan to pursue publication of peer-reviewed scientific papers regarding the results of the Reclaimed Water Infiltration Study.

8. The Panel recommends that LOTT archive the study data for future analysis, if needed. A secondary priority would be archiving a subset of water samples. Archived data should be accessible to the public. An archive of the data is important for several reasons. First, similar to the above recommendation to publish scientific results, a data archive will increase transparency and credibility. Second, the study results could be important to other wastewater treatment facilities in the U.S. and elsewhere. Third, the best scientific research makes data publicly available. Fourth, a data archive can be done cost effectively.

Study Team Response

Study data will be archived and made accessible to the public.

We are planning on collecting and archiving a subset of samples representative of disturbed soil from soil boreholes in the event that they are later needed for textural (grain-size) evaluations.

We are not planning on collecting additional soil or water samples and holding them in the event that they are required for analysis in the future. The primary reason for this is that some analytical soil parameters have preservation and hold time requirements while others would require un-disturbed core samples that need to be run within a specified time period. Except for the soil borings associated with installation of lysimeters at Hawks Prairie, we are not collecting and preserving soil core samples. Collection and storage of soil core samples at each borehole would result in a significant increase in project costs. Also, each analytical parameter has specific requirements for sample collection, hold time and preservation requirements and if they are not met, the analytical results are invalid.

9. Terminology can be an important component of the outreach effort. Therefore, the project team should be careful about the terminology used for chemicals.

Study Team Response

LOTT is using the term ‘residual chemicals’, because this term resonates with the public. The term residual chemicals may have different meanings to the scientific community than to the general public. To the general public, it is intended to refer to a broad array of compounds that may remain in the water after treatment, and the study team is careful to make clear what the term is intended to encompass.

3.2 Site Characterization

10. The approach in the scope regarding soil characterization is adequate to meet the study goals. The Panel recommends taking some core samples when drilling new wells. As an enhancement to the project, core samples could be used to conduct controlled studies of the fate and transport of residual chemicals in the laboratory and to measure organic carbon content. As indicated in the *Groundwater Recharge Scientific Study Phase 1 (Technical Data Review) Technical Memorandum – “State of the Science”* (p. 18), soil organic carbon is a key parameter to determining the potential for contamination sorption. For this reason, organic carbon on soil and aquifer sediment is an important parameter for predicting contaminant transport at a site. It would be a further enhancement to the study to archive

core samples for future use, but it may be beyond the budget to do so. If core samples of aquifer sediment are archived, they could be used in the future to conduct column studies to verify estimates of contaminant sorption to site sediments.

Study Team Response

Several core samples will be collected at the Hawks Prairie site during borings for lysimeter installation and these samples will be analyzed for soil physics parameters (organic carbon content, grain-size distribution, saturated and unsaturated hydraulic parameters, mineralogy, cation exchange capacity, etc.). This is to assist in developing the hydrogeologic model to predict mounding and travel times for advective groundwater flow (velocity) and to provide background information on soil characteristics. At other soil borings, disturbed samples will be collected and grain-size distribution analysis will be performed. This should provide the soils information needed to complete the overall analysis to determine residual chemical fate and transport and comparative risk from reclaimed water infiltration.

Column studies are not included in the project scope. Instead, we propose installing lysimeters at depth to collect in-situ pore water samples. This is a better method to determine the pore-water quality of reclaimed water traveling through the vadose zone because it avoids the issues associated with trying to replicate subsurface conditions in the laboratory using soil columns.

11. The approach proposed in the scope regarding aquifer permeability and storage is appropriate. The Panel notes that it will be useful to obtain the highest quality aquifer permeability and storage data possible. Recognizing that pump tests will not be possible on all wells because of constraints of budgets and well diameters, the Panel recommends doing slug tests where possible. As the LOTT team is aware, slug test data is not as accurate as production well aquifer tests, but can assist in determining aquifer parameters.

Study Team Response

Comment noted. Depending on the type of geologic deposits encountered, we may complete slug testing at the monitoring wells.

12. The approach proposed in the scope regarding monitoring various aquifers is appropriate. The Panel notes that observations are needed to determine vertical head gradient in the shallow aquifer, confining layer, and deeper aquifer so that both horizontal and vertical migration of contaminants can be adequately monitored. Some migration into the lower aquifer might be possible; if so, that aquifer would need to be monitored. We recognize that multi-level samplers are not feasible. Nested monitoring wells completed at different depths should be sufficient.

Study Team Response

Comment noted. We will proceed with determining the vertical head gradient as outlined in the scope.

13. The proposed approach in the scope regarding groundwater movement is reasonable. However, the Panel recommends LOTT consider the potential for transient flow and transient gradients in the system. Groundwater movement is assumed to be at steady-state, but this may not be the case. Direction and rate of flow could change throughout the monitoring period, particularly with changes in aquifer recharge and seasonal changes in boundary conditions.

Study Team Response

We agree that temporal changes need to be considered. The temporal changes in boundaries (surface water, pumping, recharge) will be evaluated for both study sites as part of data compilation to describe the hydrogeologic system and to develop the groundwater flow model. The decision on whether or not to use a steady-state or transient groundwater modeling approach has not yet been determined and is envisioned as being identified as field data becomes available. The groundwater modeling approach may incorporate a transient evaluation through a representative period of time if that is needed to properly develop and calibrate the model. The boundaries incorporated will attempt to represent regional pumping and surface water boundaries and recharge fluctuations.

For particle tracking, flow path and advective time of travel analysis we anticipate using a quasi-steady-state representation of the groundwater flow system based on average conditions. This is the typical approach used for these types of projects and is justified because the issue that needs to be evaluated is the average groundwater flow path and advective time of travel compared to the monitoring data, based on average conditions in the groundwater system. Short-term variations are not likely to be significant in evaluating average flow paths or velocities.

Once the full site and regional hydrogeologic conditions are identified and the background and site-specific water quality sampling evaluations are completed, a Work Plan will be developed describing the groundwater modeling and fate and transport evaluation approach. The details on the proposed method will be submitted for review and comment at that time.

3.3 Tracer Tests

14. The approach for the tracer test of up to 12 months in the proposed scope is reasonable. The Panel recommends that tracers be injected as long as possible and monitored for as long as 12 months. More than likely, the groundwater system is not pristine and is impacted by septic systems and other sources. Input of constituents to the groundwater from these sources could be transient and may not be detected by a tracer study that is short in duration.

Study Team Response

The length of the tracer test will be refined as the study progresses and the hydrogeology of the Hawks Prairie site is better understood through completion of early tasks. The study budget has been modified to accommodate addition of extrinsic tracers for up to six weeks. More information is needed to understand the groundwater flow paths, hydraulic gradients and velocity, which can only be determined after compiling information on nearby wells and

installing additional on-site and off-site wells. The tracer study monitoring period will also consider the logistics of siting off-site monitoring wells along the downgradient flow path from the reclaimed water infiltration basins and at a distance within the travel time period. After additional hydrogeologic data has been compiled on the site, we propose developing an approach for the tracer study that considers these details and provides a recommendation for the tracer monitoring period.

Influences from “septic systems and other sources” should not affect the results of an extrinsic tracer test because they will not be adding or changing the detectability of the proposed extrinsic tracers (bromide and SF₆).

15. Reducing the field challenges of long-term injection is important. One option may be to inject the tracer at the WWTP. The proposed approach involving an automated pumping system to deliver the tracer in the discharge piping before it enters the basins is reasonable.

Study Team Response

The study scope envisions using an on-site tank and an automated pumping system to deliver tracer into discharge piping before it enters the basins. This will ensure mixing of the tracer as it is delivered into the basin. Therefore, there is no significant advantage to injecting the tracer at the WWTP instead of in the field. We plan to use the approach as outlined in the scope.

16. Bromide and SF₆ are both excellent tracers, are conservative under most situations within groundwater, have been widely used, and are likely to produce useable results with the outlined study plan. As an enhancement to the project, LOTT may want to consider additional added tracers (reactive and non-reactive) that could be monitored using existing analytical techniques without additional costs to supplement the analysis.

Study Team Response

We have considered the use of additional extrinsic tracers (xenon, chloride, enriched boron isotopes) and have not identified any that are suitable in this instance or that would provide additional value without significant additional cost. (See response to Comment 18.) Therefore, we intend to continue with the plan as outlined in the scope, utilizing bromide and SF₆ as the two added tracers.

17. The sampling frequency and spatial resolution of wells for tracer monitoring is important. The maximum number of wells and the maximum sampling events in the scope are justified. The decisions about number of wells and sample frequency are reasonable, given that the study team has already considered higher sampling frequency and more wells, and that these numbers are similar to those used at other similar sites.

Study Team Response

Comment noted.

18. The current focus of the tracer study is on two chemicals selected for their conservative behavior. The Panel agrees that bromide and SF₆ are among the best tracers. Both SF₆ and bromide do not biodegrade, nor do they sorb to aquifer sediments such that they are not retained. As indicated, SF₆ is volatile and losses are expected depending on how and at what depth SF₆ is introduced. Solutions of bromide are dense and may take a path in which the tracer cloud sinks. However, both chemicals are well suited to defining the flow path and arrival of water at downgradient sampling sites. They are not well suited for determining the behavior of potentially reactive or sorbing organic or inorganic contaminants. For this reason, intrinsic tracers (such as boron) that are present in the infiltrated reclaimed water should be considered. These intrinsic tracers can be evaluated by ratioing their concentration in the reclaimed water to that of the conservative tracers, SF₆ and bromide.

Study Team Response

The use of boron isotopes has been evaluated recently as part of start-up monitoring of reclaimed water infiltration at the Hawks Prairie facility. The Boron 11 isotope concentration was measured at 2 to 18 $\delta^{11}\text{B}$ ‰ in reclaimed water and at 12 to 28 $\delta^{11}\text{B}$ ‰ in groundwater. These results indicate the difference between Boron 11 and Boron 10 isotope concentration in reclaimed water is not significantly different from groundwater. After consulting with Dr. Jordan Clark, it is our opinion that the difference in Boron 10/11 isotope concentrations in reclaimed water and groundwater are not large enough for it to be effectively used as a tracer. The noble-gas SF₆ is the primary extrinsic tracer that has been successfully used in reclaimed water aquifer recharge studies and the literature shows that when correctly applied, off-gassing is not a problem (Avisar and Clark; 2005; Clark et al; 2014; 2013; 2012; 2005, 2004; Clark 2009; Gamlin et al., 2001; Lee et al; 2008; McDermott et al, 2008). To decrease the loss of tracer to the vadose zone, we will likely transfer SF₆ into solution using a mixing tank and then inject this solution directly into the aquifer using monitoring wells within the basin. Bromide will be applied directly to the surface water at the recharge basin and will be a second tracer.

19. As an enhancement to the study, LOTT could examine unique compounds in wastewater effluent (such as boron) as possible tracers. The compounds would need to be different than those from septic discharge. It may be possible to obtain water quality data of groundwater at monitoring wells that have not yet received any infiltrated reclaimed water, compare those data to reclaimed water quality data, and identify constituents in the reclaimed water that are not present in the existing groundwater (or present in much lower concentrations) that may be used as a tracer.

Study Team Response

See previous response.

20. The Panel would like to review where proposed wells will be located. A review of the detailed tracer and monitoring plan by the Panel may be useful to LOTT.

Study Team Response

A Work Plan will be developed that provides details on the well locations and tracer testing approach. It will be provided to the Panel for their review and input.

21. If the layer of groundwater containing tracers/wastewater is small relative to a large screened interval of a well, sampling from a large screened interval may result in the dilution of groundwater containing tracer/contaminants with uncontaminated water. The result will be a lowering of concentrations in the sample, with the potential for dropping concentrations below the detection limit. Sampling narrower intervals potentially offers more information at the depth of the tracer cloud and minimizes the dilution of tracer/contaminant information.

Study Team Response

We agree that tracer sampling should target discrete intervals. The shallow monitoring wells near the groundwater surface will be designed to span the groundwater table and account for the changes in groundwater level that occur as the project operates, so they are required to have larger screens. We intend to utilize screens that span across and penetrate about 20 feet below the water table for shallow monitoring wells. Deeper monitoring wells will use screens completed below the water table. Screen length is not proposed to exceed 20 feet, but likely will be less for deeper wells at the nested monitoring well sets. We also intend to use low-flow sampling techniques to allow withdrawal of groundwater directly from the vertical portion of the aquifer being sampled without mixing water across the well screen.

Most of the existing monitoring wells at the Hawks Prairie site have screen intervals of about 10 to 30 feet. A few of the existing on-site wells needed for the tracer test have screens where the top of the screen is 10 to 20 feet below the top of the water table. We have recommended that some of these wells be redrilled if they are screened far below the water table.

22. It would be useful to consider multi-level sampling of the groundwater, which would allow the study to develop vertical resolution within the subsurface.

Study Team Response

The Study approach includes the use of nested wells at various depths, as opposed to multi-level sampling, in order to achieve the vertical resolution that is referenced in the comment.

23. LOTT should consider high-frequency sampling of the wastewater effluent and archiving samples. Not all samples need to be analyzed immediately – many samples could be saved to add resolution where it is needed. It may be useful to be able to return to the sample archive and analyze additional samples within the timeframe of interest. To be more cost-effective, sub-compositing samples could be considered. The proper place to do this sampling would be a location closest to the addition where the tracer is well mixed.

Study Team Response

All of the water quality parameters proposed for this project have specific hold and extraction times that would be elapsed by the time we realized that additional sampling was needed. Unless a sample is submitted to the laboratory for analysis immediately upon collection, it will not be able to be analyzed. Also, the cost for the reclaimed water characterization sample analysis is significant, and we cannot run more water quality analyses than are within the project budget.

We do plan on collecting multiple samples for tracer testing in the event that additional samples are needed. The cost for analyzing the tracers is not significant and additional samples could be run within the project budget. The final recommended schedule for sample collection for tracer testing will be developed in a Work Plan and submitted to the panel for review and comment.

3.4 Ecological Health Risk

24. In general, the approach and deliverables for ecological health risk seem reasonable given the scope and overall budget of the project. It will be important to characterize any potential effects from persistent chemical constituents (e.g., sucralose), which are resistant to degradation and may be used as surrogates for other residual chemicals, even though they themselves may not present a health concern. Although some aquatic toxicology studies exist indicating that sucralose does not alter the survival, growth, and reproduction of certain aquatic organisms, compounds such as these have not been extensively tested in species (e.g., salmonids) that may potentially receive exposures from such chemicals. Reviewing constituents after the Tier 1 (screening) assessment for the aquatic ecotoxicology effort is reasonable.

Study Team Response

Comment noted. If sucralose passes through the Tier 1 (screening) assessment then the aquatic ecotoxicology literature will be reviewed to characterize potential effects and adverse effect levels for sucralose.

25. In addition to the ECOTOX database, the Panel recommends a thorough review of other literature for sub-lethal effects of residual chemicals because the sub-lethal effects (i.e., those that occur at concentrations below those that elicit mortality) will be more relevant than lethal exposures. These sub-lethal effects include such endpoints as behavior and reproduction, which have been shown to affect the survival of aquatic wildlife. In this regard, for the “no observed effect levels” (NOELs) and “lowest observed effect levels” (LOELs), it will be important to discriminate the endpoints that these metrics are based on (i.e., growth, reproduction, behavior, etc.).

Study Team Response

We intend to thoroughly review the primary literature in the Tier 2 evaluation for a subset of residual chemicals selected as key ecological stressors based on magnitude and frequency of

detection, mode of ecotoxicity, chemical properties (e.g., persistence and bioaccumulative potential), and importance to risk management decision-making. This would include papers on sub-lethal effects.

26. The Panel is uncertain of the value of assessing ecological risk related to the use of reclaimed water for landscape irrigation.

Study Team Response

We agree. This has been removed from the scope.

3.5 Human Health Risk

27. A complete human risk assessment of potable reuse projects cannot be quantitative because of a large number of unknowns that are typically not addressed in the risk analyses. One reason is the presence of unknown compounds (largely trace organic chemicals). Another reason is the lack of appropriate toxicological data in humans or experimental animals suitable for estimating the risks they might pose. The absence of data does not translate into a lack of risk. Therefore, the emphasis of risk assessments in the area of potable reuse should focus on information that speaks broadly to the overall risk rather than the minutiae of the assessment of risk for individual chemicals. Assessing individual contaminants of the water, especially active ingredients of PPCPs, is more useful as illustrations of how effective the treatment processes are in removing chemicals than providing reliable estimates of overall risk. If done systematically, the effectiveness of treatment could allow for predicting whether other unidentified related chemicals are removed. Uncertainties in the risk assessment will remain, but examining a broad database will allow this uncertainty to be narrowed based upon the performance of the treatment train.

Study Team Response

We agree. Human health risk assessments based on environmental sampling data are not meant to precisely estimate true exposures and risks to populations, but to provide information to support decision making to protect public health. As we state in our scope of work, the risk assessment “will not provide estimates of true or absolute risks” but “it will be conducted in a consistent manner across all scenarios and exposure pathways in order to ensure valid and defensible comparisons of relative risks.” In other words, the goal is to use a consistent methodology that allows us to compare relative risks for different reuse scenarios.

To address the issue of “lack of appropriate toxicological data” we have proposed an approach to assign risk-based decision guides based on existing toxicological and medical data. While we recognize that the final values are not equivalent, they are all intended to be conservative estimates of potential risk—i.e., to not underestimate risk—and are therefore appropriate for screening purposes to identify compounds that may contribute significantly to risk.

The text in the scope of work has been modified to clarify the limitations of the quantitative element of the human health risk assessment and to stress that uncertainties in the risk assessment will exist.

28. The specific question with the scope is that it addresses a narrow group of contaminants. Many of the analytes chosen were selected because they could be detected with a single method of analysis. They were not necessarily chosen because of a higher probability of occurrence than related compounds (e.g., in the same pharmacological class or mode of action). The relative potency of the chemicals has not been used in the selection. The selection also did not necessarily include analytes that act as surrogates that will reflect the removal of other chemicals. Therefore, the risk assessment can be used to see if there is a problem with one of the measured compounds, but it will not necessarily provide a basis of comparing the abilities of different treatment processes to diminish overall risk. The scope of the project could be narrowed to reflect what can be accomplished with the analyses that are proposed.

Study Team Response

The revised study scope includes more analytes to achieve a broader characterization of reclaimed water and groundwater. The analyte list is based on chemicals that have been studied in similar previous efforts that have evaluated treatment effectiveness and their relation to reducing human/ecological health risks. The analyte list does include surrogates and indicator chemicals. In fact, the list includes those compounds recommended as surrogates by the various scientific panels involved in developing the recommendations for water quality sampling of reclaimed water as part of the California Title 22 regulations for water reuse (Anderson et al., 2010; CA State Water Board, 2013). We agree that there are limitations regarding the quantification of risk that can be made with the analyte list (as there are with any specific analyte list). The text in the scope of work has been modified to stress this fact, and to emphasize the concept of relative risk assessment among various reuse scenarios (see response to prior comment for more detail).

29. The risk model proposed could be designed to address chemicals that are found in local wastewater. The major concern related to the potable reuse of municipal wastewater remains the potential that unknown trace organics may present hazards to human health. Consequently, it is important that efforts be made to identify chemicals present in the system being studied. The most efficient means of identifying such chemicals is a source control program that actively identifies and monitors non-domestic waste discharges to the wastewater collection system.

Study Team Response

Agreed. LOTT maintains a pretreatment program for industrial dischargers and performs water quality monitoring of reclaimed water produced at its treatment plants. As stated above in No. 28, the analyte list for the characterization of reclaimed water has been expanded significantly. There are no monitoring data that indicate specific chemicals are being introduced into the wastewater stream, other than those already addressed in the study.

30. Data were not provided related to the occurrence of contaminants in the wastewater being treated for current water reuse applications. Reference is made to some analysis of three

systems (one of which was LOTT) published by the Washington State Department of Ecology. The list of chemicals appears to be largely confined to pharmaceuticals. As demonstrated in the 2012 National Research Council (NRC) report on *Water Reuse*,¹ these compounds are likely not of concern.

Study Team Response

In addition to the prior Ecology study that is referenced with respect to pharmaceuticals, LOTT conducts regular water quality monitoring for metals and organic compounds according to its permit requirements. These data have been summarized in the revised project scope and been made available to the peer review panel. The monitoring indicates that the reclaimed water produced is well below MCLs and the permit limits.

31. Demonstrating due diligence will help gain public confidence. The present effort should characterize the performance at the recharge site(s) under consideration. Chemicals with maximum contaminant levels (MCLs) and state action levels should be addressed in this analysis.

Study Team Response

Agreed. In order to be able to fully answer the question “does the reclaimed water meet drinking water standards”, the analyte list in the scope of work has been modified to include analysis of all chemicals having a primary drinking water MCL. LOTT already monitors for many of these constituents, but the list has been expanded for the purpose of this study to encompass all drinking water parameters.

32. There are some challenges in the proposed analysis of risk that will prevent the risk analysis from being quantitative. These are:
 - a. Characterization of unknown compounds, as described above.
 - b. The methods used for arriving at points of departure are not equivalent. Traditional methods, based on risk assessment paradigms of the U.S. Environmental Protection Agency (EPA), World Health Organization (WHO), and U.S. Food and Drug Administration (FDA), use human and/or animal data that are acceptable methods for estimating risk quantitatively (not necessarily failsafe). These can extend to other methods that indirectly use human data as a gauge of human sensitivity with some confidence. However, screening methods based on loose analogies to structural and functional groups are not intended to be risk assessment tools, but rather methods of triage (e.g., thresholds of toxicological concern [TTCs] to identify chemicals for which new toxicological data are necessary). These methods were developed primarily to address the likelihood that minor contaminants of various commercial products are of sufficient concern. While there is no objection to utilizing these methods for their intended purposes, they should not be used to generate acceptable daily intakes (ADIs).

¹ National Research Council (2012). *Water Reuse: Potential for Expanding the Nation's Water Supply through Reuse of Municipal Wastewater*, National Academies Press, Washington, D.C.

As long as the chemical occurs at concentrations below its TTC, it should be eliminated from the risk assessment. A compound above its TTC should be identified, but it should not be concluded that this compound presents a significant health risk.

- c. The estimates generated by the variety of methods proposed must always be identified with the method of derivation. These are not equivalent indicators of risk.

Study Team Response

As noted in previous responses, we agree that there are limitations to the quantitative element of the risk assessment. The scope of work text has been modified to clarify those limitations.

Regarding non-equivalent methods for arriving at points of departure, we propose to apply these methods primarily within Tier I, i.e., to screen for those compounds most likely to contribute significantly to overall risk, and to provide a means to remove from further consideration those compounds not likely to contribute significantly. The methods for deriving these screening criteria are conservative and are meant to arrive at values that do not underestimate risk and therefore that do not inappropriately exclude compounds from further evaluation. We will only apply the TTC approach if no other data exist-- the alternative is to exclude these compounds all together. We do not propose to conclude that a compound present above its TTC (if a TTC is used) presents a significant health risk, but to evaluate these chemicals further should they occur, in the second tier of the risk assessment.

Regardless, our preliminary evaluation of available toxicological data for the compounds of interest indicates that data are available for most compounds, and toxicological criteria applied in the risk assessment will either be based on existing values from authoritative bodies (e.g., MCLs, reference doses, cancer slope factors), therapeutic doses and animal toxicity data for pharmaceuticals, or animal toxicity data for other types of compounds. It does not appear that “lack of data” will be a significant issue, or that many chemicals will be evaluated using the TTC approach.

3.6 Monitoring (Analytes, Methods, Locations, etc.)

33. The Panel agrees that lysimeters are useful as part of the study as planned.

Study Team Response

Comment noted.

34. The January 28, 2014, *Scope of Services Phase III – Study Implementation* report includes information regarding monitoring for pathogens or indicator organisms, including total and fecal coliform organisms and coliphage to characterize WWTP effectiveness. The Panel recommends that LOTT also sample WWTP water for *Cryptosporidium*.

Study Team Response

Agreed. The analyte list has been modified to include *Cryptosporidium* in the characterization of reclaimed water.

35. The selection of chemical analytes is reasonable given budgetary constraints, notwithstanding the discussion of the risk assessment approach in Section 3.5. To support the risk assessment goals, other specific compounds that should be analyzed may need to be identified.

Study Team Response

As noted in responses to other comments (both prior to and subsequent to this one), the analyte list has been expanded, primarily to better support the risk assessment goals. The analytes added to the study include:

- *Cryptosporidium*
- All parameters having primary drinking water MCLs (including VOCs, SVOCs, herbicides, pesticides, disinfection byproducts)
- Perfluorinated compounds (see following response)
- PBDEs
- Metformin and Thiabendazole (two compounds of interest noted in prior Ecology study of LOTT's reclaimed water)

36. The Panel agrees that perfluorinated compounds (PFCs) should be included in the study. These compounds are under scrutiny due to their wide-scale production and uncertainties regarding their toxicity to humans and aquatic organisms. The EPA's Unregulated Contaminant Monitoring Rule 3² lists six PFCs and offers an explanation of their potential health effects.

Study Team Response

Agreed. The analyte list has been expanded to include perfluorinated compounds (PFOS, PFOA, and others).

- If perfluoroalkyl substances are added to the monitoring list, precautions need to be taken at the time of any well installation or sampling to avoid materials containing polytetrafluoroethylene (PTFE) (e.g., Teflon).

Study Team Response

Comment noted. We do not intend to use materials containing PTFE.

² <http://water.epa.gov/lawsregs/rulesregs/sdwa/ucmr/ucmr3/index.cfm>

37. LOTT should consider including constituents with drinking water MCLs as part of the monitoring plan. In addition, LOTT should provide the rationale as to why some contaminants are included in the monitoring plan and others are not.

Study Team Response

As previously noted, the analyte list has been expanded to include all constituents with drinking water MCLs.

The rationale for the development of the list has been discussed with the Panel, the various groups providing input to the study (e.g., the Science Task Force and LOTT's Technical Subcommittee), and the LOTT Board of Directors. Study documentation will also include discussion of the rationale for development of the analyte list.

3.7 Panel Response to Study Questions

As the study scope of work has been developed, LOTT has compiled a list of questions from several sources. Selected questions that seemed most appropriate for the Panel to address were provided to the Panel at their first meeting. Those questions came from members of the Community Advisory Group, members of the public, public workshops, and members of the study's Science Task Force and/or LOTT Technical Sub-Committee. The Panel's responses are provided below. In some cases, additional clarification was needed.

3.7.1 Study Methodology Questions

38. *Question 1 – Are the analytical methods to be used by Eurofins Analytical going to be comparable to PPCP study results from Ecology (and potentially the University of Washington) and the Case Studies provided by HDR? Are any of the constituents typically found to remain after SAT (like sulfamethoxazole) more likely to present problems with comparability?*

The PPCP analytical method used by Eurofins-Eaton Analytical is capable of providing results at the low levels (i.e., in the nanogram per liter level) and, therefore, would be comparable to other studies.

A number of chemicals are less amenable to removal through soil aquifer treatment (SAT) (including, but not limited to, sulfamethoxazole). In general, levels found in municipal wastewater are below levels of concern. However, the Panel cannot make definite statements in response to this question without reviewing the appropriate monitoring data.

Study Team Response

Comment noted.

39. *Question 2 – For evaluating SAT effectiveness, is it more important to establish site selection criteria based on estimated time of travel, distance from the infiltration location, or some combination of both? Which would give us the most information for the proposed level of effort (i.e., 12 offsite wells), and do you have recommendations for locating the wells?*

Of the two site selection criteria mentioned in the question, it would be more important to establish criteria based on the time of travel (time is important for pathogen reduction in the underground and attenuation/degradation of chemical constituents). However, site selection should include a range of criteria, including site geology, geochemistry, hydrology, and so forth.

Study Team Response

Comment noted.

40. *Question 3 – Can the results from the Hawks Prairie analysis be used to develop a template that can be applied to other future sites?*

Assuming the additional sites undergo a site assessment as characterized in the scope, it is reasonable that the work at Hawks Prairie can later be applied to future sites, such as Henderson. As long as the site assessments characterize soils, hydrogeology, geochemical conditions (e.g., redox conditions, organic matter content), and other site-specific parameters, the results could be transferrable. A minimum travel time before infiltrated reclaimed water reaches a drinking water well is reasonable.

Study Team Response

Comment noted. As indicated in a previous comment, a second study site (which might be the Henderson site, depending on results of initial feasibility assessments) will undergo a full site characterization before results from the Hawks Prairie analysis are applied to the site.

41. *Question 4 – How important would it be to have a second site as part of the study?*

It will be necessary to evaluate the effectiveness of SAT and other conditions at each individual site. The value of a second site is to gain some understanding of the variability in effectiveness of SAT from one LOTT site to another. Clearly, there is some value in a second site, provided that basic site characterization can be done and that measurements of attenuation of residual chemicals can be made.

Study Team Response

Comment noted. As indicated in the scope of work, the study anticipates the ultimate inclusion of a second site when such a site has been identified and the full site characterization has been conducted.

42. *Question 5 – Are the sampling locations, frequencies, and intensities appropriate to achieve 95-percent accuracy?*

Although it may not possible to achieve a specified accuracy for all the constituents, the information collected in this study will be able to provide important information in characterizing and understanding the role of the SAT in attenuating chemical constituents.

Study Team Response

Comment noted.

43. *Question 6 – Is the proposed duration of tracer study monitoring (6 months) sufficient? Why not extend beyond 6 months?*

The tracer study approach in the scope (i.e., up to 12 months for the tracer study) is reasonable. The actual monitoring period will be adapted to the data. If early breakthrough occurs, then prolonged observation will be less valuable.

Study Team Response

Comment noted.

44. *Question 7 – Can full-scale contaminant loading be accurately accounted for/simulated with the proposed methodology of installing a berm in Basin 4 at the Hawks Prairie site?*

The berm at the Hawks Prairie site will help create a loading rate similar to the full-scale operation. This is a reasonable approach. The only limitation is caused by site heterogeneity. If the section of the basin where the test occurs is different than the larger basin, then results may be skewed. However, in the estimation of the Panel, it is more valuable to use a fraction of the basin at full recharge rate and have more uncertainty about heterogeneity, than to have a smaller recharge rate with less uncertainty about heterogeneity.

Study Team Response

Comment noted.

45. *Question 8 – Is it acceptable to eliminate background characterization of the deeper aquifer at Hawks Prairie?*

The project scope mentions that several deep monitoring wells will be completed at both sites and that some of these will be used to create piezometer nests to measure and monitor vertical gradient. This is adequate for monitoring the hydrology. It would be useful to include a small number of samples before, during, and after the tracer test to monitor tracer and residual chemicals. The deeper wells could also be monitored periodically in the long term for residual chemicals.

Study Team Response

Background characterization of the deeper aquifer has been retained in the scope of work.

3.7.2 Background Sampling

46. *Question 1 – What level of effort is appropriate for background sampling at Hawks Prairie and in other areas?*

Some background monitoring has been previously conducted that provides some information on background groundwater quality. The approach proposed in the scope will evaluate reclaimed water loading over background loads. Now that reclaimed water is infiltrating at Hawks Prairie, more background sampling is not possible.

Study Team Response

Comment noted. The scope of work does include “background” sampling at existing wells within the vicinity of the Hawks Prairie site, including wells that are likely outside of the flow path of reclaimed water currently. While this cannot be considered true “background”, in the sense of it representing conditions with no reclaimed water infiltration occurring, the intent is for this sampling to be representative of shallow groundwater in the area that is under minimal to no influence of reclaimed water.

47. *Question 2 – For background sampling, isn't it important to characterize groundwater at various times of year/seasons to account for seasonal variations in precipitation/groundwater levels?*

In general, it would be useful to characterize groundwater at various times of the year. However, given a limited amount of available resources, there is a trade-off between seasonal sampling and sampling a larger number of wells. Obtaining one sample at a larger number of wells may provide a greater benefit than multiple (seasonal) sampling at fewer wells. A separate study would be needed to characterize the specific benefits for seasonal sampling versus sampling a larger number of wells. Sampling a larger number of wells would support the study objectives.

Study Team Response

The scope of work is predicated on obtaining one sample at a larger number of wells, as noted in the comment.

48. *Question 3 – Surface water characterization -why collect at “first flush” and high-flow inter [sic]? Are these really the best times to collect if the point is to characterize as relates to reclaimed water infiltration?*

Phenomena other than wastewater in the watershed are more likely to impact first flush signatures.

Study Team Response

Comment noted.

3.7.3 Risk Assessment Questions

49. *Question 1 – Is the risk model proposed appropriate for this project and protective of human health?*

The proposed risk assessment model involving assessment of individual contaminants in the water is sufficient for illustrating the effectiveness of the treatment processes for removing the chemicals. At the level of detail implied by the analyses that are to be performed, the Panel believes the study team should confine their risk analyses to relative risks of specific chemicals found in the percolated water with that observed in the wastewater being applied. The Panel discussed aspects of the risk assessment and risk model component of the study in Section 3.5.

Study Team Response

As indicated in previous responses, the focus of the scope of work is in fact upon characterizing relative risks between reuse scenarios based upon the analyte list, as recommended by the comment.

50. *Question 2 – Is the risk assessment approach objective and credible?*

The proposed risk assessment approach is objective and credible within the limitations discussed in Question 1 above and in Section 3.5.

Study Team Response

See above response.

51. *Question 3 – Are there other more vigorous approaches that are more protective of public health that should be considered?*

See the response to Question 1 above. In addition to the risk assessment, it will be useful to characterize the wastewater and reclaimed water after treatment (including after SAT).

Study Team Response

Agreed. The scope of work includes characterization of raw wastewater, reclaimed water (i.e., after the treatment plant processes and prior to infiltration), and reclaimed water after it has entered the groundwater system.

52. *Question 4 - Is the initial list of Tier 1 residual chemicals sufficient?*

In an initial characterization of a new drinking water source, the Tier 1 analyses (i.e., a first analysis) should include frequent contaminants of drinking water, such as the group of chemicals that have MCLs and Health Advisories. It is assumed that Tier 2 analyses are to

be directed towards derivation of more precise estimates of risk if such data are not available. The list of chemicals being assessed in the proposed analysis include active ingredients of PPCPs which, as demonstrated in the 2012 NRC report, are likely not of significant health concern at concentrations usually encountered in treated wastewater. The January 28, 2014, *Scope of Services Phase III – Study Implementation* report indicates that some additional residual chemicals (e.g., NDMA, 1,4-dioxane, nitrate, and metals) will be included. These fit into a similar category as the chemicals having MCLs or Health Advisories. If the study scope includes the proposed list of residual chemicals, along with the additions recommended by the Panel (e.g., MCLs, Health Advisories, PFCs, and *Cryptosporidium*), it would be sufficient and in keeping with other studies of this nature.

Study Team Response

As indicated in previous responses, the analyte list has been expanded to include chemicals that have drinking water MCLs, *Cryptosporidium*, perfluorinated compounds, PBDEs, Metformin, and Thiabendazole.

53. *Question 5 – Are the data reduction methods which generate the Tier 2 list of chemicals appropriate?*

The distinction between Tier I and Tier II needs to be well defined. The transition between Tier I and Tier II is based upon the frequency of a contaminant's occurrence and its probability of exceeding some reference risk level (defined in the context of cancer and non-cancer risk). A variety of methods are used, but their grounding in the available toxicological literature is different. Nevertheless, the intent seems to combine (or integrate) the outputs from these different analyses into a combined estimate of risk without distinction among the methodologies used. An explicit description of the two-tiered approach would be useful.

Study Team Response

As described in the modified scope of work, a chemical will move from Tier I to Tier II if its maximum detected concentration (measured anywhere) exceeds the DWEL, which is a risk-based value that conservatively assumes a person drinks two liters of the water a day for a lifetime. All of the methods that will be used to arrive at the DWEL values are conservative—thus, if the maximum concentration does not exceed this level, it is not likely to represent a significant risk, especially at more likely (lower) levels of exposure, regardless of the specific toxicological basis for the DWEL. This is an accepted, cost-effective approach for focusing the resources of a risk assessment on those compounds that are likely to contribute most significantly to risk.

In Tier II of the evaluation, a more specific and detailed evaluation of the toxicological significance of the compounds that pass the Tier I screen will be conducted. Because of limitations of available resources, for this project we are necessarily restricted to relying upon existing toxicological data. However, as discussed above, it appears that sufficient toxicological data to derive toxicity criteria will be available for most compounds on the list. Nonetheless, the existing (and accepted) approaches for deriving these types of toxicity

criteria to assess risks to human populations are also conservative (e.g., they are based on the toxicity results that show an effect at the lowest dose to the most sensitive population, they incorporate multiple uncertainty criteria) and therefore when combined with dose estimates do not provide an estimate of “true” risks to a population, but rather are useful for developing comparisons of relative risks and supporting decision-making. It is important to keep the nature of these types of values in context, and in our risk assessment, we will include a discussion of the uncertainties in the derivation of the toxicity estimates and the results of the risk assessment.

54. *Question 6 – Is the Tier 2 Human Health risk assessment approach appropriate?*

The Tier II assessment apparently relies on further examination of the health effects data, plus some consideration of interactive and additive effects among contaminants. However, the methods of risk assessment in Tier I and Tier II are not clearly distinguished between the two tiers. Also, some of the modes of action identified with the measured chemicals are found among more common contaminants of water that are not included in the chemical analyses of the waters in question. Consequently, the Panel would like to have an additional review of the implementation of the health effects risk assessment approach, including the scientific justification for combining estimates arrived at by different methodologies.

Study Team Response

The methods for Tier I and II are not the same. As discussed previously, Tier I is intended to consider a large list of compounds and, in light of limitations of available resources, exclude those compounds not likely to contribute significantly to risk. This will be done by comparing maximum detected concentrations to conservatively derived estimates of toxicity (the DWELs)—the specific basis of the DWELs is not as important as the fact that they will all be conservatively derived and as such will be intended to overestimate risk, such that if the maximum concentration is below this value, there is no need to investigate this compound further as it is unlikely to contribute significantly to risk. Tier II will look at a much smaller list of compounds (those that “pass” the Tier I screen). For a given compound, Tier II will consider the breadth of toxicological literature for that compound, and a more reasonable estimate of exposure. Where existing toxicity criteria (e.g., from EPA or other authoritative bodies) are not available, we will conduct a review of the toxicological data for that compound and derive an estimate of toxicity using accepted methodologies. If insufficient data are available even after that, we will compare exposure estimates for the compound to TTCs since it is impractical in the course of this project to conduct toxicological testing for such compounds. This approach will assure that no compound is excluded from the risk assessment because of lack of data (this essentially would assume no risk associated with that compound). TTCs are intended to be conservative and are based on evaluation of hundreds of existing compounds and their toxicity data. Any uncertainties in this approach will be identified and discussed in the risk assessment. However, as discussed above, it appears that existing toxicity data that can be used to develop toxicity criteria are available for most compounds on the analyte list.

With respect to interactive or additive effects, the scope of work has been modified to remove this element. We acknowledge that the analyte list is too limited to provide

meaningful evaluations of interactive or additive effects. These will be addressed in a qualitative nature in the risk assessment.

55. *Question 7 – Does the proposed approach for the ecological risk assessment seem complete?*

In general, the deliverables for ecological health risks seem reasonable (with some caveats) given the scope and overall budget of the project. These are mostly associated with the state of ecological risk assessment and include the limitations of performing extrapolations of literature studies using fish (e.g., fathead minnows, rainbow trout) that are not the actual aquatic species of concern that may receive chemical exposures in this scenario. There also exists a high level of uncertainty associated with extrapolations from the laboratory data to the field situation, as well as the probability of a lack of scientific data on sublethal injuries to the target ecological receptors (e.g., Chinook or Coho salmon). Furthermore, it is unlikely that any trace organic chemicals at levels of ecological health concern would be present in the groundwater after SAT; therefore, the Panel suggests studies in this area be limited to metals. In addition, unless background sampling of the receiving waters is conducted, it would be difficult to prove chemicals detected in fish originate from the groundwater inputs or are of sufficient magnitude to elicit adverse biological effects. Additional Panel comments on the ecological risk assessment are provided in Section 3.4 of this report.

Study Team Response

Comment noted.

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