Responsiveness Summary

"Relation Between Nitrate in Water Wells and Potential Sources in the Lower Yakima Valley, Washington"

(EPA-910-R-12-003)

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Attachment A

Washington NRCS Draft Guidance - May 2011, Appendix 2, Waste Storage Pond Practice Standard Criteria Reference Tools

I. Introduction

In February and April 2010, the U.S. Environmental Protection Agency (EPA) conducted a study to identify potential sources of nitrate contamination in groundwater and residential drinking water wells in the Lower Yakima Valley in central Washington State. The study was conducted in response to community concerns about the high nitrate levels in residential drinking water wells and the potential disproportionate impacts on low income and minority rural populations in the area. EPA released a report on this study in September 2012, entitled "Relation Between Nitrate in Water Wells and Potential Sources in the Lower Yakima Valley" ("EPA 2012 Report").

EPA provided an opportunity for public input on the EPA 2012 Report from September 27, 2012 to November 30, 2012 and received input from 43 individuals or organizations. All of the input received can be found on EPA's Lower Yakima Valley website at http://yosemite.epa.gov/r10/water.nsf/gwpu/lyakimagw. EPA has summarized the input received and developed responses that are included in this document. EPA is not responding to each individual comment, but is responding to similar comments that are grouped according to topic.

EPA received several comments that were beyond the scope of the report. EPA has acknowledged these comments in this responsiveness summary, but has not provided detailed responses to these comments. Some of the questions and issues raised in these comments may be appropriate for consideration as a part of the Lower Yakima Valley Groundwater Management Area (GWMA) process being lead by Yakima County and by state and local agencies. EPA is a member of the Lower Yakima County Groundwater Advisory Committee (GWAC) for the GWMA and continues to work with the other members of the GWAC to develop a comprehensive plan to reduce concentrations of nitrate in groundwater to below drinking water standards.

As a follow-up to the 2010 study, EPA installed and sampled ten groundwater monitoring wells in December 2012 and January 2013 in the vicinity of the Yakima Valley dairies that were included in the 2010 study. The data, and a report summarizing the information from this effort, can be found on EPA's Lower Yakima Valley website at http://yosemite.epa.gov/r10/water.nsf/gwpu/lyakimagw. EPA considered the information from this subsequent work also while preparing responses to the input on the EPA 2012 Report.

Based on review and consideration of the public input and the results of subsequent monitoring, EPA finds that sufficient information exists to support the conclusions reached in the EPA 2012 Report. EPA has identified errors in the EPA 2012 Report and has prepared an errata sheet that summarizes the corrections. EPA will post the errata sheet and a revised report that includes the listed corrections on EPA's Lower Yakima Valley website at http://yosemite.epa.gov/r10/water.nsf/gwpu/lyakimagw when they are completed.

II. Study Design

A. Study Purpose

Comment #1: One commenter stated that the EPA 2012 Report[1] appears to suffer from a redirection of the study purpose and changed from a data collection/research emphasis to a data collection effort with regulatory actions in mind.

EPA's response: EPA initiated the study in response to: 1) community concerns about nitrate levels in residential drinking water wells above EPA's drinking water standard (maximum contaminant level (MCL)) for nitrate of 10 mg/L (an estimated 12% of wells exceed the standard);[2] 2) the potential disproportionate impact on low income and minority rural populations; and 3) a series of articles in the Yakima Herald documenting the high nitrate levels in private wells and the inaction of government agencies to address the problem. The primary purpose of the study was to investigate the contribution from various land uses to the high nitrate levels in groundwater and residential drinking water wells in the Lower Yakima Valley. From the outset of the 2010 study, EPA has stated publicly that it would evaluate all appropriate actions, including enforcement, that might be necessary to address these high nitrate levels.

B. Groundwater Flow Direction

Comment #2: Many commenters indicated that EPA could not draw conclusions regarding the sources of nitrate and other contaminants in water wells because it had used a generalized groundwater flow direction developed by the U.S. Geological Survey (USGS)[3] and did not consider localized groundwater flow direction and gradients which may be very different from regional flows and gradients. Commenters also stated that EPA did not consider groundwater flow in fractured basalt which may not follow regional flow paths. Finally, commenters contended that EPA did not consider the impacts on groundwater flow direction of such factors as seasonal precipitation, snow melt, irrigation practices, drains, ditches, and canals.

EPA's response: EPA recognized that the groundwater flow direction developed by USGS was a generalized flow direction and acknowledged this limitation in the EPA 2012 Report. Also, EPA acknowledged that locally, the flow direction may be affected by geological structures and by irrigation practices, drains, ditches, canals, streams, and other hydrologic features. Any localized

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[1] U.S. Environmental Protection Agency. 2012. Relation Between Nitrate in Water Wells and Potential Sources in the Lower Yakima Valley, Washington. US EPA Region 10. EPA-910-R-12-003. September 2012.

[2] Washington State Department of Ecology. 2010. Lower Yakima Valley Groundwater Quality: Preliminary Assessment and Recommendations. Prepared by: The Washington State Departments of Agriculture, Ecology, and Health; Yakima County Public Works Department; and the U.S. Environmental Protection Agency. February 2012. Ecology Publication No.10-10-009.

[3] U.S. Geological Survey. 2009. Vaccaro, J.J, Jones, M.A., Ely, D.M., Keys, M.E.,Olsen, T.D., Welch, W.B., and Cox, S.E., Hydrogeologic Framework of the Yakima River Basin Aquifer Systems, Washington. Scientific Investigations Report 2009-5152, 106p.

variation will be of limited range, however, and the conclusions that EPA made based on regional flow information from USGS took into account such possible variations.

Moreover, in December 2012 and January 2013, EPA installed and sampled ten monitoring wells in the vicinity of the dairies that were included in Phase 3 sampling and the EPA 2012 Report. Seven wells were installed near the Dairy Cluster[4] (one upgradient and six downgradient) and three wells were installed near the Haak Dairy (one upgradient and two downgradient). The new wells were screened in the shallow unconfined alluvial drinking water aquifer.

The newly installed wells were surveyed by a Washington licensed professional land surveyor and groundwater elevations were measured by EPA. Measurements confirmed that the localized groundwater flow direction in the vicinity of these dairies is consistent with the generalized flow direction developed by the USGS that was presented in the EPA 2012 Report. Future water level measurements from these new wells could be used to determine the range of variation in localized groundwater flow direction due to seasonal changes or irrigation practices.

C. Well Construction Information

Comment #3: Many commenters stated that lack of information about well construction (e.g., well completion records, measured heads, and screened intervals) limits EPA's ability to verify if the wells identified as upgradient and downgradient of potential sources produce water from the same water bearing zone. These commenters contend that this lack of information makes it impossible to draw any conclusions about the relationship between the upgradient and downgradient wells and to conclude with any confidence that any specific sources are contributing to the nitrate in residential drinking water wells.

EPA's response: EPA acknowledged in the EPA 2012 Report that the lack of complete well information limited its ability to verify if all the wells identified upgradient and downgradient of the dairy sources draw water from the same water bearing zone. However, given that EPA had well logs for one-third of the wells and knowledge of well drilling practices, EPA had some basis for understanding the relationship between upgradient and downgradient wells.

In addition, in December 2012, EPA installed ten monitoring wells in the vicinity of the dairies that were included in Phase 3 sampling and the EPA 2012 Report. Seven wells were installed near the Dairy Cluster (one upgradient and six downgradient) and three wells were installed near the Haak Dairy (one upgradient and two downgradient). All of these new wells installed by EPA were screened in the shallow alluvial drinking water aquifer.

In January 2013, EPA collected samples from each of the ten new wells. Samples were submitted to a National Environmental Laboratory Accreditation Program (NELAP) certified drinking water laboratory for nitrate analysis and validated by EPA Region 10 quality assurance (QA) chemists.

[4] The Dairy Cluster refers to a group of adjacent dairies comprised of the George DeRuyter & Son Dairy, D and A Dairy, Cow Palace Dairy, Liberty Dairy and Bosma Dairy.

The data met the quality control (QC) criteria established for this sampling event and are useable for all purposes.

At the Dairy Cluster, the nitrate concentration in the upgradient well was 9.8 mg/L, which is elevated above the range of naturally occurring nitrate concentrations (generally below 1.1 mg/L), but below the MCL of 10 mg/L. Note that the concentration in the upgradient Dairy Cluster well also suggests that there are potential sources of nitrate upgradient of that well. The nitrate concentrations in the wells downgradient of the Dairy Cluster ranged from 2.8 mg/L to 190 mg/L, with four of six down-gradient monitoring wells exceeding the MCL.

At the Haak Dairy, the nitrate concentration in the upgradient well was 0.94 mg/L and the concentrations in the two downgradient wells both exceeded the MCL at 31 mg/L and 47 mg/L.

The new data provide further support for the conclusions in the EPA 2012 Report that the dairies in the earlier study are likely sources of nitrate in the residential drinking water wells downgradient of these dairies.

D. Residential Water Well Integrity

Comment #4: Several commenters indicated that EPA did not collect information on the integrity of the residential drinking water wells that were sampled and so could not rule out that that these wells could have been contaminated by cross connections, septic systems, fertilizer applied by the landowner to their lawns, or other sources not related to dairies.

EPA's response: EPA acknowledges that localized contamination from nearby sources, including (but not solely) septic systems, is possible as a result of a poorly sealed or poorly constructed well or a well with inadequate setbacks. Poorly constructed wells could be more vulnerable to any source of nitrate contamination, including dairy waste and commercial fertilizer.

In order to evaluate the condition of the wells sampled (per the Phase 2[5] and Phase 3[6] Quality Assurance Project Plans (QAPPs)), samplers observed the sanitary seal to assess the integrity of the well and documented their findings in the field log books. If they observed a potential problem with the integrity of the well, they submitted a sample for bacteria analysis. During the Phase 2 sampling, 166 samples were submitted for analysis of bacteria. Eight of those samples had either fecal coliform or *E. coli* contamination. In Phase 3, all twenty-nine water well samples were analyzed for total coliform. If total coliform was found, analysis for *E. coli* and/or fecal coliform was performed. Total coliform was detected in only two of the twenty-nine water wells

[5] U.S. Environmental Protection Agency. 2010. Yakima Basin Nitrate Study Phase 2 – Initial Nitrate/Coliform Screening of Domestic Water Wells February 2010 Sampling Event. Quality Assurance Project Plan. US EPA Region 10. January 27, 2010.

[6] U.S. Environmental Protection Agency. 2010. Yakima Basin Nitrate Study Phase 3 – Comprehensive Analytical Source Tracer Sampling April 2010 Sampling Event. Quality Assurance Project Plan. US EPA Region 10. April 8, 2010.

(one downgradient of the Haak Dairy and one upgradient of the Dairy Cluster), but no fecal coliform or *E. coli* was detected in those samples.

In Phase 3, very few compounds used by humans, and potentially coming from septic systems, were detected in the residential drinking water wells, and there were no detections of fecal coliform or *E. coli* in any of the residential drinking water wells. Detection of these contaminants in residential drinking water wells could have been more suggestive of contamination from septic systems.

The ten monitoring wells EPA installed in December 2012 were located where there were relatively few upgradient residential septic systems. One of the reasons EPA chose these locations was to effectively rule out the possibility that residential septic systems could be contributing to any nitrate concentrations found in the wells. The nitrate levels measured in the wells in January 2013, some of which were quite high, most likely have little or no nitrate contribution from residential septic systems.

E. Sampling Design

Comment #5: Several commenters stated that the study was not an objective endeavor to determine the sources of nitrate in water wells because EPA did not conduct a randomized sampling design, but instead used a biased design in which they concentrated only on areas of high nitrate concentrations, and the EPA 2012 Report appears designed to look at individual "hot spots" pre-identified as dairy farms. These commenters contended that sampling results obtained during Phase 3 cannot be interpreted as giving a scientifically valid picture of the nature and extent of contamination in the sampled areas. Several commenters indicated that EPA had used a GIS tool to select sites but did not provide information on how the tool was used. Other commenters stated that EPA should have collected more samples from the Yakama Reservation to make the study more spatially representative.

EPA's response: The purpose of the study was to investigate the contribution from various land uses to the high nitrate levels in groundwater and residential drinking water wells. The study was not designed to determine the nature and extent of the nitrate contamination, although EPA did collect samples from a significant number of residential drinking water wells (over 330 homes). A randomized sampling design would not have achieved the objectives of the study. Numerous other major studies have been conducted in the Yakima Valley that document widespread nitrate contamination in the drinking water aquifer and residential drinking water wells.

As described in Section IV of the EPA 2012 Report, EPA conducted Phase 1 of the study to identify potential major sources of nitrogen in Yakima County. EPA determined that about 65% of the nitrogen generated in Yakima County comes from livestock, predominately dairy cattle, 30% from synthetic fertilizers applied to irrigated crops, and 3% from septic and wastewater systems. EPA developed a GIS tool during Phase 1 of the project. The purpose of the GIS tool was to help identify potential sampling sites for Phase 2 and Phase 3 of the project.

Phase 2 sampling was conducted primarily in areas downgradient of major potential nitrate sources identified in Phase 1. Phase 3 sampling was conducted at a subset of Phase 2 residential drinking water wells where some of the highest nitrate concentrations were reported in Phase 2. In order to determine the potential sources of the nitrate contamination, EPA sampled those locations with high nitrate levels that are in close proximity to potential sources of nitrate. Criteria for selection of specific sites are listed on pages 17 and 18 of the EPA 2012 Report. EPA selected a subset of such locations on which to focus given the limited resources available for the study. In Phase 3, EPA analyzed nearly 200 chemicals and used several innovative analytical techniques to investigate the source of the high nitrate levels in the residential drinking water wells.

EPA collected samples from over sixty residential drinking water wells on the Yakama Reservation during Phase 2 of the project and found nitrate levels were generally lower than other areas in the Lower Yakima Valley. Also, based on the information collected in Phase 1 and Phase 2, there are fewer potential major sources of nitrogen on the Reservation than in other parts of the Lower Yakima Valley.

F. Number and Frequency of Samples

Comment #6: Several commenters indicated that there is no scientific certainty regarding conclusions about the sources of nitrate or other contaminants in water wells when only one sample is collected at a water well or other location because: 1) environmental guidance and standards of practice, including EPA guidance, typically recommend multiple sampling events spaced over a water-year to capture temporal variability and to take into account all of the transient events that influence groundwater conditions, such as canal/lateral leakage, irrigation, drains, streams, pumpage, and variations in recharge; 2) with a small sample size, there is very little certainty that the sample population will reflect that of the entire population; and 3) there is insufficient statistical power to determine whether concentrations measured in downgradient wells are similar to or different from the upgradient well.

EPA's response: Nitrate is an acute contaminant, meaning that adverse health effects can occur within hours or days from exposure that exceeds the MCL. Therefore, one valid sample showing nitrate levels exceeding the MCL in a residential drinking water well may provide sufficient basis for immediate action to mitigate the threat to human health.

EPA acknowledges that sampling during different times of the year would provide information on seasonal variability due to precipitation, irrigation practices and influences from other features such as canals, streams and drains. However, the sample collection conducted by EPA was sufficient for the purposes of this study. It is not unusual for EPA to take action at sites where valid results from a single sampling event show significantly elevated levels of contaminants that could threaten human health.

Sample collection was conducted consistent with EPA's Quality System, including, but not limited to, EPA's Quality System Policy [7] and Manual[8]; EPA Region 10 Quality Management Plan[9]; the Phase 2 and Phase 3 QAPPs; and other pertinent documents that can be found on

[7] U.S. Environmental Protection Agency. 2000. Policy and Program Requirements for the Mandatory Agency-wide Quality System. CIO 2105.0 (formerly 5360.1 A2). May 5, 2000.

[8] U.S. Environmental Protection Agency. 2000. EPA Quality Manual for Environmental Programs. CIO 2105-P-01-0 (Formerly 5360 A1). May 5, 2000.

[9] U.S. Environmental Protection Agency. 2009. USEPA Region 10 Quality Management Plan. January 2009.

EPA's website.[10] These documents outline the policies, required documentation and procedures to assure that environmental data generated and used to support Agency decisions are of adequate quality, objectivity, integrity and defensibility for their intended purpose.

The twenty-five residential drinking water wells sampled in Phase 3 were a subset of those sampled in Phase 2. Collecting samples at different times of the year would not change the conclusion that high nitrate levels have been detected in residential drinking water wells for several decades throughout the Lower Yakima Valley. Also, if the difference in nitrate concentrations between the upgradient and downgradient wells had been relatively small, additional sampling of the same wells might be useful to determine whether the difference was statistically significant. However, the difference in the nitrate concentrations between the upgradient wells and downgradient wells was pronounced.

G. Soil Samples

Comment #7: Many commenters stated that there is no scientific rationale for collecting soil samples from 1 inch below the surface and that, because soils below the root zone and deeper were not sampled, it is impossible to draw any conclusions regarding the possible impact on groundwater and water wells from these soil samples. These commenters stated that shallow sampling may be used when investigating potential surface water contamination but it is inappropriate for groundwater research.

Commenters stated that: 1) too few soil samples were collected from crop fields and application fields to provide any statistically sound estimates of actual concentrations of nitrogen and its species, including nitrate and other compounds; 2) no background soil samples were taken; 3) composite sampling was insufficient to determine the source of variability in the results; 4) there was no discussion on soil types in the fields even though that data was available; 5) there was no information regarding the most recent manure application or crop growth state; and 6) there was no soil sampling during and after the harvest season and therefore no assessment of the effects of soil porosity and saturation.

EPA's response: EPA conducted soil sampling to help determine the chemical constituents of materials (manure, commercial fertilizer, and pesticides[11]) that were being applied to the land. The data showed that high amounts of nitrogen had been applied to application fields and some crop fields. The sampling team selected the dairy application fields for sampling after consultation with dairy operators about which fields had most recently received application of manure.

EPA recognizes that plants uptake nitrogen and other compounds, and that not all compounds found in the surface soil reach groundwater. As part of the study, EPA reviewed soil sampling

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[10] http://www.epa.gov/quality/

[11] The term "pesticides" refers to insecticides, herbicides, fungicides, and various other substances used to control pests.

information in Washington State Department of Agriculture (WSDA) dairy inspection reports which, in some fields, showed elevated soil nitrate levels at the two foot depth.

One representative composite soil sample, comprised of thirty subsamples, was collected from each field. This is a common environmental sampling methodology used to determine the presence of chemical constituents. In addition, EPA considered soil characterization and mapping of the surface soil at the dairies and irrigated crop fields. This information was included in Appendix B of the EPA 2012 Report.

The surface soil data were compared to concentrations of compounds detected in dairy lagoons and dairy manure piles to indicate whether similar compounds were found in both locations. The surface soil data are useful to indicate which compounds are being applied by farmers and dairies to their application fields and irrigated crop lands and are therefore available for potential migration to groundwater. EPA acknowledges that more complete soil profile data could be helpful in understanding the fate and transport of the nitrate between the surface and groundwater. The GWAC and others could appropriately take up this work.

H. Lagoon Samples

Comment #8: Several commenters indicated the lagoon sampling was flawed because only taking a single sample from a lagoon will not provide a consistent baseline for evaluating nutrient concentrations and stated that these values can vary with seasons, diets of the animal, management of the manure, and time of day. Commenters contended that EPA provided insufficient documentation on the procedure for sampling the lagoons, making it difficult to evaluate whether the sampling was done correctly, for what purpose, and whether EPA followed standard sampling methods.

EPA's response: EPA inspectors collected lagoon samples consistent with EPA's Quality System[12] including the Phase 2 and Phase 3 QAPPs. Lagoon samples were, for the most part, collected at the point where the waste entered the lagoon and at the point closest to where waste was removed for application onto the fields. The purpose was to evaluate what changes occurred during the transfer of lagoon waste though the lagoon system and to characterize what was being applied to the application field. EPA inspectors have experience collecting lagoon samples and are familiar with standard lagoon sample collection techniques. The lagoon sample collection conducted was sufficient to meet the objectives of this study.

I. Historical Data

Comment #9: Several commenters stated that the problem of high nitrate levels in water wells was a result of past practices and further observed that EPA had not provided any historical land-use data such as land-use of dairy properties prior to the start of operations, well contamination prior to establishment of dairy operations, and historic crop production. Commenters stated that EPA should have used the Washington State Department of Ecology ("Ecology") study conducted between 1990

[12] Refer to EPA's response to comment #6 and footnotes 7, 8, 9 and 10.

and 2005 to better characterize the legacy contribution to nitrate levels. These commenters contended that without this information it is impossible to rule out past practices as the source of the nitrate contamination in residential water wells.

EPA's response: EPA's conclusion that the dairies are a likely source of nitrate contamination does not preclude the possibility that prior land use practices may also be contributing nitrate. EPA collected some historical data for the dairies and their application fields, including aerial photos dating back to the 1960s, but acknowledged in the EPA 2012 Report that it had limited data on past or present dairy or irrigated cropland activities. EPA requested information on past and current aspects of the dairy operations and physical setting, but the dairies in the study did not provide this information. EPA considered the data from Ecology in the design of Phase 2 and Phase 3.

The information available to EPA indicates that many of the dairies have been in operation for decades. While it is possible that pre-dairy activities, such as application of commercial fertilizer, could be contributing to the nitrate levels in groundwater and residential drinking water wells, available data from the EPA study provide strong evidence that current dairy operations are contributing to the high nitrate levels in groundwater and downgradient residential drinking water wells.

J. Sources of Nitrate

Comment #10: Several commenters indicated that EPA did not take into account other potential sources of nitrate around the dairies, croplands, and septic systems and therefore cannot conclude with any confidence that the dairies and cropland are likely sources of nitrate and septic systems are not likely sources. Some commenters questioned EPA's assessment of the contribution from different nitrogen sources and indicated the information relied on for making assessment was old or inadequate.

EPA's response: EPA considered other potential sources of nitrate such as biosolids and atmospheric deposition but concluded that these sources are not significant. As discussed in the EPA 2012 Report, Phase 1 consisted of a screening analysis to identify the potential major sources of the nitrogen in Yakima County. The estimates from the screening analysis were used to assist in the study design. EPA used the best available information at the time. Based on this screening analysis, EPA concluded that livestock accounted for 65% of the nitrogen, with dairy cows accounting for 89% of the nitrogen produced by livestock. About 30% of the nitrogen was found to come from fertilizers applied to irrigated crop lands, and about 3% from septic and wastewater systems.

Any well with nitrate levels above background could have multiple contributing sources of nitrogen. Therefore, EPA tested each residential drinking water well for a large suite of analytes that could be associated with different sources. EPA's conclusion that the dairies are a likely source of nitrate contamination in the downgradient residential drinking water wells does not preclude the possibility that there may be other contributing sources.

Comment #11: A few commenters noted that the dairies being evaluated are all operating under Nutrient Management Plans (NMPs) which require nitrogen and phosphorous to be applied to crops at agronomic rates and that EPA provided no nutrient application, soils, tissue samples or crop production data to indicate that dairies have over applied manure or green water to land application fields. One commenter noted that the EPA 2012 Report did not indicate whether the Washington State Department of Agriculture (WSDA), which is responsible for NMPs, was contacted.

EPA's response: EPA spoke to and requested information from WSDA during the study and development of the EPA 2012 Report. EPA's Report includes reference to WSDA inspection reports that document elevated levels of nitrogen in application fields at the dairies in the study. WSDA did not have copies of the NMPs for the dairies in the study. NMPs are kept on location at the dairies and are not available for public review. EPA sent written requests to the dairies in the study seeking additional information, including soil sampling data from their application fields and the dairies' NMPs; however the dairies declined to provide that information.

K. Manure and Synthetic Fertilizer

Comment #12: Several commenters indicated that lumping together land application of manure that is subject to a NMP with the use of commercial fertilizer not similarly regulated by the State creates confusion and the two have significantly different impacts. Other commenters indicated that EPA failed to adequately review published peer reviewed studies on the impacts of manure application to fields, which show minimal impacts to the environment and cited a publication in the Journal of Environmental Quality (Ferguson and others 2005).[13]

EPA's response: Both manure and synthetic fertilizer can generate nitrate which can migrate to groundwater. EPA found that many crop fields received both manure and synthetic fertilizer application. Both types of fertilizer can be applied to the same field over the course of a year. WSDA inspection reports documented nitrogen levels exceeding WSDA's threshold level of concern of 45 parts per million (ppm) nitrate as nitrogen at the two foot depth in dairy application fields in the study. In contrast, the Ferguson study reported nitrate concentrations of approximately 10 ppm nitrate as nitrogen or less at the two foot depth. There is not enough information to conclude that the conditions and practices in the Lower Yakima Valley are sufficiently similar to those evaluated by Ferguson to draw parallels. The Ferguson study further states that "manure … which is applied at excessive rates has significant potential to degrade both surface and ground water quality."

L. Additional Investigations

Comment #13: A few commenters requested that EPA perform additional investigations and data gathering to minimize study limitations and assumptions. One commenter suggested that EPA look at the fate and transport of other chemicals, such as chlorpyrifos and DEHP that have potential adverse environmental and health effects.

[13] Ferguson, R.B, Nienaber, J.A., Eigenberg, R.A., and Woodbury, B.L. 2005. Long-Term Effects of Sustained Beef Feedlot Manure Application on Soil Nutrients, Corn Silage Yield, and Nutrient Uptake. J. Environmental Qual. 34:1672-1681.

EPA's response: EPA conducted additional investigations in December 2012 and January 2013 to supplement information from the EPA 2012 Report. EPA installed and collected samples from ten groundwater monitoring wells in the vicinity of the dairies in the study. The objective of the monitoring was to enhance the understanding of the nitrate concentrations in the drinking water aquifer, confirm the direction of the groundwater flow in the shallow drinking water aquifer, and evaluate whether a shallow, perched aquifer exists above the alluvial drinking water aquifer.

Based on water level measurements from the new wells installed for the December 2012 and January 2013 investigation, EPA concluded, consistent with the regional groundwater flow direction determined by the USGS and presented in the EPA 2012 Report, that the groundwater flow direction in the vicinity of the dairies is towards the Yakima River. No shallow, perched aquifer was encountered during drilling. Also, the conclusion in the EPA 2012 Report indicated that the dairies in the study are a likely source[14] of nitrate contamination in residential drinking water wells downgradient of the dairies. The new data from the recent investigation reinforce the conclusions in the EPA 2012 Report.

Chlorpyrifos and DEHP were analyzed in the study. Chlorpyrifos was not detected in any of the residential drinking water wells but was detected in several dairy application fields and manure piles and in one mint field. DEHP was detected in several residential drinking water wells, but below the EPA MCL. In general, EPA recognizes the importance of understanding and evaluating the effects of other chemicals on human health and the environment. However, this study was focused on nitrate, a known contaminant in the Lower Yakima Valley drinking water aquifer, and on identifying potential sources of nitrate.

III. General Analysis

A. Background

Comment #14: One commenter noted that using the Nolan and Hitt (2003)[15] study background value for nitrate in groundwater of 1.1 mg/L is not appropriate because it is a nationwide value. The commenter suggested using a subset of the Nolan and Hitt (2003) data to identify a background concentration that is more representative of the Lower Yakima Valley land use (i.e., five samples in the Nolan and Hitt (2003) data set were collected in southeastern Washington and the nitrate values ranged from 1.4 to 2.7 mg/L).

EPA's response: EPA did not sample to determine the natural background concentration of nitrate for the Yakima Valley. As the commenter noted, the EPA 2012 Report identifies the background nitrate concentration of 1.1 mg/L from the Nolan and Hitt (2003) report as a national value. Nolan and Hitt refer to this value as "relative background" for groundwaters that are relatively

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[14] The primary sources of nitrogen at the dairies include application fields, manure lagoons, manure piles, silage and cow pens.

[15] Nolan, B.T, and Hitt, K.J. 2003. Nutrients in Shallow Groundwaters Beneath Relatively Undeveloped Areas in the Conterminous United States. Water-Resources Investigations Report 2002-4289. U.S. Geological Survey.

unaffected by agricultural and urban lands, but do not represent it as natural background. The Nolan and Hitt (2003) study concluded:

> *"The 75th percentile value (about 1 mg/L) obtained with the retrospective [historical] subset is a reasonable upper bound estimate of relative background concentration of nitrate in shallow, recently recharged ground waters of the conterminous United States. This value incorporates effects of nominal N load from predominantly natural sources in hydrogeologically susceptible areas mostly unaffected by agriculture and urban land."*

Nolan and Hitt also concluded:

> *"The relative background concentration of 1 mg/L is an order of magnitude less than the U.S. Environmental Protection Agency (USEPA) maximum contaminant level (MCL) of 10 mg/L for nitrate and provides a useful basis for assessing anthropogenic effects on shallow ground water quality, especially when local background data are unavailable. Management for prevention of groundwater contamination is more feasible and much less costly than if MCLs already have been exceeded. Nitrate is a naturally occurring substance. Relative background concentration is particularly useful for nitrate because, compared with synthetic chemicals such as pesticides; mere detection of nitrate does not trigger an immediate water-quality concern. Rather, nitrate concentration greater than about 1 mg/L suggests greater influence by anthropogenic factors and the need for additional monitoring to protect water resources."*

Many of the wells tested in the EPA study had nitrate levels that were around 1 mg/L, indicating that these wells were unaffected by agriculture or other anthropogenic sources. Also, even if the subset of nitrate samples collected in southeastern Washington were used, this would not change the conclusions in the EPA 2012 Report.

B. Major Ion and Trace Inorganic Elements

Comment #15: Several commenters indicate that EPA cannot use the major ion and trace inorganics data to conclude the dairies are a likely source of nitrate in residential drinking water wells downgradient of the dairies because: 1) the results are highly variable and show a range of concentrations in residential wells; 2) comparing a single upgradient measurement to the downgradient measurements is scientifically invalid and produces no meaningful results; 3) EPA did not support its assertion that barium is used at the dairies and therefore that they are a potential source; and 4) some downgradient concentrations of barium are lower than the upgradient concentrations while some directly adjacent downgradient wells have very different concentrations.

EPA's response: The major ion and trace inorganic elements data were useful for evaluating the differences between upgradient and downgradient wells at the Haak Dairy and Dairy Cluster. EPA acknowledges that the concentrations can vary between wells, especially for cations, but the pattern of increasing concentrations between upgradient and downgradient wells is clear for many of the major ions and trace inorganic elements highlighted in the EPA 2012 Report.

For barium, the concentrations in the downgradient wells at the Haak Dairy are an order of magnitude greater than the upgradient well, with the concentrations in the dairy lagoons substantially higher than either the upgradient or downgradient residential drinking water wells. At the Dairy Cluster, one downgradient well had barium levels lower than the upgradient well with the dairy lagoons having substantially higher levels than either the upgradient or downgradient wells. The source of the barium is unknown; however, barium selenate may be used on dairies as a treatment for mastitis or for selenium deficiency and barium can be present in fertilizers. EPA requested information on any compounds used at the dairies, but the dairies declined the request to provide the information.

C. Isotopic Analyses

Comment #16: Several commenters stated that the isotope data is of limited value for identifying sources of nitrate contamination because: 1) it cannot distinguish between human and dairy sources; 2) the isotopic ratio signatures are more ambiguous than assumed by the EPA; and 3) the isotopic data break points interpretation used for attributing source types is outside the range in the recognized literature on the subject (i.e., the lower range limit for $\delta^{15}N\text{-}NO_3$ values that suggest an animal waste source of nitrate by most authors or studies is 10‰).

Commenters also indicated that: 1) EPA did not directly evaluate the isotopic values for synthetic fertilizer used in the study area and therefore the actual synthetic fertilizer $\delta^{15}N\text{-}NO_3$ values are unknown; 2) the values of $\delta^{18}O\text{-}NO_3$ are significantly outside the range of previous studies and cannot be readily explained; and 3) EPA did not appear to consider the perchlorate data collected to augment the isotopic data that showed concentrations at the Dairy Cluster ranging from 0.915 to 3.08 ug/L.

EPA's response: The isotopic ranges identified in the EPA 2012 Report are appropriate given the available literature, data generated from the study, and the caveats regarding the interpretation of the isotopic data. EPA acknowledged multiple times in the EPA 2012 Report that the isotopic data could not distinguish between human and non-human sources of nitrate such as dairy cows. Also, EPA identified the source(s) as likely dominant source(s), but not necessarily the only source.

EPA also acknowledged that it did not directly evaluate the isotopic values for fertilizer used in the study area, but indicated in the EPA 2012 Report that $\delta^{15}N\text{-}NO_3$ ratios for synthetic fertilizer in the literature are often within a range of -4‰ to +4‰. EPA decided to set a lower range of 2‰ for the $\delta^{15}N\text{-}NO_3$ ratios for identifying synthetic fertilizer as the likely dominant source of the nitrate based on data from the lagoons in the study. EPA was careful not to state that water wells with isotopic signatures below 2‰ $\delta^{15}N\text{-}NO_3$ were definitely or solely from synthetic fertilizer, but that they were the likely dominant source.

In addition, for $\delta^{15}N\text{-}NO_3$ values between 2‰ and 8.4‰, EPA indicated that the source could be a combination of animal waste, synthetic fertilizer or in some cases from atmospheric contributions.

EPA stated in the EPA 2012 Report that the literature values for $\delta^{15}N\text{-}NO_3$ to identify animal waste ranged between 10‰ and 20‰ but with some values lower or higher than this range. EPA selected the 8.4‰ $\delta^{15}N\text{-}NO_3$ value based on data from the lagoons in the study and indicated that animal waste was the likely dominant source of nitrate in the water wells, but not necessarily the only source. EPA considered the perchlorate data, but was not able to draw any conclusions using the perchlorate results.

The $\delta^{18}O\text{-}NO_3$ results were used to evaluate the degree to which an atmospheric signature or contribution was dominant in a water sample. Ratios above 20‰ for $\delta^{18}O\text{-}NO_3$ were considered to have some contribution from atmospherically derived nitrate. This ratio was selected because the literature based on multiple studies of various nitrate sources suggests that $\delta^{18}O\text{-}NO_3$ ratios from synthetic fertilizer, soil cycling, and animal waste are typically below 15‰ for $\delta^{18}O\text{-}NO_3$[16] and the desire to use a value higher than 15‰ for $\delta^{18}O\text{-}NO_3$ to ensure that the atmospheric contribution is dominant in the water sample.

D. Age Dating

Comment #17: Several commenters stated that age dating data does not provide information to identify specific sources of contamination because of the mixing of waters from surface water, the alluvial aquifer and the basalt aquifer. Also, commenters requested that EPA provide a more thorough discussion of why the age dating results were not useful to determine when the nitrate contamination was introduced into the well.

EPA's response: The age dating analysis measures the time since the water infiltrated into the soil or into the ground and lost contact with the atmosphere. As stated in the EPA 2012 Report, the reported ages may not correspond to when the water in the wells was contaminated and were not useful to determine when the nitrate contamination was introduced into the well. Additionally, EPA acknowledges that the mixing of waters from surface water, the alluvial aquifer, and the basalt aquifer makes it difficult to draw definitive conclusions regarding the age dating information.

E. Fate and Transport

Comment #18: Several commenters stated that EPA did not include any analysis regarding the degradation of compounds over time and their fate and transport properties. Commenters stated that this is important as many have significantly short half-lives or have a strong affinity to sorb to the aquifer matrix, which precludes their use for downgradient evaluation if they are present.

EPA's response: Few compounds are as highly mobile as nitrate in groundwater. EPA acknowledged in the EPA 2012 Report that a number of factors can affect the fate and transport properties of organic compounds that could cause them to be less mobile than nitrate in groundwater (e.g., organic molecules are more likely to sorb to materials in the aquifer and are subject to microbial degradation). This may be the reason many organic compounds were

[16] Kendall, C, Elliot, E.M., and Wankel, S.D. 2007. Tracing Anthropogenic Inputs of Nitrogen to Ecosystems, in Michener, R.H., and Lajtha, K. eds. Stable Isotopes in Ecology and Environmental Science, 2nd ed. Blackwell Publishing, p.375-499.

detected in the dairy lagoons, manure piles, and application fields but not in the downgradient residential drinking water wells. The study was not designed to determine in detail the fate and transport of various organic compounds. However, organic compounds that are known to be relatively less mobile can still migrate to water wells where they may be detected.

In the EPA 2012 Report, EPA cited numerous studies documenting that many of these organic compounds have been detected in dairy lagoons, manure and surface soil samples from dairies and in water wells and groundwater in proximity to dairies.

IV. Dairies

A. Lagoon Leakage Estimates

Comment #19: One commenter stated that given that the basis of concern stated in the EPA 2012 Report is groundwater quality, the conclusion that the lagoons are causing considerable leaching of nitrate into the groundwater is incorrect. Some commenters stated that more consideration and focus should be given to nitrate sources that have a higher potential to impact groundwater, such as organic and synthetic fertilizers.

EPA's response: EPA concluded that the dairies are a likely source of nitrate to the groundwater and downgradient residential drinking water wells and that there are several potential sources of nitrate at the dairies including application fields, lagoons, manure piles, cow pens and silage storage areas. EPA drew no detailed conclusions regarding the relative contribution of these potential specific sources.

Comment #20: Several commenters questioned the relevance of the study by Ham[17] cited in the EPA 2012 Report because: 1) the study was done in Kansas; 2) the study states that its findings should not be extended beyond the Great Plains; and 3) of the 20 storage basins that Ham examined in his study only one was a dairy lagoon, which was relatively new and had not yet had time to properly seal.

EPA's response: It is reasonable to consider Ham's range of seepage rates with respect to lagoons in Washington State because some lagoons in Washington are likely constructed similarly to lagoons in Kansas (i.e., the Kansas lagoons studied were lined with compacted soil between 0.3 meters and 0.45 meters thick).[18] This is based on the fact that Washington State expects dairy lagoons constructed since 1994 to have a 1-foot (0.3 meters) minimum thickness compacted soil liner of acceptable United Soil Classification System (USCS) material (see Attachment A for the Washington State practice standard guidance for waste storage ponds and waste storage facilities since 1979).

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[17] Ham. J.M. 2002. Seepage losses from animal waste lagoons: A summary of a four-year investigation in Kansas. Trans. ASAE. 45(983-992. March 2002.

[18] Older lagoons in Washington State may not have compacted soil liners and therefore may allow more seepage than the lagoons in the Ham study.

Ham's 2002 paper states: "Lagoons in other regions of the Great Plains probably have similar rates of seepage." This sentence extends the relevance of the Ham seepage rates to other Great Plains states but does not limit their relevance to the Great Plains. There is precedence for considering the Ham seepage rates on the west coast. The University of California (UC) Davis (2012)[19] incorporated the Ham study seepage rates into their assessment of nitrogen sources from liquid manure storage lagoons in the Tulare Lake Basin and Salinas Valley of California, justifying their relevance by stating "*Manure lagoons in Kansas are constructed similarly to those in California*."

The UC Davis study also cites a study by Harter and others (2002)[20] which is an assessment of field data from five dairies in Stanislaus and Merced County, California, which suggests a recharge rate of at least 0.8 m/yr (2.2 mm/day), a number that is within the Ham range (near the upper end of the range, which has an upper limit of 2.4 mm/day). The Harter study suggests that the Ham seepage rate range is consistent with seepage rates measured in at least one location outside of Kansas.

In the EPA 2012 Report, EPA also estimated lagoon leakage using the current Washington State recommendation for liner permeability ($1x10^{-6}$ cm/sec with an added assumption that the effect of "manure sealing" would further reduce the coefficient of permeability to $1x10^{-7}$ cm/sec). The resulting leakage volume estimate fell within the Ham leakage range, further supporting the appropriateness of using the Ham seepage rate range with respect to lagoons in Washington State.

Of the 20 storage basins evaluated by Ham, 14 were swine sites, 5 were cattle feed-lots, and one was a dairy lagoon. The dairy lagoon appears to have been at least a year old, which may have been enough time for the effects of manure sealing to have substantially occurred. Ham's report indicates that the seepage rates from the cattle, swine, and dairy lagoons were very similar, suggesting that manure sealing had occurred. EPA would expect that the seepage rates of cattle feed lot lagoons and dairy lagoons to be similar because the sealing agent (cow manure) is from the same type of animal.

<u>Comment #21</u>: Several commenters stated that the lagoon leakage estimates in the EPA 2012 Report were not accurate because the estimates were based on limited site information and EPA used assumed values to estimate potential leakage from the lagoons. Commenters stated that more site-specific information is needed to accurately calculate the leakage rates and that there are more recent Ecology studies about lagoon leakage.

<u>EPA's response</u>: EPA's leakage estimates are sufficient to support the conclusions stated in the EPA 2012 Report. The ranges of lagoon leakage volumes in the EPA 2012 Report are

[19] Harter, T. and Lund, J.R. 2012. Addressing Nitrate in California's Drinking Water: With a Focus on Tulare Lake Basin and Salinas Valley Groundwater. Prepared for California State Water Resources Control Board. January 2012.

[20] Harter, T. Davis, H., Matthews, M.C, and Meyer, R.D. 2002. Shallow Groundwater Quality on Dairy Farms with Irrigated Forage Crops. Journal of Contaminant Hydrology. 55(287-315).

conservative estimates because EPA assumed that all lagoons are lined to current Washington State practice standards (see the response to Comment # 22). The true leakage is likely to be greater, in part because historical aerial photographs show that some lagoons in the Dairy Cluster were constructed in the 1970s and were required to meet less stringent standards. Based on these conservative estimates, EPA concluded that these lagoons are likely leaking large quantities of nitrogen-rich[21] liquid into the subsurface. It was not necessary to calculate precise lagoon leakage rates to draw this conclusion.

As described in the EPA 2012 Report, EPA did not have specific information on the design, construction and maintenance of the lagoons operated by the dairies in the study. EPA estimated ranges of lagoon leakage volumes based on liner permeability rates found in the literature and used by Washington State at the time of the study. The leakage estimates were developed to assess whether waste lagoons[22] used by the dairies could be a potential source of nitrate to the drinking water aquifer.

Because site-specific information was limited or not provided to EPA, the ranges presented in the EPA 2012 Report are necessarily broad. This increases the likelihood that the actual lagoon leakage rates from the dairies in the study fall within those broad ranges. In December 2012, EPA installed ten groundwater monitoring wells in the vicinity of the dairies in the study. The wells were screened at the top of the alluvial aquifer. Soils encountered during drilling were primarily sand mixed with small amounts of gravels of different sizes, silts, or clay. No low-permeability horizons that would inhibit infiltration through the alluvium were encountered during drilling.

EPA is aware of a series of four dairy lagoon studies conducted by Ecology that were compiled into "Effects of Leakage from Four Dairy Waste Storage Ponds on Ground Water Quality, Final Report (June 1994)".[23] Two of the waste storage ponds were in Whatcom County, one in Yakima County, and one in Lewis County. According to Ecology's report, leakage from three of the four waste storage pond systems that were evaluated had adversely affected groundwater quality. No leakage was detected at the pond in Lewis County. At some of the lagoons studied, Ecology concluded that a significant amount of ammonia, a parent compound of nitrate, had migrated from some of the lagoons into the groundwater, and that some of the ammonia would convert into nitrate:

> *"Nitrogen was present in the wastewater and groundwater primarily as ammonia-N for which there is no drinking water standard. However, some of the ammonia-N will eventually convert to nitrite and nitrate. Whatcom Dairy #1 and Whatcom Dairy #2 pond systems were substantial sources of ammonia-N. Peak concentrations up to 180 mg/L were observed downgradient of the ponds and were usually between 30 to 60 mg/L.*

[21] "Nitrogen-rich" in this context means in comparison to the nitrate MCL of 10 mg/L.

[22] The term "lagoon" as used here refers to earthen basins in which animal waste is impounded.

[23] Washington State Department of Ecology. 1994. Effects of Leakage from Four Dairy Waste Storage Ponds on Groundwater Quality, Final Report. Publication Number 94-109.

> *Although not all of this ammonia-N would be converted to nitrate, downgradient concentrations of nitrate-N may exceed 10 mg/L."*

While Ecology's report provides some useful and interesting information regarding the impacts of dairy lagoons on groundwater, it did not include liner testing or provide estimates of leakage rates through various types of earthen liners. The study generally concluded that leakage from some of the lagoons had reached and impacted the shallow alluvial aquifer and that more information should be collected to determine long term impacts to groundwater quality. To the best of EPA's knowledge, the additional information recommended has not yet been collected.

Comment #22: Several commenters stated that EPA did not specify the head for estimating the leakage rates and that the soil permeability assumed is characterized for the surface soils. These commenters stated that these two parameters, when considered, yield drastically different leakage rates than those estimated by EPA. Several commenters indicated that liquid surface area should not be used in the calculations of lagoon leakage rate because the lagoons do not have vertical walls. These commenters argue that only the area of the lagoon bottom should have been used for these calculations, the manure sealing characteristics should have been factored into the leakage calculations, and that the only truly effective means of determining cause and effect would have been to sample underneath the lagoons.

EPA's response: Ham's seepage rate ranges were calculated using a whole-lagoon water balance approach, so the issue of a possible difference in permeability of the lagoon sides versus the lagoon bottoms is not relevant. Ham used the formula below to calculate the seepage rates at specific lagoons:

$$S = \frac{(\Delta D + P - E)}{T}$$

S = Seepage Rate (millimeters per day)
ΔD = Change in surface liquid elevation over the time period
P = Precipitation
E = Evaporation
T = Time (days)

The resulting calculated seepage rate is an average for the entire lagoon.

Ham observed that "…*most lagoons are soil-lined basins between 0.5 and 2.5 ha [1.2 to 6.2 acres] in area and 2 to 6 meters [6.6 to 19.7 feet] deep."* Some of the lagoons used by the dairies in the EPA 2012 Report are within this range.

Site-specific information, such as the geometry of the lagoons, was not provided to EPA and therefore, was not available to factor into the calculation of seepage volume. If it were available, the site-specific geometry of the lagoons could have been used; however, this degree of refinement was not necessary in the context of the EPA 2012 Report. As noted above, the ranges of seepage rates used in the EPA 2012 Report are based on published literature values and design criteria required by Washington State for waste storage facilities. This information is sufficient to support the conclusion that lagoons are likely leaking nitrogen-rich liquid into the subsurface. While more precise site specific seepage measurements and the installation of upgradient and downgradient groundwater monitoring wells might be useful to further define actual impacts to local groundwater, they are not needed to support this general conclusion.

It is reasonable to assume that some seepage occurs through the sides of an earthen lagoon. The sides of a lagoon can be prone to seepage due to a number of factors including the potential difficulty of achieving a required level of compaction on the sides of a lagoon during construction due to the slope, the sides of a lagoon are vulnerable to puncture by worms and roots, lagoon sides are more vulnerable to cracking from desiccation and freeze/thaw events because of fluctuating levels of animal waste over the year, and lagoon sides may benefit less from the effects of manure sealing because solids are less likely to settle on the sloped sides of the lagoon than they are on the bottom.

The effects of manure sealing were factored into all the seepage estimates presented in the EPA 2012 Report. Both the Ham estimates and the Washington State permeability recommendation account for the effects of manure sealing.

It is not necessary to sample soils beneath the lagoons prior to drawing conclusions about the likelihood of nitrate migrating from the lagoons. Rather than by soil sampling beneath a lagoon, impacts to groundwater could be measured more directly through the installation of groundwater monitoring wells upgradient and downgradient of the lagoon. EPA acknowledges that additional soil sampling would be useful to help confirm the complete pathway.

Comment #23: Commenters indicated that due to biochemical processes underlying most liners, what leakage does occur generally does not contain significant amounts of nitrate. Commenters also indicated that EPA failed to acknowledge a condition known as coupled nitrification-denitrification (CND) that occurs under lagoons and results in significant removal of nitrogen.

EPA's response: The EPA 2012 Report was not designed to determine or explain in detail the fate and transport of nitrate and its parent compounds under the lagoons. The EPA 2012 Report did not assess the extent to which biochemical processes were occurring in the vadose zone under the lagoons, nor whether they were interacting in a manner that would prevent the migration of nitrate to the groundwater.

A recent study (Baram and others 2012)[24] concluded that nitrification and denitrification were occurring beneath a lagoon that they studied. The Baram study concluded that denitrification was significantly reducing the amount of nitrogen in the migrating lagoon leachate, but not in sufficient quantities to prevent nitrate from reaching the aquifer. The Baram study researchers found that leachate from the waste lagoon had reached the groundwater which was 47 meters (154 feet) below the ground surface. The study stated that researchers found nitrate-N in the groundwater under the lagoon at an average concentration of 71 mg/L, and that this concentration of nitrate-N was elevated compared to regional levels of approximately 20 mg/L.

[24] Baram, S, Amon, S., Ronen, Z., Kutzman, D., and Dahan, O. 2012. Infiltration Mechanism Controls Nitrification and Denitrification Processes Under Dairy Waste Lagoon. Journal of Environmental Quality. 41(1623-32).

In the subsoil beneath the Haak Dairy and the Dairy Cluster lagoons, it is not clear if conditions are amenable to biochemical processes which remove nitrogen, but they may play a role.

Comment #24: Several commenters indicated the lagoons at the dairies in the study were approved by Ecology according to National Resource Conservation Service (NRCS) standards and that these standards should be adequate.

EPA's response: It is EPA's understanding that in the State of Washington, dairy lagoons are expected to meet the NRCS design criteria and construction guidelines that are in place at the time of construction. EPA requested information on lagoon design and construction from the dairies in the study, but the dairies declined the request. EPA, therefore, has very limited information regarding when these lagoons were designed or constructed, what design criteria was used, what location-specific information may have been taken into account (e.g., soil type, depth to groundwater, aquifer vulnerability, etc.), and whether the lagoon construction was overseen by a professional engineer to assure that the construction was completed in accordance with the design specifications. All earthen lagoons leak, it is just a matter of how much they leak and whether or not groundwater is being polluted by the leakage. Over time, Washington State recommendations regarding lagoon permeability have changed and become more protective of groundwater (see Attachment A).

Older lagoons may not be lined, may be built to less stringent practice recommendations, and are likely to leak more than newer lagoons. Historic aerial photographs show that some lagoons in the vicinity of the Dairy Cluster were constructed in the 1970s. Since EPA does not have specific information regarding the lagoons in question, EPA could only support the general conclusion that the lagoons are likely leaking into the subsurface.

Comment #25: Several commenters stated that comparing volumes of dairy lagoon waste to people and swimming pools is irrelevant as long as the dairy uses these nutrients in accordance with its NMP and crop needs, and because the majority of the animal waste is utilized by crops with high nitrogen needs.

EPA's response: The EPA 2012 Report provides a range of estimated volumes of waste that could be leaking into the soils beneath the animal waste storage lagoons. Animal waste that is leaking from storage lagoons is not utilized as nutrients for land application purposes; instead, it is lost to the underlying soils where no vegetation exists to utilize the nutrients. The leakage volume is compared to swimming pools in the text of the EPA 2012 Report to provide the lay reader with a visual comparison; the text is only included to enhance understanding and is a commonly used point of reference when discussing large volumes of liquid.

As discussed above, EPA was not able to directly determine whether the dairies followed their NMPs because the NMPs were not available to EPA. However, WSDA inspection reports that were available noted elevated post-harvest levels of nitrate in the dairy application field soils, indicating they had applied nitrate in excess of the amount that crops could uptake, which was therefore available to potentially migrate to the aquifer.

B. Haak Dairy

Comment #26: Several commenters stated that the designated upgradient well at the Haak Dairy was not upgradient given the groundwater flow direction in Figure 12 in the EPA 2012 Report and thus any conclusions based on the designated upgradient and downgradient wells are not valid. Also, commenters stated that EPA failed to consider the location of the upgradient well, which is immediately downgradient of an irrigation canal and leakage from this canal could result in considerable dilution of groundwater near this well. Commenters also stated that to the north and east of the well is at least one square mile of agricultural land.

EPA's response: There were very few residential drinking water wells directly upgradient and near the Haak Dairy. EPA selected the residential drinking water well identified as WW-01 in Figure 12 to be representative of conditions upgradient of the Haak Dairy, which was sufficient for the purposes of this study. There is some agricultural land north and east of the upgradient well. However, based on the nitrate concentration of 0.38 mg/L in this well, the upgradient agricultural land use does not appear to have had an impact on the nitrate concentration in groundwater at this location.

EPA considered the location of the irrigation canal, and agrees that leakage from the canal could influence groundwater in this well and in the vicinity of the Haak Dairy. However, the well reflects conditions in the aquifer upgradient of the Haak Dairy.

In December 2012, EPA installed three new groundwater monitoring wells, one upgradient and two downgradient of the Haak Dairy. The new wells were screened in the shallow unconfined alluvial drinking water aquifer. Water level elevation measurements confirm the groundwater flow direction in the vicinity of the Haak Dairy. In January 2013, EPA collected samples from these new wells. The nitrate concentration in the new upgradient well, which was also installed downgradient of the canal, was 0.94 mg/L. The concentrations in the two new downgradient wells were 31 mg/L and 47 mg/L. The similar concentrations of nitrate measured in the two upgradient wells suggest that groundwater nitrate levels in the upgradient wells of the Haak Dairy are low.

The new data support the conclusions in the EPA 2012 Report that the Haak Dairy is a likely source of nitrate in the drinking water aquifer and in the residential wells downgradient of this dairy. Also, the new data confirm that any upgradient sources of nitrate do not appear to have a significant impact on the concentrations of nitrate in either of the upgradient wells.

Comment #27: Several commenters stated that EPA cannot draw the conclusion that the detection of atrazine in the wells downgradient of the Haak Dairy indicates that there is a likely source from a crop field associated with the Haak Dairy because: 1) the upgradient well had higher concentrations than two of the downgradient wells; 2) all of the detections were estimated ("J" qualified); and 3) a single upgradient sample is insufficient to determine whether there is a statistical difference in upgradient and downgradient concentrations.

EPA's response: EPA acknowledges that the detection of atrazine in the upgradient well at the Haak Dairy indicates that there are other likely sources of atrazine in the area. While EPA acknowledges that there is only one upgradient sample, this is sufficient to provide information for purposes of this study. A likely source of the atrazine in the downgradient residential drinking water wells is a field associated with the Haak Dairy. Atrazine was detected in the dairy application field associated with the Haak Dairy. This dairy application field was historically planted with corn and triticale and atrazine is a pesticide commonly applied to corn fields.

EPA disagrees that the qualification of a sample as estimated ("J") means it cannot be used in assessing contamination. A "J" qualification means that the analyte was positively identified, but the associated numerical value is an estimate.

Comment #28: Several commenters stated that the conclusion that the Haak Dairy is a likely source of tetracycline in the downgradient water wells is unfounded because: 1) while small amounts of tetracycline are used by dairies to treat animals, a much larger amount is used for apple and pear orchards for fireblight; 2) tetracycline is used as a human pharmaceutical and was detected in one of the WWTP samples; 3) tetracycline is naturally produced by soil microorganisms; 4) dairy cows are fed substantial quantities of raw and partially processed fruit and in many cases the fruit contains FDA allowable amounts of tetracycline; and 5) the laboratory identified problems with the reproducibility of the pharmaceutical data and indicated that the data could only be used for screening purposes.

Several commenters stated that the conclusion that the Haak Dairy is a possible source of monensin in the downgradient wells is not defensible because: 1) monensin was detected in the upgradient well; 2) the laboratory does not stand by the results; 3) monensin was approved for milking cows in 2004 (approved for non-milking cows earlier) and it is unlikely that it has migrated in significant quantities to groundwater; and 4) monensin has a short half-life and that when incorporated in soil is degraded below laboratory detection limits in one month.

EPA's response: EPA is aware that there are potential sources of tetracycline (e.g., use as antibiotic for apple and pear growers) other than the dairies. EPA found tetracycline in lagoons, manure piles, and application fields at the Haak Dairy and in residential drinking water wells downgradient of the Haak Dairy. Tetracycline at the dairies could be from dairy cows consuming raw and partially processed fruit, or from the therapeutic treatment of animals. Since tetracycline was detected in all of the dairy sources and in two downgradient wells, the Haak Dairy is a likely source of tetracycline in the downgradient residential drinking water wells.

EPA acknowledges that monensin was detected in the upgradient well. Given the higher concentrations of monensin detected in the dairy sources and the fact that there are few other sources of monensin, the Haak Dairy is among the possible sources of monensin in the downgradient wells.

C. Dairy Cluster

Comment #29: Several commenters indicated that the upgradient well at the Dairy Cluster is at best upgradient from the Cow Palace Dairy and Liberty/Bosma Dairies but is not upgradient of the DeRuyter or D&A Dairies and therefore the conclusions for the DeRuyter and D&A Dairies are not valid. These commenters also stated that: 1) the upgradient well appears to be more representative of a well completed in the bedrock aquifer based on the geochemical analysis data; 2) the well is not representative of groundwater in the shallow aquifer upgradient of the Dairy Cluster; and 3) the well data should not be used to draw conclusions about the groundwater quality as a result of potential sources between its location and downgradient wells.

Also, commenters noted that the Dairy Cluster is bounded on the north by an irrigation canal that has been shown to have significant concentrations of nitrate. Several commenters stated that EPA's assertion that there are no significant upgradient sources of nitrate at the Dairy Cluster is false as there are thousands of acres of intensively farmed irrigated fields which are generally upgradient from the Dairy Cluster and also suggested the majority of nitrate found in current sampling of drinking water wells are of historic origin.

Two commenters indicated the upgradient well was the only well at the Dairy Cluster that had detectable levels of total coliform, indicating that the aquifer in which it was screened was receiving bacteria.

> EPA's response: The designated upgradient well is upgradient of the Dairy Cluster and is sufficient for the purposes of this study. Moreover, the monitoring wells EPA installed in December 2012 confirm the direction of groundwater flow in the vicinity of the Dairy Cluster (refer to EPA's response to comment #2).
>
> There is an irrigation canal north of the Dairy Cluster and south of the upgradient well. However, according to a document entitled "Water Quality Conditions in Irrigation Waterways within the Roza and Sunnyside Irrigation Districts, Lower Yakima Valley,"[25] the nitrate levels in the canals in this area are typically below 5 mg/L.
>
> Some of the nitrate in the residential drinking water wells downgradient of the dairies may be from past practices. However, the Dairy Cluster dairies have been in operation for decades. The suggestion that the majority of nitrate observed today in the residential drinking water wells originated from practices that preceded the dairy operations is not well supported by available information.
>
> While there are irrigated crop fields upgradient of the Dairy Cluster, some of which are owned or operated by the dairies, the area of cultivated land upgradient of the Dairy Cluster is relatively small compared to the footprint of the Dairy Cluster. EPA does not have a well log for this upgradient residential well; therefore, it is unknown if the well was screened in the shallow unconfined alluvial aquifer or the basalt aquifer.
>
> Total coliform, but not fecal coliform, was detected in the Dairy Cluster upgradient water well. The detection of total coliform in the well is not, by itself, meaningful because coliform bacteria can be naturally occurring and does not necessarily indicate a mammal source (human, bovine or otherwise). No fecal coliform was detected in this well. Detection of fecal coliform at the location would have indicated human or other animal waste contamination, and EPA would have done microbial source tracking analysis to further clarify the source of bacteria.

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[25] Roza-Sunnyside Board of Joint Control. 2009. Water Quality Conditions in Irrigation Waterways within the Roza and Sunnyside Valley Irrigation Districts, Lower Yakima Valley, Washington, 1997-2008.

Comment #30: Several commenters stated that EPA provides no evidence to support the conclusion for the Dairy Cluster that "Given the historical use of these pesticides (atrazine, bentazon, and alachlor) and the detection of these compounds in other studies, it is likely that these pesticides are from the current and historical use of pesticides for agriculture, which could include application by the dairies on the associated fields." Also, commenters stated that none of the pesticides detected in the water wells were detected in application fields or manure pile samples which would be expected if the dairies were sources of these chemicals in the water wells and that the data from the lagoons samples for pesticides were not useable.

EPA's response: Information from a 2002 USGS report[26] and WSDA[27] indicate that atrazine, bentazon, and alachlor are used in the Lower Yakima Valley. Atrazine and alachlor are primarily used for corn production.[28] Bentazon is used on a variety of crops including corn, alfalfa, mint, and soybeans.[29]

While EPA has no specific information that the dairies in the Dairy Cluster applied atrazine, bentazon, or alachlor to their application fields, these compounds are used on crop fields in the Lower Yakima Valley and could have been applied by the dairies on their associated fields.

Comment #31: Several commenters indicated the conclusion that the Dairy Cluster is a possible source of tetracycline, tylosin, virginiamycin, and chlorotetracycline in the downgradient residential drinking water wells at the dairies is unfounded because: 1) there are insufficient upgradient samples; 2) samples were collected at only one point in time; 3) there was no confirmation that samples were collected in the same aquifer; 4) the compounds have a short half-life; 5) the compounds are adsorbed or degrade in the environment; and 6) there were problems identified with the data by EPA.

Commenters also stated that the conclusion that the Dairy Cluster is a likely source of monensin in the downgradient wells from the Dairy Cluster is not defensible because: 1) the number of wells sampled upgradient of the Dairy Cluster was limited; 2) it is impossible to definitively conclude that monensin was not present upgradient of the Dairy Cluster as well; and 3) monensin was detected in the field blank for the water samples and it should have been qualified as nondetect in other water well samples.

EPA's response: EPA is aware that there are potential sources of tetracycline (e.g., use as antibiotic for apple and pear growers) other than the dairies. EPA found tetracycline in lagoons, manure piles, and application fields at the dairies in the Dairy Cluster. The tetracycline detected

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[26] U.S. Geological Survey. 2002. Pesticides in Surface Water of the Yakima River Basin, Washington, 1999-2000 – Their Occurrence and an Assessment of Factors Affecting Concentrations and Loads. Water Resources Investigations Report 01-4211. 2002.

[27] Information provided to Mike Cox, EPA Region 10 from the Washington State Department of Agriculture.

[28] U.S. Geological Survey. 2002. Pesticides in Surface Water of the Yakima River Basin, Washington, 1999-2000 – Their Occurrence and an assessment of Factors Affecting Concentrations and Loads. Water Resources Investigations Report 01-4211. 2002.

[29] U.S Environmental Protection Agency. 1994. R.E.D Facts – Bentazon. Office of Prevention, Pesticides, and Toxic Substances. EPA-738-F-94-026. September 1994.

in the dairy sources could be from dairy cows consuming raw and partially processed fruit, or from therapeutic treatment of animals. Although tetracycline was detected at a higher concentration in the upgradient water well, the dairies in the Dairy Cluster are a possible source, although not likely the only source, contributing to the tetracycline in the residential drinking water wells downgradient of the dairies.

Similarly, tylosin, virginiamycin and chlortetracycline are used at the dairies and were detected in several dairy sources, which supports the conclusion in the EPA 2012 Report that the dairies are a possible source of these compounds in residential drinking water wells downgradient of the dairies.

Monensin is a feed additive approved for use in lactating cows for increased milk production by the US Food and Drug Administration in November 2004.[30] EPA determined that while monensin was detected in the field blank, the other data that were five-times greater than the concentration in the field blank were useable and were appropriately qualified (see EPA's response to comment #46 for additional information). The dairies are a likely source of the monensin in the downgradient wells given the high concentrations detected in the dairy sources and the fact that there are few other sources of monensin.

Comment #32: Several commenters stated that the data do not demonstrate that the Dairy Cluster is a possible source of androstendienedione and testosterone in the residential water wells downgradient of the Dairy Cluster because: 1) they were detected in all of the WWTP samples; 2) they were detected at locations not near the Dairy Cluster; 3) they were detected in only some of the dairy source samples; 4) testosterone was detected in the upgradient well; and 5) the data are only suitable for screening purposes.

EPA's response: Testosterone was detected in the majority of the dairy lagoons, but in only one dairy manure pile and none of the dairy application fields in the Dairy Cluster. Also, testosterone was detected in one downgradient well, not two as indicated in Table 22. Table 22 inadvertently included the results for WW-18, which is not downgradient of the Dairy Cluster. Other studies cited in the EPA 2012 Report indicate testosterone has been found in dairy lagoons and several studies have found testosterone in groundwater underneath dairy lagoons (e.g., Kolodziej and others 2004[31] and Arnon and others 2008).[32] It is not surprising that testosterone was detected in dairy lagoons given dairy cows excrete it in their urine and feces.

Although testosterone was detected in the upgradient well, given that it was detected in the majority of lagoons and in several downgradient residential water wells in the Dairy Cluster,

[30] http://www.fda.gov/AnimalVeterinary/Products/FrequentlyAskedQuestions/ucm129991.htm.

[31] Kolodziel, E.P., Harter, T., and Sedlak, D.L. 2004. Dairy Wastewater, Aquaculture, and Spawning Fish as Sources of Steroid Hormones in Aquatic Environment. Environ. Sci. Technol. 38(6377-6384).

[32] Arnon, S., Dahan, O., Elhanany,S., Cohen, K., Pankratov, I., Gross, A., Ronen, Z., Baram, S., and Shore, L.S. 2008. Transport of Testosterone and Estrogen from Dairy-farm Waste Dairy Lagoons to Groundwater. Environ. Sci. Technol. 42(5521-5526).

these dairies are a possible source of testosterone. Given that androstandienedione was detected in several dairy sources in the Dairy Cluster and in a drinking water well downgradient of the Dairy Cluster, the dairies are a possible source of androstandienedione.

V. Irrigated Croplands

Comment #33: Commenters stated that cropland sampling was limited to sampling of corn, hop, and mint fields, and contributions from other types of crops (e.g., alfalfa, wheat, hay, tree fruit, and grapes) were not assessed. Several commenters stated that the conclusion that irrigated croplands are likely sources of nitrate in drinking water wells downgradient of croplands is circumstantial and the EPA 2012 Report does not provide any evidence that the analytes detected in the soil migrated to the groundwater and residential water wells and that EPA cannot conclude that leaching is attributed to the land treatment where manure and fertilizers are applied.

The commenters stated several reasons for their opinions: 1) soil sampling techniques were inadequate to determine whether the compounds detected in the soil samples were migrating to groundwater; 2) upgradient well information was lacking; 3) bentazon has a short half-life and does not migrate to groundwater according to two reports cited by the commenter;[33,34] 4) the EPA 2012 Report underemphasizes that the majority of nitrogen derived from manure and applied to crop fields is either sequestered via crop uptake and converted into biomass, denitrified, volatilized, or mineralized and that by not accounting for these losses the EPA 2012 Report provides an inaccurate depiction of the potential problems; 5) EPA did not evaluate irrigation practices which can significantly affect the likelihood of field-applied nitrogen infiltrating to groundwater; and 6) that the possible manure application to the hop field could account for the monensin detected in the residential well is speculation and should not be the basis for the conclusion.

EPA's response: EPA selected corn, hops, and mint because they require significant quantities of nitrogen to produce the large amounts of plant biomass for yield in contrast with other crops such as tree fruit and they comprise a large amount of the irrigated cropland in Yakima County.[35]

EPA concluded that, given the historic and current application of nitrogen-rich fertilizers in the Lower Yakima Valley, it is expected that irrigated crop fields would be a likely source of nitrate in downgradient residential drinking water wells. The data collected in the study provide some corroboration that irrigated crop fields are a likely a source of nitrate in groundwater, but the data supporting this conclusion is not as strong for the crop fields as it is for the dairies.

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[33] Huber, R, and Otto, S. 1994. Environmental Behavior of Bentazon Herbicide. Rev. Environ. Contam. Toxicol. 137:111-134.

[34] 9th Edition of WSSA Herbicide Handbook.

[35] U.S. Environmental Protection Agency, 2012. Yakima Valley: Screening Analysis – Nitrogen Budget. EPA Region 10. Office of Environmental Assessment. June 2012.

EPA identified the following limitations and uncertainties with respect to the conclusions about the irrigated crop fields: 1) lack of upgradient well data; 2) the irrigated crop fields sampled are situated amongst other agricultural uses, including upgradient dairy operations; 3) fewer analytes were detected in both the crop field samples and the corresponding downgradient wells; 4) limited information about crop field operations; and 5) the position of the crop field on the landscape relative to other potential sources.

EPA reviewed the bentazon literature referenced by the commenter who indicated that bentazon does not leach based on field lysimeter studies and the half-life of bentazon. However, other literature indicates that bentazon has the potential to leach into groundwater. "Bentazon has a low binding affinity to soil and therefore is expected to leach into the groundwater and undergo runoff to surface water. Leaching of bentazon through the soil appears to be a major route of dissipation in the environment".[36] "Bentazon has a low binding affinity to soil and therefore may leach into groundwater and runoff into surface water."[37] The half-life of bentazon ranges from 24 days in clay loam soil, 31 days in loamy sand soil, and 65 days in sandy loam soil[38] which is what is generally encountered at the sites sampled. Bentazon is used in the Lower Yakima Valley,[39] is commonly used on mint fields[40] and was detected in soils samples collected at the two mint fields sampled by EPA. Based on this information, EPA concluded that bentazon was applied to the crop field and is likely migrating to groundwater and the water wells.

VI. Septic Systems

Comment #34: Several commenters stated that: 1) there is no scientific data or research presented in the EPA 2012 Report to support the EPA hypothesis that the municipal treatment plant influent bears any resemblance to rural septic systems; 2) municipal treatment plants should not be considered representative of septic systems; and 3) that EPA should have sampled directly from septic systems.

Many commenters also indicated that: 1) poorly constructed and failing septic systems can contribute contaminants including nitrate and bacteria to the groundwater; 2) EPA did not consider literature indicating nitrate levels from residential septic systems can be in excess of 35 mg/L; 3) no upgradient wells were sampled at septic sites; and 4) the EPA 2012 Report fails to account for the likelihood of

[36] Office of Environmental Health Hazard Assessment. 1999. Public Health Goal for Bentazon in Drinking Water. Prepared by California Environmental Protection Agency. February 1999.

[37] U.S Environmental Protection Agency. 1994. R.E.D Facts – Bentazon. Office of Prevention, Pesticides, and Toxic Substances. EPA-738-F-94-026. September 1994.

[38] Office of Environmental Health Hazard Assessment. 1999. Public Health Goal for Bentazon in Drinking Water. Prepared by California Environmental Protection Agency. February 1999.

[39] Information provided to Mike Cox, EPA Region 10 from Washington State Department of Agriculture.

[40] Extension Toxicology Network. 1993. Pesticide Information Profile – Bentazon. September 1993.

unregistered septic systems and the rigor with which current septic systems are inspected for proper functioning.

EPA's response: As explained in the EPA 2012 Report, wastewater treatment plant (WWTP) influent was sampled as a surrogate for septic systems. EPA did not sample directly from septic systems. EPA selected smaller rural WWTPs that receive wastewater from residential sources with less influence from industrial and commercial sources.

Like septic systems, WWTPs receive human waste, although they also may receive commercial and industrial waste streams. Residential wastewater from homes on septic systems should be similar in nature to residential wastewater from nearby homes connected to sewers. EPA also acknowledges that no wells upgradient of the septic system sampling sites were identified and sampled.

The concentration of nitrate is only one point of comparison between a septic tank and dairy nitrogen sources. A more important point is the total loading from each source, which entails comparing the volume of waste from a residential household to that generated at a dairy with hundreds or thousands of cattle. It is the combination of concentration and volume of nitrogen that comprises the total loading.

Septic systems could contribute nitrate to groundwater. Fecal coliform or E. coli, which could be an indicator of contamination from a septic system, were detected in only a few of the wells sampled in Phase 2 and none of the wells sampled in Phase 3. Based on the screening analysis from the EPA 2012 Report[41] and estimates from studies in Whatcom County[42] and California,[43] the potential contribution from septic systems to the nitrate problems in groundwater and water wells is minor compared to the two largest potential sources of nitrogen, which are livestock (mainly dairies) and synthetic fertilizer.

VII. Quality Assurance and Quality Control

A. Quality Assurance Project Plan

Comment #35: Commenters indicated that the primary purpose of this study does not align with the purpose and objectives for Phase 2 and Phase 3 as stated in the respective Quality Assurance Project Plan (QAPPs). The stated objective in the QAPPs was "… to conduct research/sampling under a Regional Applied Research Effort (RARE) grant to test techniques which may improve our abilities to

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[41] U.S. Environmental Protection Agency, 2012. Yakima Valley: Screening Analysis – Nitrogen Budget. EPA Region 10. Office of Environmental Assessment. June 2012.

[42] Washington State Department of Ecology. 2012. Sumas-Blaine Aquifer Nitrate Contamination Summary. June 2012 (revised 2013). Publication No. 12-03-026.

[43] Harter, T. and Lund, J.R. 2012. Addressing Nitrate in California's Drinking Water: With a Focus on Tulare Lake Basin and Salinas Valley Groundwater. Prepared for California State Water Resources Control Board. January 2012.

link specific human practices to high nitrate levels in groundwater and private wells." At least one commenter noted that this is different than the stated objective in the EPA 2012 Report which was "…to investigate the contribution from various land uses to the high nitrate levels in groundwater and residential drinking water wells."

Specific examples provided by commenters include: the Phase 2 QAPP states that well head information for the residential drinking water wells would be collected, but there is no information indicating that it was collected; and the Phase 3 QAPP states that Piper diagrams and other methods would be evaluated to track the chemical evolution of migrating groundwater, but no apparent information that this was done.

EPA's response: The commenters are correct that the project was conducted in part under the RARE program. RARE projects are a collaborative effort between EPA Regional Offices and EPA's Office of Research and Development (ORD). The objectives in the QAPPs and the EPA 2012 Report are consistent. The EPA 2012 Report describes in detail the use of different techniques (age dating, isotopic analysis, and microbial source tracking) and use of various compounds (pharmaceuticals, hormones and trace organics) to investigate potential linkage between the nitrate contamination in groundwater and residential drinking water wells and specific sources.

Deviations from the Phase 3 QAPP were identified in Table E1 of the EPA 2012 Report. Prior to sampling, EPA visually examined each well to assess the integrity of the sanitary seal. Any observable problems were recorded in the field log books.

EPA developed Piper diagrams using the general chemistry data, but the diagrams were not informative and were not included in the EPA 2012 Report.

B. Quality Control and Data Usability

Comment #36: Several commenters reiterated some of the QA and data quality issues that are described in the EPA 2012 Report and the associated data validation QA memoranda that are publically available via a link posted on EPA's the Lower Yakima Valley web page http://yosemite.epa.gov/r10/water.nsf/gwpu/lyakimagw.

EPA's response: The Lower Yakima Valley Nitrate studies Phases 2 and 3 were conducted in accordance with EPA's Quality System[44], including the Phase 2 and Phase 3 QAPPs. Any deviations from the QAPP were documented in Appendix E of the EPA 2012 Report. These documents outline the policies, required documentation and procedures to assure that environmental data generated and used to support Agency decisions are of adequate quality, objectivity, integrity and defensibility for their intended purpose.

Data verification was conducted by each individual laboratory prior to submission of final data to EPA. A data usability review and validation independent of the laboratories was conducted by the EPA Region 10 QA team with the exception of the soil pesticide results which were verified by

[44] Refer to EPA's response to comment #6 and footnotes 7, 8, 9 and 10.

an EPA Manchester Environmental Laboratory (MEL) chemist who did not conduct the analysis. The EPA Region 10 QA team performed a Stage 1, 2A, 2B, and 4 data validation. The data validation protocol was chosen based on the contents of the data package submitted by the analytical laboratory.

Data usability is indicated by data qualifiers in the data summary tables in the EPA 2012 Report. A discussion of data bias, where it could be determined, is included in Appendix E and in the data validation memoranda. The data qualifiers are defined in the footnotes of the data summary tables and further explained in Appendix E and the data validation memoranda.

Most of the usability limitations relate to the results for the organic compounds (hormones and pharmaceuticals). There are no EPA standardized analytical methods for hormone and veterinary pharmaceutical target compounds. As part of the RARE project, EPA ORD and their contract laboratories developed and tested non-standard, innovative analytical techniques to analyze for these compounds.

Comment #37: One commenter asked several specific questions about the QC protocol including: 1) did EPA follow its protocol regarding analysis of internal QC samples for every 20 field samples; 2) were method blanks and continuing calibration standards analyzed on the same day as the field samples and did they meet established criteria; 3) were sufficient QC samples analyzed on the same day as the field samples for nitrate analysis; 4) were surrogate recoveries, matrix spike recoveries, calibration and holding times in compliance for every analysis; and 5) were samples stored beyond the holding time frozen?

EPA's response: EPA followed analytical method protocols for the analysis of environmental samples and QC samples. The analytical sequence and the frequency of analysis of calibration standards, method blanks, internal standards, and QC samples were met. Method blanks and continuing calibration standards were analyzed the same day as the samples or the data were qualified. QC samples were analyzed on the same day as field samples for the nitrate analysis. Surrogate recoveries, matrix spike recoveries, calibration and holding times were all met. The frequency of analysis of matrix spike and matrix spike duplicates for some organic analyses were not met due to insufficient sample volumes. Sample control logs indicate that samples stored beyond the holding time were frozen.

The data validation memoranda were based on the evaluation of information available at the time of review. The QC elements associated with the actual level of review (i.e., Stage 1, 2A, 2B, or 4) that did not meet the QAPP criteria were discussed in the data validation memoranda. In addition, if the data were already flagged due to systematic problems like calibration, internal standard recoveries or retention times, no additional discussion of other QC element outliers that may indicate process errors due to method execution were included in the data validation memoranda. If a problem was observed in the data submitted, and the instrument raw data output was not available at the time of review to confirm or verify the concern, a statement on the general assessment of the data was included in the data validation memoranda.

Comment #38: A commenter expressed concern with the project not meeting the completeness goals that were established in the QAPP (i.e., 85% completeness). Several commenters were concerned that the stated QAPP goals regarding data quality, including elevated reporting limits, were not met.

> EPA's response: Completeness is the percentage of valid results obtained compared to the total number of samples taken for a parameter. For this project, the majority of the analyses met the project completeness goal of 85%. Some organic compounds (e.g., tricolsan and naproxen) did not meet the completeness goal. The pesticide analysis did not meet the completeness goal because the WWTP influent and lagoon samples could not be analyzed due to complexity of the matrix. Although the completeness goal of 85% was not met for each individual parameter, the conclusions in the report are still valid.
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> Some of the data quality criteria specified in the QAPP were not met because the extraction protocols and analytical methodologies were modified to remove interferences and enhance chromatographic resolution and analysis which resulted in elevated reporting limits.

Comment #39: A commenter was concerned with the data validation process utilized by EPA, specifically that the data validation memoranda lacked detail and that the validation was not performed by an independent third party.

> EPA's response: As stated in each data validation memorandum, EPA data validators followed a process specified in the *Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use* (EPA 540-R-08-005).[45] This document outlines the different stages that are utilized to validate analytical data packages and generally describes which checks should be performed according to each stage. The criteria for data validation vary depending on the technical acceptance specifications and QC requirements of the analytical methods or Standard Operating Procedures (SOPs) followed by the laboratories during analysis and the data quality and project goals specified in the QAPP.
>
> The term "independent third party reviewer" refers to entities who conduct validation that are not part of the laboratory that generated the analytical data. For this project, the EPA QA team that validated the data was independent from the laboratory generating the data and did not participate in any data collection activities, with the exception of the soil pesticide results which were verified by an EPA laboratory chemist who did not conduct the analysis.

Comment #40: A commenter noted that: 1) several analyses were qualified as "estimated" based on out-of-control QC sample results and questioned the usability of these data; 2) a substantial percentage of the analytical data are "J" qualified, which indicates that the reported concentrations are estimated; and 3) the "J" flag alone does not identify either a low or high bias in the result.

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[45] U.S. Environmental Protection Agency. 2009. Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use. OSWER No. 9200.1-85 (EPA 540-R-08-005) Office of Solid Waste and Emergency Response. Washington, DC. January 2009

EPA's response: During validation, the EPA QA team noted all QC results that did not meet the criteria and qualified the associated data as estimated, and applied "J" or "UJ" qualifier flags to the numerical result. Any bias that was identified was noted in the data validation memoranda.

A "J" qualification means that the analyte was positively identified, but the associated numerical value is an estimate. A "UJ" qualification means that the analyte was not detected and the reported numerical value is an estimated detection limit.

Comment #41: Commenters noted that: 1) the EPA 2012 Report contained significant uncertainties and limitations with respect to key analytical data, specifically trace organics analyses conducted by the USGS National Water Quality Laboratory; 2) veterinary pharmaceuticals and steroid/hormone analyses conducted by the University of Nebraska, Lincoln (UNL) Laboratory; 3) age dating analysis conducted by the USGS Reston Laboratory; and 4) hormone analysis conducted by EPA's Kerr Environmental Research Center. Commenters contend that despite these uncertainties and limitations, the EPA 2012 Report presented definitive conclusions regarding specific human practice or land use related to nitrate sources and the nitrate contribution to groundwater from these specific sources. Commenters also asked why trace organics that are not associated with human usage are included in the analyte lists.

EPA's response: Uncertainties and limitations with analytical data were noted in Appendix E of the EPA 2012 Report as well as in the data validation memoranda. Because of these uncertainties and limitations, EPA provided qualified conclusions regarding the sources of nitrate in residential drinking water wells in the EPA 2012 Report. The information from the analyses identified by the commenter above was used as supporting information in EPA's conclusions, but was not the main basis for the conclusions.

Many of the trace organics selected for analysis are used by humans. Additional trace organics were reported because each analytical method has a prescribed list of target compounds. The entire suite of compounds was reported regardless of whether they were compounds of interest for this study.

Comment #42: One commenter suggested adding a discussion of the data QA review and data quality issues currently presented in Section VIII and Appendix E of the EPA 2012 Report to the limitations discussion in Section II, VII and IX and to the Executive Summary and Conclusion section.

EPA's response: EPA described in detail the data quality issues in Appendix E of the EPA 2012 Report. However, based on comments, EPA will provide a reference to Appendix E in the Executive Summary, Section II, IX and X. There already is a reference to Appendix E in Section VIII of the Report. A reference to Appendix E in Section VII would not be relevant because this section discusses the reasons for selecting the different compounds (e.g., hormones) and analytical techniques (e.g., age dating).

Comment #43: Several commenters asked about what impact the lack of duplicates for water well and lagoon samples had on the ability to validate and qualify the data.

EPA's response: As stated in Table E1 in Appendix E of the EPA 2012 Report, field duplicates were not collected due to an oversight in the field. Field duplicate samples are collected to assess field precision in sample collection and handling techniques. Laboratory duplicate samples are analyzed to assess analytical precision. While lack of field duplicate samples limits the ability to assess field precision, it does not compromise the ability to validate and qualify the data. The quality of the data generated is more dependent on the laboratory analytical process. When available, field duplicate results are assessed in conjunction with other duplicate results such as laboratory analytical duplicates, laboratory control samples and duplicates, and matrix spike and matrix spike duplicates. Analytical precision is discussed in the data validation memoranda; however, field precision was not assessed because field duplicate samples were not collected.

Comment #44: A commenter stated that the wastewater pharmaceutical detection limits for the water well samples were higher than those typically achieved for drinking water samples. The commenter was concerned that the high detection limits would lead EPA to erroneously conclude that the septic systems were not contributing to residential well contamination.

EPA's response: Currently there is no EPA approved drinking water method for pharmaceuticals. The detection limits achieved for pharmaceuticals were based on the laboratory's method detection limit study in their SOP. In general, there is always a possibility that chemicals exist in the environment at concentrations below laboratory detection limits. Regardless of the results of the pharmaceutical analysis, EPA did not conclude that septic systems are not contributing to the nitrate contamination in drinking water wells. The conclusions in the EPA 2012 Report stated that there was insufficient information from this study to support this conclusion.

C. Specific Compounds

Comment #45: A commenter was concerned with the preservation of the lagoon samples as they were received by the laboratory with a pH greater than 2 which is outside the specified preservation criteria. A commenter noted that the analytical methods for several nitrogen species specified in the QAPP are not commonly used to quantify wastewater.

EPA's response: As indicated in the data validation memorandum, fifteen lagoon samples received by MEL for nitrogen analyses had a pH greater than 2 and the results were qualified ("J" or "UJ") accordingly.

All nitrogen methods specified in the QAPP for water samples are Clean Water Act (CWA) prescribed methods (40 CFR Part 136). All wastewater samples were analyzed for nitrogen species by MEL using the following methods: ammonia by EPA method 350.1, TKN by EPA method 351.2, and nitrite + nitrate by EPA Method 353.2.

Comment #46: Several commenters questioned the validity of the UNL data for wastewater pharmaceuticals, veterinary pharmaceuticals, and hormones/steroids. The commenters cited the data validation memoranda generated by EPA indicating the limitations and qualifications associated with the data.

In addition, commenters stated that EPA indicates in the data validation memoranda that monensin was detected in three water well samples and the samples were flagged as non-detect ("U") due to monensin contamination in the field blank WW-29; however, Table C12 does not indicate that monensin was detected in the field blank. Commenters also stated that since EPA reported detections of monensin in several other well water samples, it is not apparent why all these reported detects weren't also qualified as non-detects, since the single field blank sample WW-29 should be applicable to all of the well water samples.

EPA's response: EPA's QA team conducted a stage 2A data validation review on the UNL analytical data based on the information provided for review by the laboratory. UNL did not provide the raw data for the analyses they conducted. The list of information provided by UNL for data validation is listed in the validation memoranda. Appendix E of the EPA 2012 Report states that the UNL data may not meet the third-party reproducibility criterion set forth by EPA's Information Quality Guidelines.[46] EPA considered the limitations and qualifications of the UNL data in the context of the EPA 2012 Report.

UNL analyzed the water and lagoon samples twice for the veterinary pharmaceuticals using different analytical methods. The first analysis of the veterinary pharmaceuticals was conducted in 2010 and the second analysis was conducted in 2011. As stated in the validation memoranda, sample analyses with better surrogate recoveries and associated QC sample results (i.e., laboratory control samples, internal standard area and spike recoveries) were recommended by the validator for use in the EPA 2012 Report. EPA reported results for twenty-one water wells and five lagoons from the first analysis. The remaining eight water wells and ten lagoons were from the second analysis. Table C12 includes the results from the second analysis for field blank sample WW-29 in which monensin was not detected, though lincomycin was.

In the first analysis, field blank sample WW-29 reported a trace concentration of monensin. EPA QA/QC protocols specify that sample results that are five times or greater than the concentration detected in a field blank should not be qualified as estimated and are useable. Consequently, any monensin sample result from the first analysis whose concentration was greater than five times the monensin concentration in the field blank was reported and not qualified. Conversely, monensin results from the first analysis with a detected concentration less than five times the field blank concentration were reported as non-detects. In the second analysis, lincomycin was qualified following the same protocol.

Comment #47: Several commenters indicate that QC issues were identified which would cause detected and nondetected herbicide results to be qualified, leading to results that should not have been used. A commenter also stated that an "experimental method" was used for the analysis of water samples for herbicides and that no holding time would be applied.

EPA response: In the data validation memorandum for herbicides, EPA identified any QC issues for herbicides and qualified those data as needed. These data are useable as qualified.

MEL analyzed the water samples for herbicides using Modified Method 551.1 for extraction and Modified SW-846 Method 8270D for quantification. These methods are not "experimental" and are considered definitive methods. All water samples met the holding times specified in the QAPP.

[46] EPA-260R-02-008, October 2002.

Comment #48: One commenter asked why bacteria testing was performed at two different laboratories using different methods. One commenter stated that since the wastewater treatment plant influent samples exceeded holding times for bacteria analysis, the associated fecal coliform concentrations in these samples are meaningless.

EPA's response: To meet the six hour holding time for bacteria analyses of wastewater samples, WWTP samples were analyzed by either the Cascade Analytical Laboratory, or the EPA Region 10 MEL mobile microbiology laboratory staged on-site.

Both laboratories used either SDWA prescribed methods listed in 40 CFR 141[J1] or CWA prescribed methods listed 40 CFR 136. Cascade Analytical Laboratory used Standard Method 9222D for fecal coliform and Standard Method 9223B for both *E. coli* and total coliform. The Region 10 MEL mobile laboratory used Standard Method 9221E for fecal coliform, Standard Method 9221F for *E. coli*, and Standard Method 9222B for total coliform.

While these methods employ different techniques, the end results are comparable except for fecal coliform. For fecal coliform, the results from Standard Method 9222D are an exact count whereas in Standard Method 9221E the results are an estimate of the number of fecal coliforms originally present in the sample.

Three of the four wastewater treatment plant influent samples met the required holding time of six hours. The fecal coliform result for the wastewater treatment plant sample (SP-01) that did not meet the holding time was reported as "too numerous to count" or "TNTC"; however, a "J" qualifier was not applied because the result was not quantified.

D. Peer Review

Comment #49: Several commenters contended that the peer review conducted for the EPA 2012 Report was inadequate because: 1) EPA did not follow its own peer review guidance; 2) the EPA 2012 Report was classified as "influential" by Office of Management and Budget (OMB) and required more extensive review; 3) EPA's selection of peer reviewers was not transparent and all four peer reviewers were from federal agencies; 4) with the exception of one reviewer, the comments received were brief and not adequately rigorous; and 5) one peer reviewer stated that the nitrate in many of the wells is most likely from a mix of sources which would be challenging to tease apart, probably requiring a much more extensive sampling campaign and more knowledge of well depth and screen lengths.

EPA's response: Agency guidance provides several options for the peer review of documents classified as "Influential" under the OMB work product criteria. Consistent with Agency Peer Review Guidance, EPA utilized an external peer review approach, which included scientists from USGS, and the U.S. Department of Agriculture. In addition, scientists from EPA's Office of Research and Development and EPA Region 10 conducted internal peer review. EPA considered the peer reviewers' comments on the EPA 2012 Report and revised the report in response to the comments. The independent peer review process helped EPA solidify its conclusions and clarify the limitations and uncertainties of the study.

Brief comments do not necessarily imply a lack of rigor; brief comments could have resulted from a rigorous review in which the reviewer found the EPA 2012 Report's conclusions to be well supported by data. As noted in previous responses above, EPA's conclusions do not preclude the possibility of multiple sources of nitrate. This possibility does not negate or diminish the conclusions that were stated in the EPA 2012 Report.

VIII. Other

A. Role of Nutrient Management Plans

Comment #50: Many commenters stated that they follow the specifications given to them by the Conservation Districts in their NMPs and that they are good stewards of the lands and believe that they have complied with all the necessary regulations. Some commenters were concerned that EPA is now adding a second contradictory set of standards on top of federal USDA guidelines. Some commenters stated that the data collected in the report are inadequate to determine if NMPs are being properly implemented or if NMPs reduce nitrate contamination in groundwater.

EPA's response: The purpose of EPA's study was to investigate the contribution from various land uses to the high nitrate levels in groundwater and residential drinking water wells. The focus of EPA's study was not on the NMPs. EPA's study does not establish new standards. Since the NMPs are generally not publicly available, EPA cannot comment on the adequacy of the NMPs for the dairies in the study in protecting groundwater quality. Further, work more directly related to NMPs is likely an appropriate area for follow-up by the GWAC or appropriate agencies.

B. Enforcement Actions from Report

Comment #51: Some commenters expressed concern about the draft Administrative Order, which they referred to as a contract, being used to negotiate response options with four dairies believed to be singled out for punishment after acting in good faith to work with EPA. One commenter thought that the draft Administrative Order, which they referred to as a Consent Decree, asked the farmers to do too much. A few commenters stated that they didn't think the report was a document from which policy should be made or which should form the basis for enforcement actions. Several commenters stated they did not want to be driven out of business by lawsuits and fear.

EPA's response: These comments are outside the scope of the EPA 2012 Report. However, the dairies in the Dairy Cluster have agreed to an Administrative Order on Consent.

C. Legal Authority

Comment #52: A commenter asserted that EPA has not met any of the prerequisites for invoking Section 1431 under the Safe Drinking Water Act.

EPA's response: This comment is outside the scope of the EPA 2012 Report.

D. Lower Yakima Valley Groundwater Management Area

Comment #53: Several commenters stated that a GWMA was formed to address the nitrate issues in the Lower Yakima Valley. Commenters also suggested that EPA drop its legal actions against the four families and continue working with the GWMA in order to determine where the nitrate issue originates.

EPA's response: These comments are outside the scope of the EPA 2012 Report. EPA is a member of the GWAC and continues to work with other members to develop a comprehensive plan to reduce concentrations of nitrate in groundwater to below drinking water standards. EPA, like all agencies with regulatory responsibilities represented on the GWAC, has not set aside its regulatory responsibilities as it participates in the GWMA.

E. Extend Time for Public Input

Comment #54: A few commenters requested that EPA extend the comment period and felt that the timeframe for review was inadequate.

EPA's response: EPA believes that the 60 days allowed for public review and input was sufficient. EPA received input on the report from many citizens and stakeholders, including the dairy industry and local agencies. The effort to address nitrate in groundwater in the lower Yakima Valley is an ongoing process in which participation by a wide range of stakeholders is a welcome and critical part of this continued information exchange and solution focused dialogue. Although the public input period has ended, EPA continues to consider additional input provided by the public regarding the issue of nitrate in groundwater.

F. Hold Dairies Accountable

Comment #55: One commenter stated that EPA should immediately act to hold dairies in the Yakima Valley accountable under its authority of the CWA; should along with WSDA and other appropriate agencies, regulate higher standards and enforce requirements for manure handling, storage, application and disposal under its rulemaking authority; should work to ensure clean and safe drinking water to the 24,000 Yakima Valley residents who depend on private residential drinking wells.

EPA's response: This comment is outside the scope of the EPA 2012 Report; however the dairies in the Dairy Cluster have agreed to an Administrative Order on Consent. The Order requires the dairies to do the following:

- Provide alternate drinking water sources for nearby neighbors (within one mile) whose wells have levels of nitrate above EPA's drinking water standard.
- Take steps to control nitrogen sources at their facilities.
- Conduct soil and water monitoring at each dairy to evaluate if nitrogen sources are effectively being controlled.

Moreover, EPA expects to follow-up with other relevant federal, state, and local entities.

G. NRCS Standards

Comment #56: Some commenters asked whether or not the report is questioning the NRCS standards and stated that this is a national issue, that the report challenges best conservation, scientifically-based, proven practices promoted by USDA NRCS and land-grant universities, and that these practices are implemented by dairy farmers across the nation. Some commenters stated that the outcome of this report has a much broader impact than just on the dairy farm families that the report used.

EPA's response: These comments are outside the scope of the EPA 2012 Report. The purpose of the EPA 2012 Report was not to question NRCS standards, but rather to identify the sources of the high nitrate levels in groundwater and residential drinking water wells in the Lower Yakima Valley.

H. Request for Correction

Comment #57: The *Yakima Herald Republic* requested a correction to information contained on Page 1 of the EPA 2012 Report pertaining to a letter a reporter wrote to EPA's Regional Administrator in October 2008. The *Yakima Herald Republic* also informed EPA that, following the series, the reporter received a number of inquiries from citizens asking whether EPA could take action under the Safe Drinking Water Act.

EPA's response: EPA agrees to revise the report to include the additional information provided and to correct the misstatement in the report. The following will replace the second sentence in the fourth paragraph on Page 1 of the revised report: "According to the Herald, following the series, the reporter received a number of inquiries from citizens asking whether EPA could take action under the Safe Drinking Water Act (SDWA). These inquiries prompted the reporter to send a letter to EPA asking whether the agency would consider invoking emergency authority under Section 1431 of the SDWA to address the problem."

Attachment A

Washington NRCS Draft Guidance - May 2011
Appendix 2
Waste Storage Pond practice Standard Criteria Reference Tools

Appendix 2

WSP Practice Standard Criteria Reference Tools

Table outline for – NRCS Practice Standard Criteria Revisions

Waste Storage Pond, PS-425

Dated: 1979-1994

Waste Storage Facility, PS-313 (Includes Pond Criteria)

Dated 2000- Current

313 PRACTICE STANDARD PERFOMANCE MEASURE CHECKLIST

Washington State NRCS REVISION Dates:

- **April 1979**
- **February 1987**
- **January 1994**
- **February 2000**
- **June 2001**
- **December 2004**

Common pond construction dimension criteria for all WSP practices and all revisions: April 1979 to December 2004		
Minimum Top Width	Inside and Outside Slopes	Side Slopes Combined
8 ft	No steeper than 2 H to 1 V	5 H to 1 V or Flatter

Revised Practice Standard Adoption Dates	Design Criteria Revised		
	Separation Distance in Feet From - -	**Seasonal High Groundwater Table: Separation Distance From Pond Bottom**	**Liner Criteria: Soil type, Compaction, Permeability**
1979, April PS- 425	Not specified	Do not construct to an elevation below the SHGWT unless considered a special design	Soils of slow to moderate permeability. Avoid gravel and shallow soils. If self-sealing is not probable, the storage pond shall be sealed by mechanical treatment or by the use of an impermeable membrane.
1987, February PS-425	300 ft from a neighboring residence, 200 ft from domestic well in an unconfined aquifer and 25 ft from water courses. All measured from outside toe of fill or top edge of pit pond	The operation and maintenance plan shall specify that the liquid level in the pond be maintained at least 6-in. above the ground water	No liner required for dense glacial till soils. GM, SM and ML materials may be used for a 12-in compact liner GC and SC materials may be used for a 9-in compacted liner CL and CH materials may be used for a 6-in compacted liner
1994, January PS-425	300 ft from any existing water wells unless aquifer evaluated for reduced distance	Do not construct below the SHGWT and shall have a properly designed and installed liner	1-ft minimum thickness, compacted soil liner of acceptable USCS soil material identified and listed as: CH, CL, MH, ML, and SM, SC, GM, GC if they contain more than 20% fines (passing #200 sieve)
2000, February PS-313	300 ft from any existing water wells unless aquifer evaluated for reduced distance	Pond bottom elevation shall be a minimum of 2 ft above SHGWT. Depth to SHGWT shall be determined from soil features with the assistance of a soil scientist or from monitoring wells.	1-ft minimum thickness, compacted soil liner of acceptable USCS soil material identified and listed as: CH, CL, MH, ML, and SM, SC, GM, GC if they contain more than 20% fines (passing #200 sieve)
2001, June PS-313	300 ft from any existing water wells for storage pond unless aquifer evaluated for reduced distance.	Pond Bottom, Minimum 2 ft above SHGWT. SHGWT may be lowered by perimeter drains if feasible. Engineering Tech Note #7 (formerly agronomy Tech Note #42) shall be used to identify soil features for establishing the SHGWT.	Foundation permeability cannot exceed $1x10^{-6}$ cm/s or it must be lined. All soil liners shall have a minimum compacted thickness of 1-ft. Compacted soil liner permeability must be equal to or less than $1x10^{-6}$ cm/s.
2004, December PS-313	100 ft from any existing water wells. Aquifer evaluation required for variance but, must meet state and local regulations.	Pond Bottom, Minimum 2 ft above SHGWT. SHGWT may be lowered by perimeter drains if feasible and buoyant forces are considered.	1-ft minimum thickness of compacted soil liner. Permeability not to exceed $1x10^{-6}$ cm/s