Comments regarding *Estimated Nitrogen Available for Transport in the Lower Yakima Valley Groundwater Management Area*

Jean Mendoza, April, 2017

I. It appears to me that WSDA and perhaps Yakima County did not comply with the Interlocal Agreement that funded this study. That agreement states in part:

> 1. PURPOSE The purpose of this Agreement is to provide funds to the WSDA from Ecology's grant to develop a Comprehensive Nitrogen Loading Assessment for the Lower Yakima Valley Groundwater Management Area (PROJECT) to support the development of the Groundwater Management Program as set forth in WAC 173-100.
>
> 2. PROJECT. The WSDA agrees to do all work and furnish materials necessary for performing the work in accordance with this Agreement. The WSDA will provide the necessary resources for performing such work as set forth in the Scope of Work and Budget (Attachment "A")

On page 5 the SOW describes an overriding equation for this mass balance model.

> NLGW = RL + BL + IACF + IAOF + CAFOPP +AL   Where
>
> • NLGW = <u>nitrogen load to groundwater</u>, which assumes that all nitrogen present below the root zone will become nitrate and either be denitrified or leach to groundwater.
>
> • RL = <u>nitrogen loading to groundwater</u> from residential sources including septic tanks, lawn fertilization, and onsite septic systems
> .
> • BL = <u>nitrogen loading to groundwater</u> from sites with municipal biosolids, and municipal and industrial wastewater (under State Waste Discharge Permits, or NPDES permits)
>
> • IACF = <u>nitrogen loading to groundwater</u> from irrigated agriculture land use where chemical fertilizers are applied and further discussed below
>
> • IAOF = <u>nitrogen loading to groundwater</u> from irrigated agriculture land use where organic fertilizers (e.g., manure) are applied
>
> • CAFOPP = <u>nitrogen loading to groundwater</u> from livestock pond and pen sources this will include such activities as lagoon operations, composting activities, feeding and milking areas
>
> • AL = <u>nitrogen loading to groundwater</u> from atmospheric deposition. Local values from national atmospheric monitoring data sets will be used and applied evenly across the GWMA.

However, the lead agencies have stopped calling this a nitrogen loading assessment. On page 1 the introduction to the study states,

> In 2015, the Yakima County Public Services Department and GWAC partnered with WSDA to conduct a study to provide a scientific baseline estimate of the amount of potential nitrogen available for transport from different nitrogen sources within the GWMA boundaries. Nitrogen available for transport is nitrogen that has the potential to move from the land surface or soil profile into groundwater. The study addressed how much nitrogen could be available, but did not calculate how much is actually transported to groundwater. <u>The processes controlling nitrogen movement through the soil were not evaluated, and loading to groundwater was not estimated.</u>

On page 7 the SOW states:

> WSDA and Yakima County have taken steps toward the development of a GIS linkage structure. This structure will be submitted for review to the County, and the Data, RCIM, IA, and Livestock/CAFO working groups prior to entering source data into it.

To my knowledge this has not been done.

On page 10 the SOW states:

Task 4.2	Identify and analyze N loading from permitted land application sites. This task will be coordinated with the Washington State Department of Ecology. *Estimated Budget 30 hours @ 30.00/hr $ 900.00*

In Washington State the laws require Ecology to put sewage sludge and bio-solids to a beneficial use. (RCW 70.95J) With this in mind King County and Kitsap County transport bio-solids to Yakima, Benton, Klickitat, Kittitas and Douglas Counties for application to cropland. Yakima County receives the largest portion of bio-solids and also applies biosolids from the City of Yakima. 40,000 acres, mostly in the lower valley is approved by Ecology for application of bio-solids. (See Attachment B) Yakima County states that they will add this source to the study.

The Port of Sunnyside has a Waste Water Treatment Plant and a National Pollutant Discharge Elimination System (NPDES) permit, No. WA0052426, that permits the facility to spread up to 432 lbs of nitrogen per acre per year on 398 acres. (See Attachment C, page 9) This could potentially add 86 tons of nitrogen to the mass balance for the GWMA target area. This source was not included in the Nitrogen Balance Assessment. Yakima County states that they will add this source to the study.

On page 10 the SOW states:

Task 4.3	Develop N loading estimates from municipal Underground Injection Control devices. This will include analysis of stormwater management structures, but will not include an assessment of potentially existing UIC's nor will there be an attempt to identify UIC not currently noted in Ecology's UIC database. *Estimated Budget 60 hours @ 30.00/hr $ 1800.00*

Ecology lists 47 underground injection wells at 15 sites in the GWMA target area. These UICs were not addressed in the study. (See Attachment D for a list of the sites)

On page 12 the SOW describes a process for gathering data regarding Irrigated Agriculture

> Data for the irrigated agriculture nitrogen loading assessment will be collected using three different methods:
>
> 1) County specific crop use, irrigation method, and fertilizer databases
>
> 2) Information gathered from a voluntary grower questionnaire that will report site-specific information regarding nitrogen application and removal over several growing cycles and
>
> 3) Information collected through a series of group interviews/surveys with local crop consultants and agronomists.

To my knowledge, growers who receive a newsletter from the Sunnyside Irrigation District were informed about the GWMA Deep Soil Sampling study and the survey that accompanied it. To my knowledge the survey was not sent with the newsletter and only those who participated in the DSS study completed the survey. To my knowledge there might have been one or two newspaper articles that described the survey but there was no mailing or direct attempt to reach the thousand plus farmers in the target area.

To my knowledge there were no group interviews/surveys. Crop consultants and agronomists were interviewed by phone. <u>It is very concerning that these sources are anonymous. Readers have no way of verifying the credentials for these experts</u>. My calculations show that, for each of ten major crops, a single consultant spoke for:

- 81% of the surveyed alfalfa acreage
- 56% of apple acreage
- 65% of cherry acreage
- 85% of corn silage acreage
- 78% of juice grape acreage
- 80% of hops acreage
- 90% of mint acreage
- 57% of pear acreage
- 61% of wheat acreage
- 70% of triticale acreage

The study did not tell us whether there were ten different experts for the ten crops or whether one expert spoke for more than one crop. It is possible that the majority of estimates for irrigated agriculture are based on the opinions of just a few people.

On page 13 the SOW states:

> For crops that fix nitrogen (legumes such as alfalfa and peas), either a fixation term will be included in the nitrogen input term or a calculation using a leached concentration and recharge volume will be used to calculate loading (as performed in other studies), depending on data availability.

This was not done. Alfalfa was treated like any other crop and there was no calculation of nitrogen fixation numbers. A brief review of commonly used guides from agricultural universities and extension services gives a range of nitrogen fixation in alfalfa fields. Nitrogen fixation ranges from 20lbs/acre/yr to 500 lbs/acre/yr. (See Attachment E)

In the frequently cited 2012 study, *Nitrate Sources and Loading to Groundwater, Technical Report 2 in: Addressing nitrate in California's drinking water with a focus on Tulare Lake Basin and Salinas Valley Groundwater. Report for the State Water Resources Control Board Report to the Legislature*, Viers et al noted on page 10:

> *The mass balance approach is not applied to alfalfa because it does not receive significant amounts of fertilizer, while fixing large amounts of nitrogen from the atmosphere. Little is known about nitrate leaching from alfalfa; we used a reported value of 30 kg N/Ha/Yr (27 lb N/ac/yr) (Letey et al., 1979; Robbins et al., 1980, see Appendix Table 1). In total, 170,000 ha (420,000 ac) of alfalfa fields are estimated to contribute 5 Gg N/yr (5,000 t N/yr) in the study area. Alfalfa harvest exceeds 400 kg N/ha/yr (360 lb N/ac/yr), or 74 Gg N/yr (82,000 t N/yr), in the study area.*

Throughout the California study alfalfa is described separately and is not part of the routine calculations for field crops.

On page 13 the SOW states:

> The following equation will be used to estimate nitrate loading to groundwater from irrigated agricultural fields:
>
> ***Nitrogen load to ground water = (Nitrogen input - Nitrogen removed by cropping)*(1-denitrification fraction)***
>
> Use of the above equation requires the following assumptions and limitations:
>
> All nitrogen not consumed by the crop and removed will become nitrate
>
> Excess nitrate is denitrified in the vadose zone or leaches to groundwater
>
> Input and results are not variable over time and can be approximated with average annual values
>
> Removal of nitrogen from a field via runoff or tile drainage is negligible

The study did not estimate de-nitrification rates. The study did not describe typical pathways in the vadose zone. The study did not assume that "excess nitrate is denitrified in the vadose zone or leaches to groundwater". There was no de-nitrification fraction. (I do understand that there is little de-nitrification in the well aerated soils of the GWMA target area.)

On page 15 the SOW states:

> Additional data that will be obtained through a literature review or data collection include:
>
> • Manure produced per dairy cow and per beef cow and manure nitrogen content
>
> • A range of lagoon seepage and nitrogen leaching rates
>
> • Ammonia volatilization rates from stored and applied manure
>
> • Typical nitrogen loads generated in unpaved animal yards
>
> • Typical manure management practices for animal yards
>
> • Amount of solids/compost or other nitrogen-containing material that is exported from the GWMA

Much, even most of this data was not collected. There is no estimate of the manure produced per dairy cow or beef cow, no estimate of manure nitrogen content, no ammonia volatilization rates, no statement of typical manure management practices and no statement about the amount of solids/compost exported from the area.

On page 16 the SOW says:

> The following equation will be used as a basis for calculating a livestock N loading mass balance:
>
> *(Number of cows x Manure generated per cow x Nitrogen content of manure) = Nitrogen leached from storage ponds + Nitrogen leached from unpaved animal yards + Nitrogen removed for local land application + Nitrogen exported from the GWMA as compost or in other forms + Nitrogen lost to volatilization + Nitrogen lost to denitrification*

This equation was not used. Several components of the equation were never evaluated, including manure generated per cow, nitrogen content of manure, nitrogen removed for land application, nitrogen exported as compost, and nitrogen lost to volatilization or denitrification. There is no estimate of the excess nitrogen available from manure in the GWMA target area.

On page 16 the SOW says the study will complete several tasks:

Task 6.1	Conduct literature review to assemble peer reviewed data on lagoon leakage rates, regional nitrogen content of manure from dairy and beef cattle, required manure handling activities on facility sites. Coordinate with EPA regarding “lagoon” data collected from “Dairy Cluster”.		
	Estimated Budget	*30 hours @ 26.00/hr*	*$ 780.00*
Task 6.2	Conduct evaluation of manure generation using latest livestock population data, evaluate 3rd party application, develop lagoon leakage rates, evaluate soil testing results and evaluate manure export activities.		
	Estimated Budget	*90 hours @ 45.00/hr*	*$ 4050.00*

Most of the activities in these tasks were not done.

On page 17 the SOW states:

Quality Assurance/Quality Control evaluations are proposed to check assumptions and parameters used in the Nitrogen Loading Assessment. These activities include:

- Compare livestock mass balance results with grower survey results to verify assumptions used related to manure application. If the total nitrogen applied across the GWMA as organic fertilizer based on grower survey data differs significantly from the mass expected based on the number of livestock in the GWMA and other identified organic nitrogen sinks, input parameters for the nitrogen loading assessment will be reevaluated. This activity will be addressed through periodic revisions to the document as is warranted as new information become available.
- Conduct an assessment on synthetic fertilizer use using the mass applied to fields (based on grower surveys and WSU rates) compared to nitrogen fertilizer mass sold by fertilizer distributors (assuming data are available). This will provide a check on amounts claimed on grower surveys.

Because there was no livestock mass balance calculation it was not possible to verify assumptions related to manure applications. To my knowledge there was no attempt to determine the amount of fertilizer sold in the area. This was discussed within the Irrigated Ag work group but WSDA rarely attended these meetings.

Because there was no attempt to estimate manure generation based on the number of cows; because there was no attempt to quantify the amount of fertilization from organic fertilizer and compare to synthetic fertilizer; because manure export was not quantified, it is almost impossible to draw conclusions regarding the source of nitrates in lower valley groundwater.

On pages 17 & 18 the SOW states:

(These activities include) Upon completion of the Deep Soil Sampling analysis, compare and contrast Nitrogen Loading Assessment with DSS findings. Existing shallow groundwater nitrate data may also be used for this purpose.

and

Task 7.2 Evaluate DSS results with N Assessment results and determine relative gaps in assessment.

Estimated Budget 80 hours @ 55.00/hr $ 4400.00

The last round of Deep Soil Sampling was completed almost a year ago. To my knowledge there has been no effort to analyze the data. We are proceeding with the Nitrogen Loading Assessment, moving toward development of a plan to address nitrates in groundwater and we will apparently ignore this $350,000 study. Task 7.2 says that WSDA will evaluate the DSS results and will compare those results to the Nitrogen Loading Assessment. This was certainly not done in the first draft.

II. I have concerns regarding the Methodology and Data Collection in the Nitrogen Loading Assessment.

Executive Summary

On page 1 the summary states that the study will evaluate inputs from CAFOs. It appears that input from animals on pasture was omitted. In 2012 there were 258,663 head of cattle and calves in Yakima County, most in the lower valley and many on pasture. During the five years between the 2007 and 2012 the number of milk cows in Yakima County increased from 89,575 to 99,532 and the number of beef cattle decreased from 28,594 to 15,414. (USDA NASS, 2014).

On page 2 the summary states that the study will evaluate both wet and dry deposition of nitrogen. This was not done.

On page 2 the report states, “Atmospheric calculations included adjustments to avoid double counting with other categories that already included atmospheric nitrogen.” As a result over half of the atmospheric deposition was classified under other sources. This gives the reader a faulty understanding of the amount of atmospheric deposition.

Tables 1 & 2 on page 3 leave out composting areas, dairy ponds, application of bio-solids and other permitted land applications. The Irrigated Agriculture row is not broken down into organic fertilizer and inorganic fertilizer. The numbers for Atmospheric Deposition apply to less than half of the GWMA area and are not broken down into wet and dry.

On page 4 the summary states, “The irrigated agriculture mass balance estimates could be compared to current and future deep soil sampling results to improve the accuracy of the analysis.” Comparing to current deep soil sampling was part of the SOW for this project.

Introduction & Study Area

Suggestion: The introduction states on page 5, “The current population of Yakima County is just over 240,000 people, and the major metropolitan area is the city of Yakima (Census 2010).” It would be useful to state the population for the GWMA target area as well.

Question: The introduction states on page 5, "The lower valley agricultural landscape includes more than 50 active dairy farms and approximately 100,000 acres of irrigated farmland (WSDA 2016)." It is nearly impossible for readers to access the WSDA data source for these numbers. Steve George from the Yakima Farm Bureau states that there are 94,000 acres of irrigated agriculture in the area. Does the 100,000 acres include double counting for land that is double cropped in corn and triticale? According my reading this was done in the UC Davis study. (Viers et al, 2012, pages 71 & 115)

Methodology & Limitations

On page 8 the study describes the treatment zone for each source. For "residential fertilizer" and "small commercial and hobby farms" the treatment zone is the land surface. This means that the total amount of fertilizer applied is assumed to be available for leaching to the groundwater. There is no assumption that this fertilizer is taken up by plants. The result is an over-estimate of nitrate from this source. An estimate that even half of this fertilizer is utilized by plants would be more accurate.

On page 9 the study states, "In order to allow readers to evaluate data sources on a case-by-case basis each data source used, the calculation it was used for, the source, and potential concerns with the data source have been collected in a table (Appendix A: Data Sources, Uses, and Potential Concerns)." However, the only way for readers to access the following listed sources and verify data is through public records requests:

2014 dairy registration locations
WSDA DNMP
WSDA Animal Services
DNMP lagoon assessment project
Nutrient management plans
DNMP staff onsite data collection using ArcGIS Collector
DNMP lagoon assessment
Self-reported data to SYCD
Telephone survey
Dr Ranil Dhammapala
Virginia Prest, WSDA DNMP
GWMA Survey "Well Assessment Survey"
ESD 2015
Scott's Turf Builder

1. Concentrated Animal Feeding Operations

a. Background and Literature Review

The SOW states:

Task 6.1	Conduct literature review to assemble peer reviewed data on lagoon leakage rates, regional nitrogen content of manure from dairy and beef cattle, required manure handling activities on facility sites. Coordinate with EPA regarding "lagoon" data collected from "Dairy Cluster".		
	Estimated Budget	*30 hours @ 26.00/hr*	*$ 780.00*

It appears that WSDA relied almost exclusively on the work performed by UC Davis in their study of the Tulare Lake Basin in California for a review of the literature. Please note that, in 2014, I shared a listing of relevant sources with the GWMA CAFO/Livestock work group. (See Attachment F) This was not a literature review but it is more extensive than the work done by WSDA in the Nitrogen Loading Assessment. This listing provides a broader look at leakage from dairy lagoons.

b. Pens and Compost Areas

Under "Pens" the study cites research by Mielke from 1974. This was a limited study conducted on beef feedlots in Nebraska during a time when the Clean Water Act was first being developed. It has been replaced by more current, more accurate and more relevant research. It should not be part of this review.

I disagree with the numbers stated on page 12. The study says:

> *As of 2014 DNMP dairy registration, dairies in Yakima County had just over 100,000 milking and dry cows (the vast majority of which were within the GWMA boundary), making for a stocking rate of around 50 cattle/acre, based on the NRAS estimate of pen acreage, similar to that of dairies in the UC Davis study.*

Assuming that 89% of the milk cows in Yakima County are within the GWMA target area (there are about 5,000 milk cows on the Yakama Reservation and about 6,000 in the Moxee Valley) then the stocking rate in the GWMA area is 55 to 57 cows per pen-acre. (See Attachments I & J). This puts the stocking rate for the GWMA area at a higher concentration than the Tulare Lake Basin as a whole and most closely aligned with Tulare County.

On page 14 the study states,

> *NRAS did not have the amount of facility-specific on-site information that would be needed to generate rates for dairy and nondairy CAFOs.*

If WSDA does not have this information who does? Most of us believe that it is WSDA's job to understand agriculture and to know what is happening on Washington farms. What is wrong with calling the two beef feed lots and asking for their average stocking rates?

On page 14 the study states,

> *With no information available in scientific literature about potential loading from compost areas, NRAS did not attempt a calculation for these areas.*

I have found considerable research from both academic and USDA sources regarding the environmental impacts from compost areas. In addition, WSDA's own research shows significant leaching from Yakima Valley composting operations. See the table below with data from Attachments K, L & M. This source is too important to be ignored.

Compost Yards		**Nitrate in mg/kg**							
Soil Testing									
Site		Surface	1 Ft	2 Ft	3 Ft	4 Ft	5 Ft	6 Ft	7 Ft
1C1		364.0	116.3	95.6	82.6	31.1	15.4	15.6	8.3
1C2		292.7	49.8	24.5	28.6	27.1	21.0	19.8	
5C1		159.0	118.8	133.8	225.0	153.9	116.7	28.0	8.5
2Cl		139.0	1.3	6.3	1.0	3.2	1.9	8.5	
2Cu		649.4	30.0	2.2	36.9	150.0	175.1	151.5	
4C1		48.3	164.5	226.1	216.9	222.5	132.1	59.1	
6C		123.2	73.5	34.7	24.7	17.7	9.1		
Average		253.7	79.2	74.7	88.0	86.5	67.3	47.1	8.4
Range		48.3-649.4	1.3-164.5	2.2-226.1	1-216.9	3.2-222.5	1.9-175.1	8.5-151.5	8.3-8.5

On page 14 the study says,

> *Potential emissions of nitrogen compounds to the atmosphere from pens and corrals have not been estimated in this report. It is unknown what proportion of emissions from GWMA CAFOs may redeposit within the GWMA, as emissions may travel large distances before eventual deposition (Viers et al. 2012)*

Nearby Idaho has studied ammonia emissions on dairies. Leytem et al (2010) found:

> *Average emissions per cow per day from the open lots were 0.13 kg NH_3, 0.49 kg CH_4, 28.1 kg CO_2, and 0.01 kg N_2O. Average emissions from the wastewater pond (g m^{-2} d^{-1}) were 2.0 g NH_3, 103 g CH_4, 637 g CO_2, and 0.49 g N_2). Average emissions from the compost facility (g m^{-2} d^{-1}) were 1.6 g NH_3, 13.5 g CH_4, 516 g CO_2, and 0.90 g N_2O. The combined emissions of NH_3, CH_4, CO_2, and N_2O from the lots, wastewater pond and compost averaged 0.15, 1.4, 30.0 and 0.02 kg cow^{-1} d^{-1}, respectively. The open lot areas*

generated the greatest emissions of NH_3, CO_2, and M_2O, contributing 78, 80, and 57%, respectively, to total farm emissions.

The UC Davis study took volatilization losses seriously. Viers et al (2012, pages 152 & 157) estimated that 38% of all excreted N was lost to the atmosphere before it was applied to the land.

This route of nitrogen loading or unloading is too significant to be ignored. In 2008 the EPA estimated that animal agriculture in Yakima County emitted 6,078 tons of ammonia to the atmosphere. In 2011 that number had increased to 8,054 tons. (Attachments N & O)

c. Lagoons

Here is a comparison of the lagoon capacities for California dairies and for GWMA dairies:

	# milk cows	Acres of Lagoons	Cows/lagoon acre
County	U of C Table 30	U of C Table 29	
Fresno	132,588	325	408.0
Kings	177,696	547	324.9
Tulare	545,689	1,740	313.6
Kern	164,127	514	319.3
Total TLB	1,020,100	3,126	326.3
Yakima NASS	99,532	210	474.0
Yakima DNMP	103,089	210	490.9

Based on surface area we have less lagoon space per cow and this impacts a comparison between the two areas. It is possible that GWMA lagoons are deeper than California lagoons.

On page 22 the study states:

The average capacity used for each lagoon was then itself averaged across all lagoons, resulting in an average percent capacity used for 2015 visited of 43%. The depth used in the Darcy's Law calculations is 43% of the actual or estimated design depth.

This is mathematically incorrect. The only time that volume (capacity) is proportional to depth is when the sides of a container are vertical. This is not the case for lagoons.

If the 43% depth is used to calculate volume for the average square lagoon with a 1:3 slope as described in Appendix C the result is a lagoon about 37% full.

Question: Were the lagoons on the "dairy cluster" included in the calculations?

On page 24 the study states,

> *Lagoon liner permeability options were also discussed with some GWMA workgroups in 2015. The groups agreed that 2 liner permeability scenarios should be considered in lagoon seepage calculations. Based on these discussions and limitations in the data available, liner permeabilities of 1 x 10-7 and 1 x 10-6 cm/s were used to determine a low and high rate seepage estimate, respectively.*

I do not recall the referenced meetings and I find no record for those discussions. I disagree with the assumptions WSDA has made regarding lagoon leakage. For purposes of the Nitrogen Loading Assessment, WSDA assumes that all dairy lagoons in the GWMA target area are adequately lined and uses the ranges for compliance when calculating low and high amounts of lagoon leakage. There is no adjustment for aging, poorly maintained lagoons.

The most intensively studied lagoons in the GWMA target area are the lagoons on the "dairy cluster". There are 41 waste management lagoons that cover 40 acres on these sites. It is a fact that the four dairies involved chose to line their lagoons rather than provide proof of proper lining. (U.S. Environmental Protection Agency 2014; U.S. Environmental Protection Agency, 2016).

WSDA states in the Nitrogen Loading Assessment on page 24,

> *Construction dates for lagoons in the GWMA are unknown. Without information on how many lagoons were constructed before the 2004 standard, it is impossible to say how many lagoons may have permeabilities higher than 1 x 10^{-6}.*

And,

> *Clearly lagoons constructed prior to the current guidance documents are unlikely to meet current NRCS standards. However, no information is available about what*

seepage might be for lagoons constructed before 1990, or between the 1993 guidance and the 2004 guidance

Then, incredibly, WSDA goes on to decide

> *Darcy's law calculations were run using the two different permeabilities discussed above (1x 10-7 and 1x10-6 cm/s) to determine a low and high range estimate. Since this is the only parameter that differed between the two calculation scenarios, the estimated loss for high and low differs by a factor of 10. The medium rate was calculated by averaging the low and high rates. Table 7 displays the results from these calculations. The rate per area was determined by dividing the total loss by the total design surface area of lagoons in the GWMA.*

It is unconscionable to just assume, in the face of contrary evidence, that leakage from GWMA lagoons meets current safety standards.

On page 25 the study states,

> *For lagoons with depths of 16 feet or less, the minimum liner thickness required is 1 foot (USDA NRCS 2016a)*

This is not correct. Here is what the NRCS Practice Standard 520 actually says regarding compacted clay liners.

Liner Thickness.
The minimum thickness of the finished compacted liner must be the greater of—

- *The liner thickness required to achieve a specific discharge (unit seepage) design value, or*
-

Table 1. Minimum liner thickness by design storage depth. Design Storage Depth (ft)	Liner Thickness (in)
≤16	12
16.1–24	18
24.1–30	24

- *A liner thickness required by State regulations, or*
- *The minimum liner thickness as shown in table 1.*

The formulas for liner thickness required to achieve a specific discharge are provided in Chapter 10, Appendix D of the Agricultural Waste Management Field Handbook.

As an example: Use Method A on page 10-D 17 and calculate the liner depth to achieve leakage less than 5,000 gal/acre/day, with a hydraulic permeability of 6.5 x 10^{-7} cm/s and a lagoon depth of 12 ft. The result is a liner thickness requirement of 1.6 ft.

Darcy's Law says that deeper lagoons require thicker liners.

Soils in the GWMA target area usually have a compacted hydraulic conductivity much greater than $1x10^{-6}$ cm/s; in other words greater permeability. The practice of excavating and compacting native soils is not sufficiently protective of the aquifers. The appropriate hydraulic conductivity must be used when estimating required lagoon thickness and determining leakage using Darcy's Law.

On page 27 the study says,

> *The work involved in correctly identifying and characterizing settling ponds or basins well enough for an accurate calculation makes addressing settling ponds beyond the scope of this report.*

On the other hand, settling ponds are a significant source of nitrogen loading to the groundwater. We cannot just ignore them.

2. Irrigated Agriculture

On page 30 the study states,

> *This study does not include information on the use or benefits of nitrogen-fixing cover crops used within the GWMA boundaries. Although cover crops benefit soil health, reduce erosion, and can provide nutrients for future crops, the behavior and cultivation of different cover crops and/or winter crops used in double cropping systems was beyond the scope of this study.*

There is a big difference in the nitrogen balance when there are cover crops on the 17,333 acres of land planted in apples, the 6,336 acres planted in cherries and the 843 acres planted in peaches/nectarines. This is about 25% of the irrigated land. There should be an estimate of the nitrogen uptake from cover crops and this could have been addressed in the telephone interviews for irrigated agriculture.

There are 10,780 acres in triticale. Is this land double cropped? If so, please note this in the narrative.

On page 31 the study says,

> *Results from this study were not compared to the Yakima county deep soil sampling results: that was beyond the scope of this study.*

This is incorrect. On page 18 the SOW states:

Task 7.2	Evaluate DSS results with N Assessment results and determine relative gaps in assessment.		
	Estimated Budget	*80 hours @ 55.00/hr*	*$ 4400.00*

Beginning on page 31 the study describes data collection. The narrative suggests and promises credible numbers. Friends of Toppenish Creek obtained the written notes and spreadsheets that were recorded during these telephone surveys through a public records request. There is not very much. The documents are in Attachments P, Q & R. This data gathering is completely inadequate for our purposes. This is not science.

Question: Under inputs there is a listing for irrigation water. In the spread sheet this source reportedly adds 0 and 7.41 lbs N/acre. (Asparagus apparently receives no nitrogen from irrigation water.) If irrigation water comes from dairy ponds and lagoons is the higher N content in those waters considered?

a. Data Collection Please look at Attachment C. This document describes the sources for the data regarding manure and fertilizer applications on irrigated crops. In over 70% of the categories one lone "expert" spoke on behalf of an entire class of crops. This expert was frequently not even a farmer; rather he sold fertilizer, packed and processed crops or advised growers. If I participate in a scientific study I want to be acknowledged. Why would these experts want to remain anonymous? Here is a summary table that shows what percentage of the cropland was characterized by one person.

Survey of Yakima Valley Crops for the Lower Yakima Valley GWMA	

Crop	Acres Surveyed	One Consultant	% One Consultant
Alfalfa	6,194	5,000	81%
Apple	14,165	8,000	56%
Cherry	3,826	2,500	65%
Corn Silage	11,480	9,800	85%
Juice Grapes	3,849	3,000	78%
Hops	3,760	3,000	80%
Mint	780	700	90%
Pears	1,741	1,000	57%
Wheat	490	300	61%
Triticale	7,500	5,250	70%
Total	53,785	38,550	72%

Looking at alfalfa it is easy to see how one person can strongly influence the numbers. Here are the nitrogen application estimates from the three commercial consultants who responded regarding alfalfa:

Alfalfa	Acreage		Organic N #/acre	Commercial N #/acre
Comm Consultant	100	acres	0	30
Comm Consultant	200	acres	225.7	0
Comm Consultant	5000	acres	0	80
Average			75	37
Weighted Average			8.5	76

If you just look at the opinions of three men and give each person's opinion equal consideration then the average grower applies 75# of organic N and 37# of commercial N per acre to alfalfa. Because consultant #3 speaks for such a large acreage, the numbers closely match his estimates when the averages are weighted. In this weighted scenario the average grower applies 8.5 #/acre of organic N and 76#/acre of Commercial N. See Attachment T for a more complete look at alfalfa.

b. Irrigation water nitrogen

Dairies own about 29,000 acres of land in the Lower Yakima Valley. (WSDA, 2016) They grow a large amount of silage corn and triticale on this land. Much of their irrigation water does not come directly from the canals. It comes from lagoons and ponds that collect manure and liquids from the milk parlors, pens and corrals. This effluent is high in nitrogen content. Nutrient management plans actually require dairies to test this liquid for nitrogen levels before applying to fields.

It is important to remember that more nitrogen is excreted in urine than in feces. Rotz (2004, page E123) states

> *With all diets balanced to meet the RDP and RUP requirements of lactating dairy cows, urine N excreted from a high-protein diet (18% CP) was 2.3 times greater than that from a low-protein diet (12%CP; Tomlinson et al., 1996). Fecal N excretion was only 25% greater using the high-protein diet, which illustrates that excess protein is primarily excreted in urine.*

Dairy ponds are a source of nitrogen. If we fine tune this study to include 5#/acre from irrigating with surface water, then we certainly should not ignore the much larger contribution from irrigation with pond and lagoon water.

c. Calculated Residual Nitrogen

This study appears to shift responsibility from the crops where fertilizers are over-applied and direct it towards crops that are less likely to contribute to nitrate pollution. Fruits and grapes must take in a significant amount of nitrogen in order to build structure. Only the fruit is harvested but the trees and vines must be maintained.

Here is an abbreviated table taken from the large spreadsheet that WSDA shared at the Nitrogen Loading presentation. These numbers are for inputs and outputs at the medium or average level.

	Comm N	Manure N	Compost N	At. Depos.	Calc. Residual	Irr. Water	Soil Conv.	Crop Uptake	Loss to Atm.	Total #/acre
Apples	52	0	6	2.05	50	5.5	92	100	17	90.5
C Silage	106	110	0	2.05	10	5.23	92	270	30.4	24.7

Juice Grapes	72	0	7.4	2.05	60	4.86	92	90	17	131.3
Triticale	29	78	1	2.05	13	5.23	92	212.5	17	-9.2

At this average level the amount of manure/fertilizer applied is:

- Apples: 58#/acre
- Juice Grapes: 79.4 #/acre
- Triticale: 108 #/acre
- Corn Silage: 216 #/acre

But the excess #N/acre per crop is:

- Triticale: negative 9.2
- Corn Silage: 24.7
- Apples: 90.5
- Juice Grapes: 131.3

Apples and grapes actually end up with more nitrogen than the growers applied. I suggest that the calculated residual and soil conversion contribute to this problem. In addition, there is no quantification of the nitrogen taken up by cover crops in the orchards.

d. Soil Organic Matter Conversion to Nitrate

The study states:

> *This term represents the breakdown of organic matter (containing nitrogen) to nitrate-nitrogen available for both crop uptake and leaching below the crop root zone. This input was the same for every commodity analyzed. The native organic matter content of most lower Yakima Valley soils is around 1% but when these soils have a history of organic inputs such as manure, it can increase by 2 to 3 time..*

The study averaged organic matter readings for the Deep Soil Sampling in 2015 and applied the results to all crops, whether they received manures or not. I re-calculated the numbers and found that cropland with alfalfa, corn, triticale and Sudan grass had an average of 2.28% organic matter while all other crops - grapes, apples, mint, hops - had an average organic matter content of 1.69%. This is a difference of .59 percentage points and I believe it is significant.

e. Alfalfa

Here is a summary table for the GWMA Deep Soil Study – 2014 to 2016. For more analysis see Attachment T.

Deep Soil Sampling for Alfalfa – Levels in #N/Acre							
		1FT	2 Ft	3 Ft	4 Ft	5 Ft	6 Ft
Average for all DSS, N = 26		45.5	54.6	104.8	121.7	106.6	92.6
Average for fields receiving liquid manures, N - 10		53.2	91.6	188.3	205.0	124.7	136.0

It is clear that nitrates leach to the groundwater from these Lower Yakima Valley alfalfa fields. This contradicts the prediction that alfalfa depletes the soil of nitrogen. There is a gap between the theoretical work and the field work.

Various academic institutions and extension services clearly state that alfalfa fixes nitrogen in the soil at rates of 20 to 500 #/acre/year. See Attachment E.

Pacific Northwest Extension (WSU, OSU & U of I) states.

> *Fertilizer N rates should be reduced 60 to 100 pounds per acre when field corn follows alfalfa grown for forage or seed. Shorter growing seasons likely will not mineralize as much N from alfalfa residues as longer growing seasons. Also, poor alfalfa stands won't release as much N the following year as good stands. Reduce the alfalfa N credit by 20 to 30 lb N per acre if the alfalfa stand is less than two plants per square foot.*

The role of alfalfa in the GWMA nitrogen balance should be revisited.

f. Results and Discussion

Can someone explain how only 2.8% of the pasture land received manure?

3. Atmospheric Deposition

"Atmospheric deposition and nitrate-nitrogen in groundwater used as irrigation water are approximately one-tenth of all nitrogen input."

(Viers et al in the U of C Davis study, *Nitrogen Sources and Loading to Groundwater. Technical Report 2 in: Addressing Nitrate in California's Drinking Water with a Focus on Tulare Lake Basin and Salinas Valley Groundwater,* page 11)

Consider Tulare County in California, the county that most closely resembles the GWMA target area in concentration of milk cows. Here is a deposition map from that study:

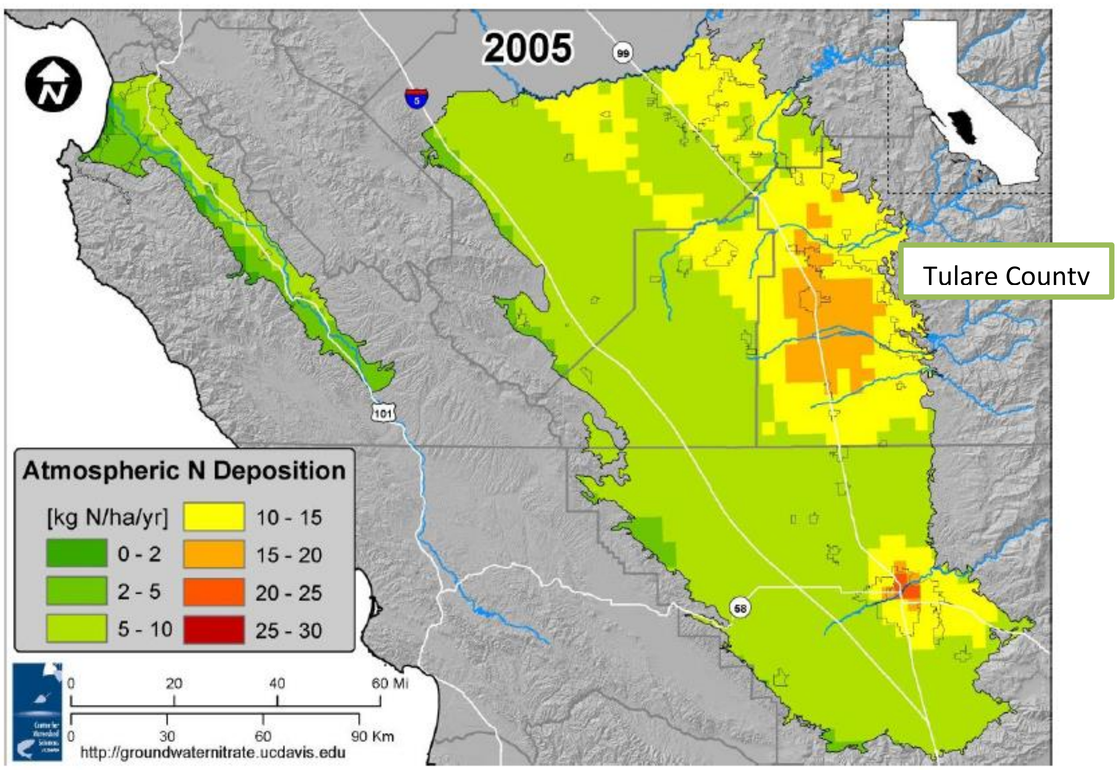


Figure 61. Atmospheric N deposition, spatially distributed across the study area, based on the Community Multiscale Air Quality model developed by U.S. EPA.

While the average atmospheric deposition of nitrogen in the Tulare Lake Basin is 9 lbs/acre (Viers et al, 2012, page 226) the atmospheric deposition in Tulare County target area ranges from 9 to 18 lbs/acre/year (page 228). (Lbs/acre/yr = .89 kg/ha/yr) Between a quarter and a half of the ammonia that goes up comes down in the same area.

Potter et al (2008, page 114) provide an overview of nitrogen inputs for the nation as a whole and for the western states as a whole. They say:

> *Total nitrogen input for the West region averaged 147 pounds per acre (table 34, fig. 14). The largest source was commercial fertilizer at 48 percent, followed by bio-fixation at 40 percent, manure at 11 percent, and atmospheric deposition at 1.6 percent (fig. 15). The West region had the lowest amount of nitrogen from atmospheric deposition, averaging only 2.3 pounds per acre in these model simulations*.

This document estimates that corn fields volatilize 30.4 lbs of nitrogen per acre per year. There are a lot of corn fields in the lower valley. How can we say that all of this reactive nitrogen goes up into the ambient air and only 2.05 lbs per acre comes back down?

Dr. Ranil Dhammapala from the WA State Dept. of Ecology has conducted research in the Sunnyside area regarding wintertime nitrates. He found that 31% of fine particulate matter in the area is ammonium nitrate, a very high percentage compared to most areas. (Attachment U)

WSDA cites Dr. Dhammapala as the expert who recommended 2.05 lbs/acre for average atmospheric deposition and a high level of 6.15. I have read the e-mails leading up to this estimate. I am not sure he intended 6.15 to be the high level. He may have recommended it as a potential average.

Ecology's study of the Upper Yakima Valley documents that we have problems with winter nitrates in the air. There is more than enough ammonia in the air to combine with all available nitrate and sulfate and this leads to increases in fine particulate matter and thus deposition. (Van Reken et al, 2015).

Finally, on page 68 the Nitrogen Loading Assessment states,

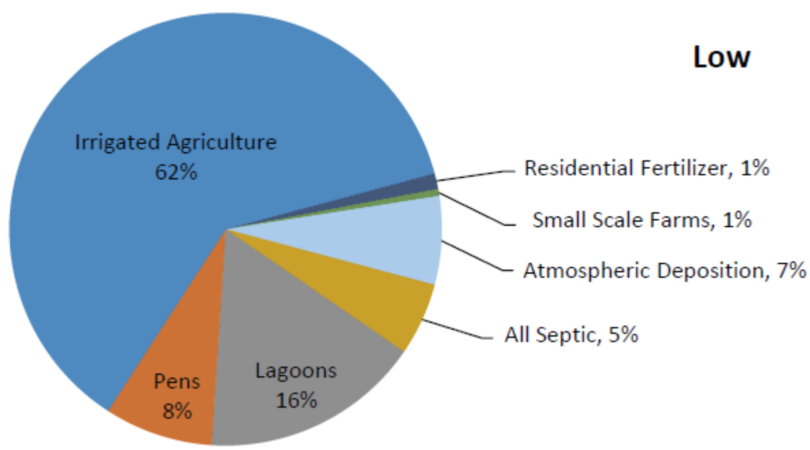
> *The lowest number used is the combination of the most recently available annual wet and dry deposition data from the NADP Mt. Rainier station. Deposition reported includes dry nitric acid, dry ammonium, dry nitrate, wet ammonium, and wet nitrate (EPA 2016). This is believed to be a good surrogate for low deposition due to the considerable transportation corridor along I-5 in western Washington mimicking farm-related emissions and deposition seen in eastern Washington.*

<u>The transportation corridor along I-5 mimics farm related emissions and deposition in eastern Washington?</u> Really?. . . . . Really?

Conclusions

The pie charts on Page 72 of the report are based on faulty reasoning. These charts are misleading and just plain wrong, especially with respect to Irrigated Agriculture.

Nitrogen Available for Transport, Lower Yakima GWMA April 6, 2017



Where did the authors find 62% from IA in the low assessment? Here is how they did it.

Look at the chart on page 71:

Table 32. Estimated nitrogen available per acre from all sources at low, medium, and high range

Source		Area (acres)	Low (lb/acre-year)	Medium (lb/acre-year)	High (lb/acre-year)
Irrigated Agriculture		96,186	11	60	181
CAFO	Pens	2,096	67	480	892
	Lagoons	210	1,354	7,448	13,542
RCIM	ROSS	398	223	403	662
	LOSS	3	195	209	225
	COSS	30	163	173	183
	Residential Fertilizer	4,381	4.7	11.7	18.6
	Small Scale Farms	2,096	4.3	10.7	17.1
Atmospheric Deposition		73,976	1.53	2.05	6.15

Blue shading indicates top 3 contributors in each range (low. medium, high).

Carrying out the calculations for the low range gives the following results. These percentages correlate with the pie chart:

	Acreage		Low Lbs/Acre		Total Lbs	% of the Whole
Irrigated Agriculture	96,186		11		1,058,046	62%

CAFO Pens	2,096		67		140,432	8%
CAFO Lagoons	210		1,354		284,340	17%
ROSS	398		223		88,754	5%
LOSS	3		195		585	0%
COSS	30		163		4,890	0%
Residential Fertilizer	4,381		4.7		20,591	1%
Small Scale Farms	2,096		4.3		9,013	1%
Atmospheric Deposition	73,976		1.53		113,183	7%
Total	179,376				1,719,834	100%

Now ask, where did the authors find 11 lbs/Acre of N application for Irrigated Ag? Look at the chart on page 43.

Table 14. One year's worth of inputs and outputs for the top 15 crops in the GWMA

Commodity	**Acreage**	**Sum of inputs and outputs for one year (lb N/ac-yr)**		
		Low	**Medium**	**High**
Apple	17,333	-5	91	219
Corn (silage)	16,778	-200	25	242
Triticale	10,780	-135	-9	250
Grapes (juice)	10,257	61	132	197
Alfalfa	7,989	-365	-236	-46
Pasture	6,731	-186	-68	62
Cherry	6,336	27	105	210
Hops	5,961	-84	78	113
Grapes (wine)	5,126	40	94	156
Pear	3,331	-1	92	173
Mint	1,418	-166	73	157
Wheat	1,283	-79	23	113
Corn (grain)	1,166	-48	126	284
Asparagus	854	58	157	210
Peach/Nectarine	843	12	81	158

These calculations yield -92 Lbs/Acre/yr from Irrigated Ag. In everyday terms this tells us that most crops are taking more nitrogen from the soil than farmers are putting back. This means soil depletion.

But this does not fit with the framework of the study and the esthetics of the report. It is impossible to show negative input in a pie chart. The authors solved the problem by only including the positive inputs from juice grapes, cherries, wine grapes, asparagus and peaches/nectarines on the balance sheet. They only looked at the surplus and not the deficit. See the Table on page 44.

Table 15: Sum of inputs and outputs for the top 15 crops in the GWMA (entire acreage)

	Estimated total N surplus in GWMA (ton N/yr)		
Commodity	**Low**	**Medium**	**High**
Apple	-	786	1,897
Corn (silage)	-	208	2,029
Triticale	-	-	1,346
Grapes (juice)	312	677	1,008
Alfalfa	-	-	-
Pasture	-	-	209
Cherry	87	333	666
Hops	-	232	337
Grapes (wine)	103	240	400
Pear	-	153	288
Mint	-	52	111
Wheat	-	14	72
Corn (grain)	-	74	165
Asparagus	25	67	90
Peach/Nectarine	5	34	67
Total	532	2,870	8,685

532 tons equals 1,064,000 lbs and 1,064,000lbs/96,186 acres equals 11 Lbs/Acre. The low assessment of nitrogen input for the study tells us what the input would be if the excess nitrogen that is applied on the 23,453 acres of juice grapes, cherries, wine grapes, asparagus, and peaches/nectarines were evenly distributed over all the cropland in the GWMA target area. What does this mean? It means very little. It has no purpose. It makes no sense.

Thank you for reading my comments. I look forward to further discussions.

Jean Mendoza

Friends of Toppenish Creek

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