City of Santa Rosa Offset Credit Proposal for Beretta Dairy BMPs

Credit Proposal Summary

Selected Project:
Installation of three agricultural best management practices (BMPs) at an existing Laguna dairy operation.

Discharge Location in the Laguna:
Roseland Creek discharging into the Laguna approximately 1.1 miles downstream of the Todd Road crossing.

Credit Generating Practices:
BMP #1: Manure stacking pad installation and buffer
BMP #2: Heavy use area buffer, fencing and cattle crossing upgrades
BMP #3: Relocation of heavy use loafing pen

Margin of Safety Factors:

- Edge-of-field calculated loads discounted for overland delivery to the stream
- Bioavailability of total nitrogen (TN) and total phosphorus (TP) in manure compared to wastewater treatment plant (WWTP) effluent

Calculated Credits and Credit Life for Proposed BMPs:

Proposed Crediting Option	BMP Elements	Annual Credits (lbs TP+TN/yr)	Proposed BMP Eligibility Period
BMP #1 Manure Stacking Pad and Buffer	Concrete Stacking Pad	1,194	Long-term (20 years)
	Buffer	300	Long-term (20 years)
BMP #2 Heavy Use Area Upgrades	Fencing and Cattle Crossing	201	Short-term (2.5 years)
	Buffer	84	Long-term (20 years)
BMP #3 Relocate Heavy Use Area	Relocation of use area to interior field	1,119	Long-term (20 years)

Beretta Dairy Project Synopsis:

An examination of the Beretta Dairy by Kieser & Associates, LLC (K&A) on behalf of the City of Santa Rosa in November and December 2011 identified potential nutrient offset credit options through voluntary installation of new practices at this operation. The dairy site is located along Roseland Creek (lat: 38°23'27.15"N, long: 122°46'21.42"W) which discharges to the Laguna de Santa Rosa (Laguna). New practices will result in a reduction of nutrients (total phosphorus and total nitrogen) that can reach the Laguna. The City desires to implement these voluntary practices at the Beretta Dairy to offset annual WWTP discharges to the Laguna. The dairy owner is willing to install these practices under an agreement with the City if the Executive Officer of the Regional Board approves this proposal.

Implemented land management practices are considered eligible for generating nutrient reduction offsets according to Resolution No. R1-2008-0061 (Resolution) and this proposal is submitted for Regional Water Board consideration pursuant to the terms of the Resolution. When offsets are described as pounds of phosphorus and nitrogen reduced per year from land management practices, they are referred to herein as credits. Credit life (i.e., number of years credit would accrue to the City) will depend on the time until these practices are required of the land owner to meet a regulatory requirement or the termination of the agreement with landowner to implement the measure, whichever occurs first. Final crediting calculations are being provided with this proposal in a separate MS Office Excel spreadsheet format. Relevant information on BMP verification and annual reporting are also are included in this formal proposal. The City, working with the Sotoyome RCD, is submitting this formal crediting proposal to the Executive Officer of the Regional Board using site-specific design details provided by a local agricultural engineer, and TN and TP soil test results for the project site. This submission also follows a verbal request from Mr. David Leland of the Regional Board based on their review of an initial concept proposal for the Beretta Dairy. BMP installation will occur in 2012 pending Executive Officer approval of this formal proposal. Following such approval, the City will finalize contracting arrangements with the dairy owner.

This document is submitted to the RWQCB with the permission of the dairy owner, Mr. Doug Beretta. It contains the required information associated with the Resolution.

Introduction

This document describes the Beretta Dairy Nutrient Offset Project (Project) and is intended for consideration by the North Coast Regional Water Quality Control Board (RWQCB or Board) as a basis for Project approval under the Santa Rosa Nutrient Offset Program adopted by the Board with Resolution R1-2008-0061 (Resolution). This proposal is organized according to the Nutrient Offset Program information requirements identified in Attachment 1 to Resolution R1-2008-0061. The Resolution approving the Santa Rosa Nutrient Offset Program and the new dairy General Waste Discharge Requirement (GWDR) Order No. R1-2012-003 and Waiver Order No. R1-2012-0002 from the RWQCB generally define conditions for credit-generating BMP project eligibility and credit life. This formal proposal complies with those conditions and relies on previous discussions with the RWQCB regarding voluntary dairy inspections by Tetra Tech, Inc. on behalf of the RWQCB. It was agreed in a series of meeting discussions between the Regional Board and the City of Santa Rosa that these inspections could serve as a baseline for dairy credit generation. It is on this basis that several BMP eligibility assumptions are made in this section of the credit proposal.

Relevant information is provided in the following sections of this City of Santa Rosa offset project proposal:

- Project location
- Description of N & P practices
- Quantity of N and P Removed/Expected Life of Crediting Practices
- Monitoring and Reporting Plan
- Description of Anticipated CEQA Documentation

Project Location

The Beretta Dairy is located along Roseland Creek (lat: 38°23’27.15”N, long: 122°46’21.42”W) which discharges to the Laguna approximately 1.1 miles downstream of the Todd Road crossing. This area is upstream of Mark West Creek where the City periodically discharges treated wastewater from their Delta Pond in winter when storage capacity is exceeded in wet years.

Description of N & P Practices

This section provides a brief description of the Beretta Dairy and relevant attributes of this working operation as they apply to BMP eligibility for crediting in the context of the Dairy Waiver program. Proposed BMPs are introduced in the context of credit practice life considering waiver requirements and expected life of practices. Additional BMP details, credit calculations and proposed credit life are introduced in the next section of this proposal entitled, “Quantity of N and P Removed/Expected Life of Crediting Practices”.

Crediting Project Considerations under Dairy Waivers

Three separate BMP project options for offsets are being proposed by the City at the Beretta Dairy. The Beretta Dairy runs approximately 450 head and is expected to qualify for the Dairy Waiver. The considerations below explain how these three BMPs would qualify as offsets in respect to the Dairy Waiver regulations.

Applicable Resolution Language

For potential offset crediting projects at dairies, the City recognizes that the approved Nutrient Offset Program under the Resolution, "prohibits the City from continuing to receive nutrient reduction credits for a project that later becomes subject to additional regulatory controls imposed by the Regional Water Board" (finding 7, page 2). This would apply to practices at Beretta Dairy that would ultimately be required as part of a Waiver.

Applicable Waiver Language

Item 38 of the Waiver (Order No. R1-2012-0003) under the Enrollment Process states that, "The Regional Water Board may give special TMDL nutrient offset dairy projects an alternative schedule for enrollment and submittal of associated documents for a maximum of two years past the due dates in this Order…Also, these projects must be of long-term water quality benefit to the watershed".

Assessment of dairy project eligibility and credit life is therefore determined by which practices are required to comply with the Waiver and consideration of when the dairy becomes formally enrolled. This eligibility and credit life approach was presented to the RWQCB staff on February 22, 2012, and subsequent to this presentation, David Leland of the RWQCB validated that this approach is consistent with the Resolution. As such, the City is proposing for RWQCB consideration and approval nutrient reduction BMP projects for crediting that meet at least one of the following three conditions:

1. BMPs that bring the dairy into compliance with the Waiver application which are minimally eligible to generate credits until the end of the extended enrollment period;
2. BMPs that might otherwise be retired after the extended enrollment period (as in condition 1) except would be eligible for additional credit life where they provide long-term water quality benefit to the watershed; and,
3. BMPs that exceed the level of implementation required in the Waiver which supply credits during and after the extended enrollment period.

Applicable Consideration for Voluntary Dairy Site Assessments

Site-specific decisions regarding BMP eligibility and credit life shall be based on the "Voluntary Assessment Report" (VAR) authored by Tetra Tech, Inc. following their voluntary dairy assessments. This approach is based on discussions with the RWQCB staff in a meeting held on October 31, 2011. Attendees at this meeting included representatives from the North Coast RWQCB, the U. S. Environmental Protection Agency (EPA) and the City of Santa Rosa (City). This group generally agreed

with the RWQCB's suggestion to use the voluntary Tetra Tech, Inc. dairy site assessments for these decisions (where such assessments had been completed). The site assessments inform a Board determination of the BMPs necessary for compliance in GWDR or Waiver Orders. The assessment recommendations inform the dairy producer which BMPs would improve the operation and enhance compliance opportunities.

Site-specific BMP recommendations from a Tetra Tech, Inc. assessment (performed on behalf of the RWQCB) were included in a VAR provided to the Beretta Dairy. Relevant voluntary site assessment recommendations quoted directly from the voluntary site assessment report are:

1. *Continue working with the NRCS to develop the facility's CNMP. The CNMP should describe land application practices implemented at Beretta Dairy and include protocols for land application and associated records that ensure the manure application rates that are reasonable for the crop, soil, climate, special local situations, management system, and type of manure. The CNMP should verify that liquid manure is applied at rates that do not result in surface runoff and minimize percolation to ground water. Such documentation will demonstrate compliance with Title 27 requirements, which will apply to dairies under all three of the dairy program permit types. The draft dairy permits were distributed for public review on October 24, 2011. A recommendation for this dairy to apply for a particular permit type will be given after the permits are finalized.*

2. *Ensure that the clean water diversion northwest of Pond 3 is closed, scraped and reseeded each year prior to the wet weather season to prevent storm water from coming into contact with manure. The dairy should consider additional best management practices in and around this clean water diversion such as permanent fencing or belowground pipe to convey the diversion underneath this heavy use area or provide photo-documentation that additional best management practices are not needed in this area.*

3. *Ensure that manure piled adjacent to ponds is land applied, covered, or moved to a contained area prior to the wet season. The operator may consider other best management practices to ensure that runoff does not transport piled manure away from the production area.*

Key BMP interpretations arise from these VAR recommendations for proposed offset projects at Beretta Dairy. First, the CNMP is listed in site assessment recommendations but is not a <u>requirement</u> of the Waiver program. Instead, the Waiver language lists CNMPs as a <u>recommendation</u> of the Waiver program. (CNMPs are, however, <u>required</u> in the GWDR program.) As noted by Doug Beretta prior to receiving the VAR, his dairy is developing a CNMP with NRCS technical assistance. (Noted here is that the CNMP may include suggestions suitable for additional crediting opportunities beyond the three proposed herein.)

The second key interpretation is the intent of the use of the words "ensure", "should" and "may" in the VAR. The word "ensure" is interpreted to be a mandatory condition (i.e., a technology/practice requirement) necessary to comply with eligibility requirements of the Waiver (and thus, a limited credit life). In contrast, the use of the words "should" or "may" in front of recommendations indicates a level of effort that exceeds the minimum eligibility requirements to obtain a Waiver (thereby inferring long-term credit life eligibility).

Proposed Credit Eligibility and Credit Life Considerations

Based on these two key interpretations, the City is proposing application of these eligibility and credit life considerations for the three proposed Beretta Dairy BMPs as outlined in Table 1.

Table 1. Proposed eligibility and credit life considerations for Beretta Dairy Offset Credit BMPs.

Proposed Crediting Option	BMP Elements	Recommended in VAR	VAR Language for BMP		Exceeds Current Requirements	Proposed BMP Eligibility Period
			"Ensure"	"Should" or "May"		
BMP #1 Manure Stacking Pad and Buffer	Concrete Stacking Pad	No	No	Yes	Yes	Long-term
	Buffer	Yes	No	Yes	Yes	Long-term
BMP #2 Heavy Use Area Upgrades	Fencing & Cattle Crossing	Yes	Yes	No	No	Short-term
	Buffer	Yes	No	Yes	Yes	Long-term
BMP #3 Relocate Heavy Use Area	Relocation of use area to interior field	No	No	No	Yes	Long-term

K&A observations and evaluation at the Beretta Dairy yielded three opportunities for new BMPs at the dairy that could generate nutrient offset credits under these considerations. Runoff from the Beretta Dairy ultimately reaches Roseland Creek discharging into the Laguna. The credit generating practices for this site include:

BMP #1: Manure stacking pad installation and buffer
BMP #2: Heavy use area buffer, fencing and cattle crossing upgrades
BMP #3: Relocation of heavy use loafing pen

Figure 1 is an aerial view of all three option locations.

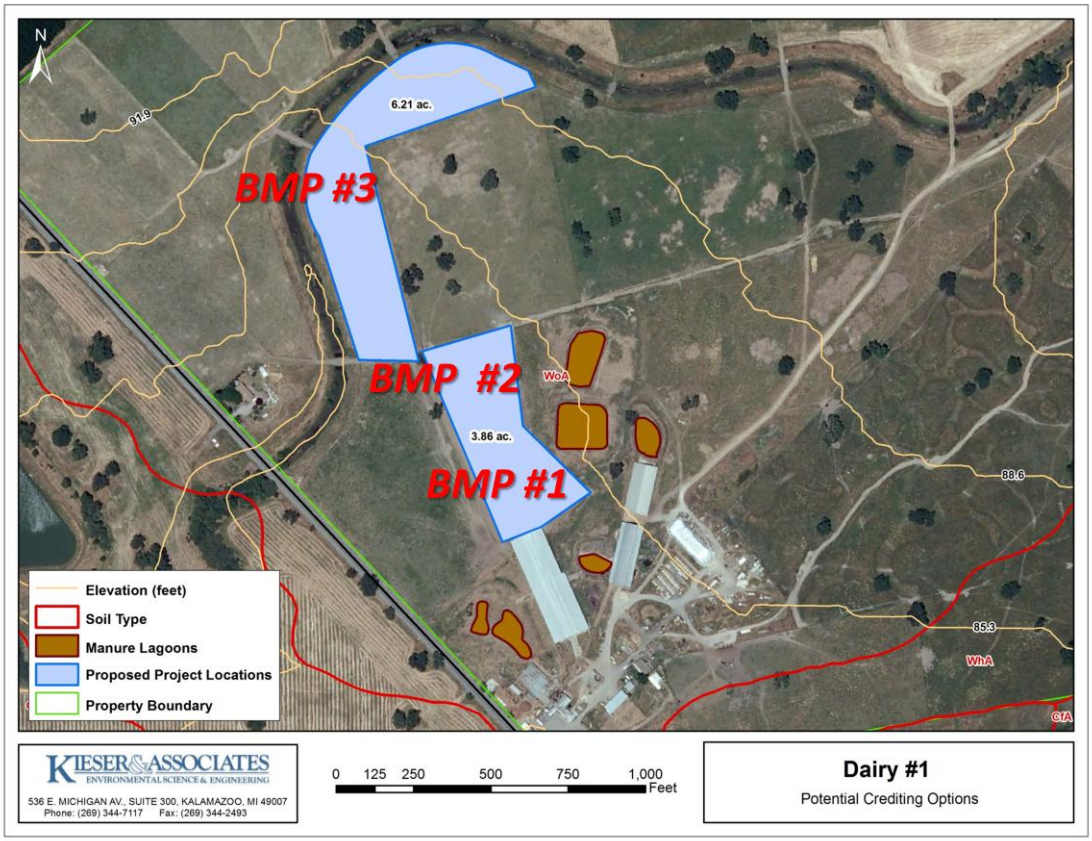

Figure 1. Location of the three options for installation of new BMPs to generate nutrient offset credits.

Quantity of N and P Removed/Expected Life of Crediting Practices

The three proposed crediting options and associated credit calculations are presented in this section. Calculations also include expected life of credit forecast in the previous section (as related to Dairy Waiver conditions, the life of practice, facility life or the owner's maintenance commitment with the City). The reduction of TP and TN is dependent on the source (manure rate and timing) being controlled and the BMP type. The separately submitted MS Office Excel spreadsheet presents a summary of the credit calculations examined for dairy applications in the context of stipulations in the Resolution. It highlights the various applications considered for the Beretta Dairy using credit calculations approved by the Commonwealth of Pennsylvania for their approved Water Quality Trading program. Because of the complexity of various site-specific conditions and a lack of readily applicable and published BMP load calculations and/or efficiency factors for dairies, the state-approved credit calculator with relatively direct applicability was used here. These calculations are commonly referred to as the, "Pennsylvania Credit Calculator" for nitrogen[1] and phosphorus[2] associated with animal operations. These calculations

[1] Pennsylvania Department of Environmental Protection, 2007. Nitrogen Credit Calculation Form, Effective December 4, 2007. Available at: http://www.dep.state.pa.us/river/nutrienttrading/calculations/index.htm.

were previously introduced to and discussed with the Regional Board over a series of meetings leading up to this proposal. It is anticipated by the City of Santa Rosa that additional and specific discussions regarding these calculations may be necessary for crediting proposal approval.

BMP #1 — Concrete Manure Stacking Pad

This BMP involves installation of a large manure stacking pad to capture runoff and leachate generated when solids are dewatered after they are removed from the main lagoon that serves a large free stall barn. Figure 2 is an aerial view of the free stall barn (A) and the adjacent manure lagoon (B). Currently, the operation empties the lagoon by agitating the waste and pumping off the liquid portion. The remaining solids are stacked next to the lagoon to allow for additional dewatering at point (C). Later the solids are hauled off for land application. The proposed option will add a manure stacking pad that captures and redirects all leachate and precipitation in contact with the waste back into the lagoon in this same area. Prior to the wet season, the stacking pad will be cleaned off and allowed to drain clean water into the water conveyance (D – blue line) which will be protected by a fenced/grass buffer (E). The grass buffer will utilize occasional flash grazing management techniques in order to maintain a robust, healthy vegetative stand. If a more strategically placed stacking pad can be constructed on the south side of the lagoon (B) on existing concrete surfaces already draining to the lagoon, alternative designs will be discussed with the Regional Board before final installation as appropriate. This alternative location on the opposite side of the lagoon is more distant from water conveyances which could additionally reduce potential nutrient runoff from reaching the Laguna, improve manure management and better serve operational needs of the dairy. Final engineering assessment and design is pending Executive Officer approval of this crediting proposal.

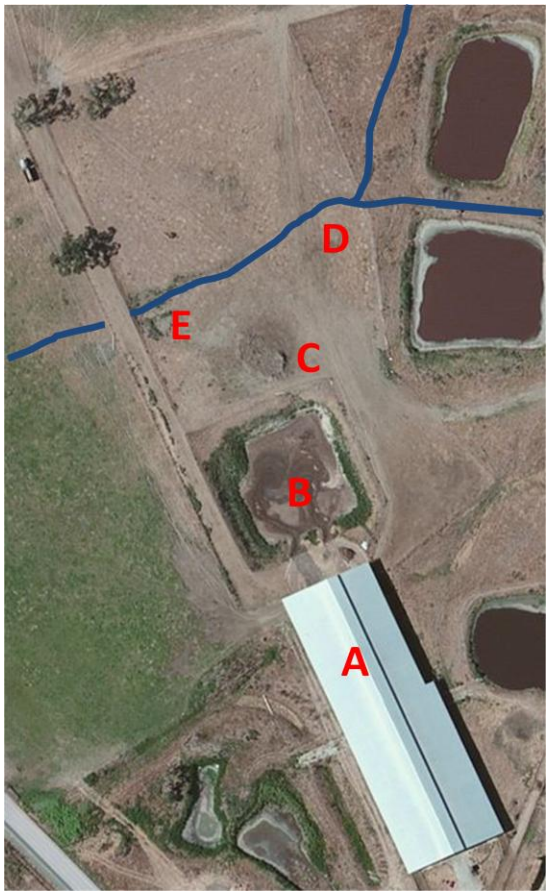

Figure 2. Current manure dewatering site for a larger manure lagoon serving the free stall milking cow barn. [Manure from a free stall barn (A) is placed in a manure lagoon (B). The method to empty the lagoon includes drawing off the liquids then placing the remaining wet solids next to the lagoon to dewater (C). The project proposal is to install a manure stacking pad to redirect all leachate and precipitation in contact with waste back into the lagoon.] (Photo Credit: Bing Maps)

[2] Pennsylvania Department of Environmental Protection, 2008. Draft Phosphorus and Sediment Credit Calculation Form, Effective January 30, 2008. Available at: http://www.dep.state.pa.us/river/nutrienttrading/calculations/index.htm.

BMP #1 Credit Calculations

The Pennsylvania credit calculation for pastures was adapted for heavy use areas. The method calculates the before (current condition) and after (BMP installed) TP and TN loading of particulate and dissolved nutrient fractions. Pennsylvania estimation of fertilizer and manure applied to the soils uses typical operational practices and rates.

Site-specific credit calculations consider:

- Area served
- Pond solids dewatered during dry season
- Solids scraped and hauled away for land applied before wet season
- Soil erosion rate calculated by RUSLE
- Enriched soil nutrient content from manure and leachate deposits

To account for appropriate considerations for a Margin of Safety, the following discount factors were applied to preliminary credit calculations (as percent remaining nutrients reaching Roseland Creek):

- Concrete Stacking pad:
    - Edge-of-field factor = 49.5% (calculated at 30 feet)
    - Bioavailability Factors:
        - TP = 94.5 %
        - TN = 85%
- Buffer:
    - Edge-of-field factor = 49.5% (calculated at 30 feet)
    - Bioavailability Factors:
        - TP = 94.5 %
        - TN = 85%

In addition, several conservative factors are introduced by the soil nutrient test method applied to this BMP. The first conservative factor is that the credit calculator requires a manure nutrient input for estimation of applied manure availability. For this BMP, the nutrient concentrations used in the calculation were based instead on soil nutrient concentrations. Using the soil test results in place of the manure test results is conservative because the nutrient concentrations are further diluted by inert soil particles. The second conservative factor is the timing of soil sample collection. The samples were collected from the site on April 19, 2012. By this date the wet season was almost over after several months of rain. The rains and resulting runoff during the season most likely reduced the nutrient concentration in the soil when compared to concentrations present in the fall, prior to the wet season. Both of these factors combine to create a conservative approach in calculating credits for this site.

Table 2 provides a summary of the proposed TP and TN annual credits for the actions associated with BMP site #1. A minimum credit life of 20 years is proposed for this BMP reflecting the expected life of

an engineered concrete manure stacking pad, and long-term maintenance of the buffer under agreement by the owner with the City.

Table 2. Proposed credits (combined pounds of TP + TN) calculated for BMP #1.

Proposed Crediting Option	BMP Elements	Annual TP Credits in lbs/yr (% of combined total)	Annual TN Credits in lbs/yr (% of combined total)	Annual Combined Credits (lbs TP+TN/yr)	Proposed BMP Eligibility Period
BMP #1 Concrete Stacking Pad	Concrete Stacking Pad	184 (15.4%)	1,010 (84.6%)	1,194	Long-term (20 years)
	Buffer	7 (2.4%)	293 (97.6%)	300	Long-term (20 years)

BMP #2 — Heavy Use Area Buffer and Cattle Crossing

This option adds a buffer and culvert cattle crossing for protection of a clean water diversion crossing a heavy use area. Currently, the heavy use area is used as a milk cow loafing and staging pen. Figure 3 is an aerial view of the heavy use loafing pen. The BMP #2 location currently surrounds the BMP #1 stacking pad. Under current operations, cows are released to this area for about five hours after milking. The cattle are staged in this pen while waiting to be released into grazing pastures. Approximately 140 cows utilize this pen for approximately five hours per day. The loafing pen, outlined in black in Figure 3, covers 3.1 acres.

The current dairy practices to protect water quality in the adjacent waterway are to scrape the heavy use area prior to the wet season and remove cow access during the wet season. The practices are identified in the VAR. The VAR also indicates the operator “should” consider additional practices such as fencing or below ground pipe “or” provide photos which indicate these practices are not necessary. The site enhancements proposed for offsets include the VAR recommendations of a fence and buried pipe as a crossing. In addition, a well managed buffer is being implemented. This buffer exceeds the stated considerations in the report. Figure 3 illustrates the installed fenced buffer (area outlined in red dotted line) and cattle crossing (culvert in black, animal traffic in orange). The grass buffer will utilize occasional flash grazing management techniques in order to maintain a robust, healthy vegetative stand. (The proposed large manure stacking pad from BMP #1 is indicated as a white box inside the proposed buffer.)

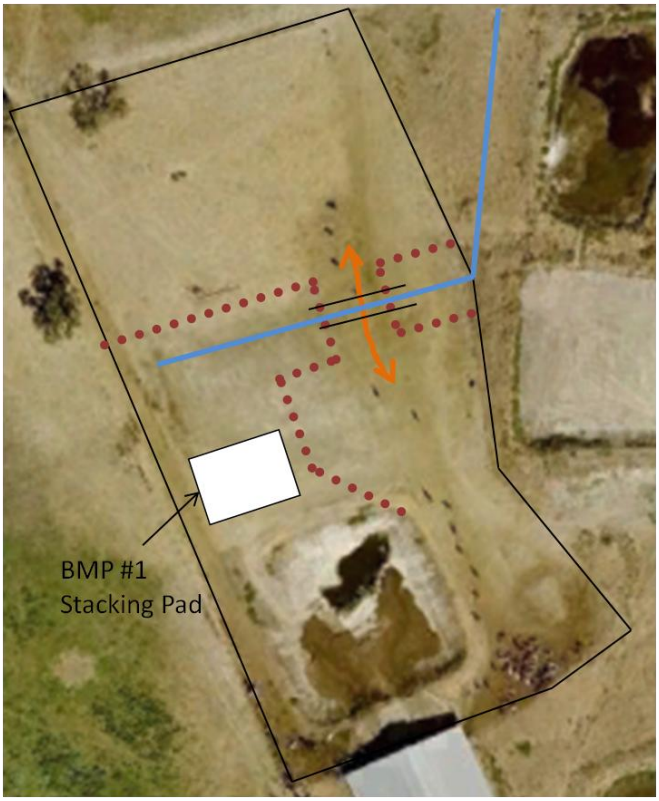

Figure 3. A dairy heavy use milk cow loafing area. (Photo Credit Google Earth, taken on October 6, 2007)

BMP #2 Credit Calculations

The Pennsylvania credit calculation for pastures was adapted for heavy use areas. The method calculates the before (current condition) and after (BMP installed) TP and TN loading of particulate and dissolved nutrient fractions. Pennsylvania estimation of fertilizer and manure applied to the soils considers typical operational practices and rates.

Site-specific credit calculations consider:

- Manure deposited in heavy use area
- Time of animals in the field
- Days per year in typical dry season
- Tons per acre of manure applied
- Remnant manure after scraping
- Nitrogen available for release from remnant manure
- Soil erosion rates for heavy use area
- Buffer treatment efficiency

To account for appropriate considerations for a Margin of Safety, the following discount factors were applied to the credit calculations (as percent remaining nutrients reaching Roseland Creek):

- Fencing and Cattle Crossing
  - Edge-of-field factor: Before 100% ; After = 49.5% (calculated at 30 feet)
  - Bioavailability Factors:
    - TP = 94.5 %
    - TN = 85%
- Buffer:
  - Edge-of-field factor = 49.5% (calculated at 30 feet)
  - Bioavailability Factors:
    - TP = 94.5 %
    - TN = 85%

The conservative calculation factors applied to BMP #1 also apply to BMP #2. These conservative factors include using soil nutrient concentrations in place of manure nutrient concentrations and lower nutrient

concentrations collected from soils after the wet season. The credit calculation results are provided in Table 3.

Table 3. Preliminary credits (combined pounds of TP + TP) calculated for BMP #2.

Proposed Crediting Option	BMP Elements	Annual TP Credits in lbs/yr (% of combined total)	Annual TN Credits in lbs/yr (% of combined total)	Annual Combined Credits (lbs TP+TN/yr)	Proposed BMP Eligibility Period
BMP #2 Heavy Use Area Upgrades	Fencing and Cattle Crossing	86 (40.5%)	115 (59.5%)	201	Short-term (2.5 years)
	Buffer	34 (42.8%)	50 (57.2%)	84	Long-term (20 years)

A credit life of 2.5 years is assumed for the fence and crossing because these appear in the VAR prepared by Tetra Tech, Inc. As such, these would expire at that conclusion of the extend enrollment period for the waiver. A life of 20 years is proposed for the buffer as it is above and beyond what is required and will be maintained.

BMP #3 — Relocation of Heavy Use Loafing Pen

The proposed BMP will enhance and protect Roseland Creek by relocating a heavy use loafing pen to a remote field. The heavy use area is a staging area for milk cows before being released into nearby rotational grazing paddocks. The existing loafing pen is located adjacent to Roseland Creek and has a creek bank length of approximately 1,900 feet. The heavy use area has a small setback to Roseland Creek which acts as an unmaintained buffer. However, the area also is served by several cattle crossings which are necessary to operate the rotational paddocks on the other side of Roseland Creek (see Figure 4). The cattle crossings allow concentrated runoff to reach the creek. This BMP relocates this heavy use area to an interior field and converts the heavy use area to rotational grazing paddocks.

The water quality benefits are associated with two significant factors. The first factor is moving the site to a remote location thus reducing the edge-of-field delivery ratio. This ratio can be reduced because of the greater upland attenuation of nutrients that occurs as the distance from surface water increases. The second factor is the conversion of land use from denuded soils for the majority of the year to rotational paddocks, which remain in perennial vegetation and act as a permanent buffer. The operation runs approximately 140 cows loafing in this heavy use area for five hours a day for 198 days in a typical year. Current nutrient management practices at the site include the existing buffer, scraping the pen prior to the wet season (collected manure enriched soils are land applied) and limiting cow access during the wet season.

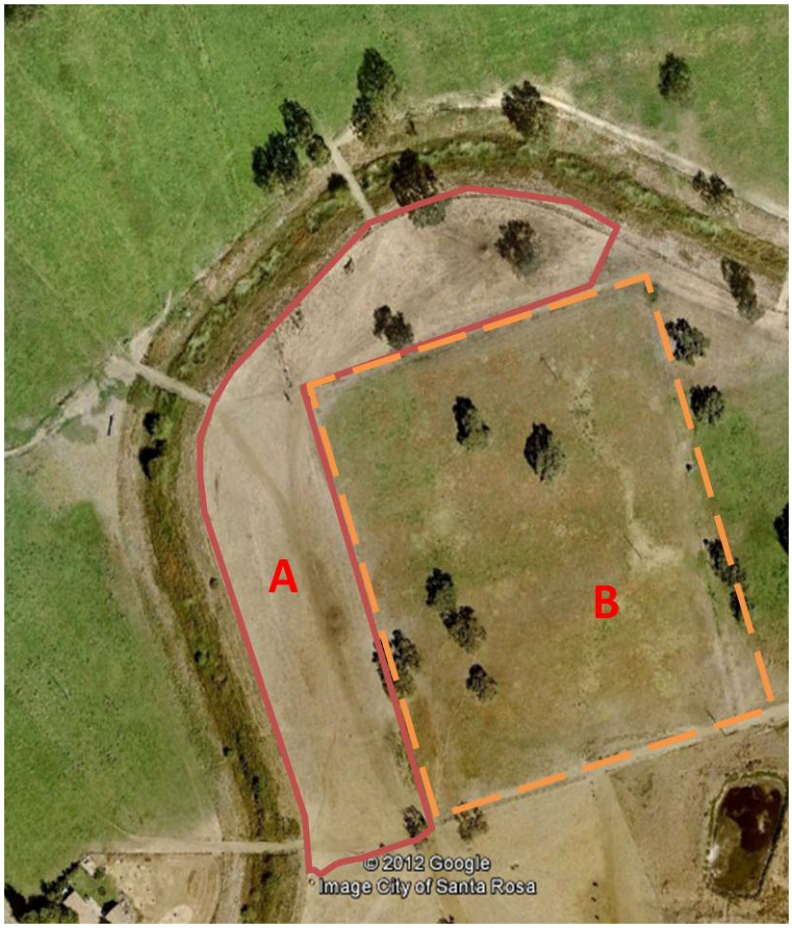

Figure 4. Relocation of heavy use area. (Area A outlined in red is currently used to stage cows prior to release into rotational grazing paddocks located both across Roseland Creek and in adjacent fields to the east. This BMP will relocate the heavy use activities into an equivalent area in field B. Area A will be converted into rotational grazing paddocks with limited cattle travel lanes. Currently, cows utilize this pen from April 1 to October 15 of every year. The loafing area is 6.2 acres and has five pour points into Roseland Creek.) (Photo Credit Google Earth, taken on October 5, 2007.)

BMP #3 Credit Calculations

The Pennsylvania credit calculation for pastures was adapted for heavy use areas. The method calculates the before (current condition) and after (BMP installed) TP and TN loading of particulate and dissolved nutrient fractions. The Pennsylvania estimation of fertilizer and manure applied to the soils considers typical operational practices and rates. Site-specific credit calculations consider:

- Manure deposited in heavy use area
- Time of animals in field per day
- Days per year in typical dry season
- Tons per acre of manure applied
- Nitrogen available for release from remnant manure
- Soil erosion rates for heavy use area considering disturbed soils
- Buffer treatment efficiency
- Distance new area is from Roseland Creek

To account for appropriate considerations for a Margin of Safety, the following discount factors were applied to the credit calculations (as percent remaining nutrients reaching Roseland Creek):

- Relocation of use area to interior field
    - Edge-of-field factor: Before = 100%, After = 33.4% (as calculated at 200 feet)
    - Bioavailability factors
        - TP = 94.5 %
        - TN = 85%

The conservative calculation factors applied to BMP #1 also apply to BMP #2. These conservative factors include using soil nutrient concentrations in place of manure nutrient concentrations and lower nutrient concentrations collected from soils after the wet season.

Preliminary credits calculated for this BMP are provided in Table 4. A credit life of 20 years is proposed based on an expected operation and maintenance agreement for this voluntary implementation action.

Table 4. Proposed credits (combined pounds of TP + TN) calculated for BMP #3.

Proposed Crediting Option	BMP Elements	Annual TP Credits in lbs/yr (% of combined total)	Annual TN Credits in lbs/yr (% of combined total)	Annual Combined Credits (lbs TP+TN/yr)	Proposed BMP Eligibility Period
BMP #3 Relocate Heavy Use Area	Relocation of use area to interior field	174 (15.5%)	945 (84.5%)	1,119	Long-term (20 years)

Monitoring and Reporting Plans

This section outlines the proposed monitoring and reporting plan that the City proposes to implement if this proposal is approved the Regional Board Executive Officer. Expected agreements between the various parties that will be enlisted to ensure this plan is followed are also identified herein.

Monitoring and Reporting

The City will require all BMPs implemented for offset credits to be maintained to NRCS standards and/or specific engineering designs to ensure nutrient reductions and water quality benefits continue throughout the life of the contract period (either short-term or long-term). This will be accomplished through annual site inspections to verify the proper operation and maintenance of each BMP. Similar to other environmental trading programs in the nation, the following verification protocol is proposed:

- Annual site visit to inspect and confirm operation and maintenance of BMP prior to the appropriate season of expected operation (as applicable).
    - RCD or other authorized agent will visit the BMP site.
    - Agent will inspect all components of the BMP and surrounding area to ensure proper function /operation (using final engineering specifications).
    - Agent will document BMP operation and maintenance through forms and photographs.
    - Any deficiencies must be noted on the inspection documentation.
    - All site inspection documentation must be submitted to the City within a set period following inspection.
- Deficiencies
    - All deficiencies will be reported to the land owner immediately after the City receives the inspection documentation.
    - These must be appropriately corrected to previously specified conditions within 60 days of discovery, or within 90 days if an alternative improvement is necessary to avoid future failures. (The Regional Board will be notified of this latter condition where applicable.)
    - Temporary BMPs considered acceptable under the Waiver Order will be installed within 15 days of the City's receipt of inspection documentation.
    - Agent must complete a second site visit to verify all deficiencies have been corrected.
- Verification letter stating the BMP passed the annual inspection will be included in the City's annual report to RWQCB.
- Verification letters for all BMPs will be forwarded to the RWQCB as proof that offset credits are being maintained.

Agreements for Implementation

The City anticipates entering into several agreements to fully implement, verify and monitor the proposed BMP projects at the Beretta Dairy, once RWQCB approval is obtained. The City will rely on written agreements for the following activities:

- Project implementation oversight
- Engineering
- Construction
- Long-term maintenance
- Annual site inspections

The City will likely enter into an agreement with the Sotoyome RCD to oversee implementation of the BMPs and provide annual BMP verification. For implementation, this will involve the RCD contracting directly with an engineer to design the BMPs and a separate contractor for BMP construction. The City will enter into a long-term agreement with the dairy operator/land owner, Mr. Doug Beretta, to maintain the BMPs and ensure continued nutrient reductions and water quality benefits for the life of the practice.

Description of Anticipated CEQA Documentation

Final engineering design of the BMPs will provide further information on whether permits may be necessary to implement the proposed projects. The Soyotome RCD anticipates no need for a permit from the US Army Corps of Engineers or other California State Resource Agencies due to the location of the project. A permit from the Sonoma County Permit and Resource Management Department or Water Agency will depend on the final design (e.g., amount of excavation involved in BMP implementation). The RCD will be responsible for obtaining all permits related to the BMP projects. If permits are required, the RCD will submit a "mitigated negative declaration" as appropriate to ensure proper practices are used for excavation and work within a waterway to assure no significant, negative impact to the environment.

Section 15168(c)(2) of the CEQA Guidelines provides that "If the agency finds that pursuant to Section 15162, no new effects could occur or no new mitigation measures would be required, the agency can approve the activity as being within the scope of the project covered by the program EIR, and no new environmental document would be required." The Discharge Compliance Project (DCP) EIR evaluated an Enhanced Nutrient Removal (ENR) component at a program-level. The EIR Project Description for the ENR component specifically includes manure management at up to eight dairies and agricultural land management in the Laguna Watershed. The Beretta Dairy Nutrient Removal Project is entirely consistent with the Project Description for the ENR component in the DCP EIR. Further, the City has evaluated whether the Beretta Dairy Nutrient Removal Project would have new effects that are greater than those identified in the DCP EIR and that, pursuant to Section 15162 of the CEQA Guidelines, would be new significant impacts or significant impacts of a substantially more severe nature. The evaluation found no new significant impacts or significant impacts of a substantially more severe nature beyond those impacts already identified for the ENR component in the DCP EIR. And, therefore, the Berretta Dairy Nutrient Removal Project is adequately evaluated by the program-level review in the DCP EIR, and no subsequent environmental document is required.

To: Lynn Small, Deputy Director
Environmental Compliance

Date: July 6, 2012

From: James A. Klang, PE, K&A
Mark S. Kieser, K&A

cc: Dave Smith, Merritt Smith

RE: Beretta Dairy Summary of Best Management Practice Reduction Estimation Methods for City of Santa Rosa Offset Credits

This memorandum provides details of the City of Santa Rosa Nutrient Offset Program calculations used for estimating nitrogen and phosphorus credits from the Beretta Dairy site under current conditions and under a future condition with proposed Best Management Practices (BMPs). Tables and figures (found at the end of this memorandum) are provided for additional illustration and support of crediting approaches. Crediting methods were derived from the Pennsylvania Department of Environmental Protection (PA DEP) Chesapeake Bay Water Quality Trading Program[1]. The following narrative presents the rationale for selecting this credit estimation method, a description of the calculations, and example credit computations for BMPs at the Beretta site. Computed credit values are consistent with the City of Santa Rosa Crediting Proposal for the Beretta Dairy BMPs dated June 5, 2012 (and submitted on June 6, 2012).

The City of Santa Rosa Nutrient Offset Program defines the term "offset" to be an equal or greater load reduction obtained from a remote location whereby the pound for pound exchange is adjusted to account for differences in bioavailability and introduced uncertainties. The term offset can be used interchangeably with the term "credit" (mass of nutrients reduced per year after accounting for bioavailability and uncertainty). Credits are generated by implementation of a Best Management Practice (BMP) that results in a nutrient load reduction to a water body.

Selection of the Calculation Method

The PA DEP nutrient credit calculation method was selected based on comparisons of alternative methods. In addition to the Pennsylvania method, the EPA Region V model and the USDA-NRCS Nutrient Tracking Tool (NTT) were examined. These latter two methods were removed from further consideration due to limitations in their applicability with characteristics found in the Laguna de Santa Rosa setting. The Region V model has limited applicability related to crediting soluble nutrient parameters and lacks manure nutrient management considerations. NTT has a high cost for regional calibration without which the local dairy BMP simulations cannot be adequately performed.

[1] PA DEP. 2007, 2008. Nutrient and Phosphorus calculation spreadsheets. Accessed May 15, 2012; available at http://www.dep.state.pa.us/river/nutrienttrading/calculations/index.htm

The strengths of the PA DEP method include ease of use, load generation for soluble nutrient fraction load reduction estimates, and its application of best available science during development. The Pennsylvania nutrient calculations were developed by representatives of PA DEP, the Pennsylvania Environmental Council and the World Resources Institute. The equations were based on literature[2], agronomy guides[3], and the professional judgment of researchers at Pennsylvania State University (Dr. Doug Beegle, Dr. Peter Kleinman, and Dr. Barry Evans). The calculations are performed on Microsoft Excel spreadsheets and are based on standard methods to determine non-point source runoff estimates. A description of the calculation process is provided as follows.

Calculation Description

The crediting method developed by PA DEP involves conducting the calculations twice; once for present-day practices (before credit-generating BMPs are implemented) and a second time assuming new BMPs are installed. The difference in edge-of-field nutrient loading between the two scenarios provides the total load reduction value. Appropriate discount factors are then applied to calculate a final credit value eligible for offsetting City of Santa Rosa discharges.

Nitrogen fate and transport dynamics within the land and river environments are different than phosphorus dynamics. The nitrogen water quality cycle includes conversion of organic forms of nitrogen into inorganic form ammonium and then nitrification (conversion of ammonia to nitrite and nitrates). In some settings denitrification can also occur (conversion of nitrates into N2). Phosphorus forms remain as dissolved or sediment attached forms within both soil and water media. Because of these different interactions, the credit calculation equations for nitrogen reductions and phosphorus reductions are different. As such, the nitrogen equations focus on the total nitrogen (organic forms) and their eventual breakdown and conversion into ammonium, while the phosphorus equations focus on particulate phosphorus loss associated with soil erosion and the soluble fraction in runoff. The following text provides a brief background on nitrogen and phosphorus dynamics, which establishes the rationale for focusing on specific forms of each nutrient.

Nitrogen is present in the environment in organic and inorganic forms[4]. Both organic and inorganic nitrogen can be present in dissolved forms as dissolved organic nitrogen (DON) and dissolved inorganic nitrogen (DIN)[5]. The DIN fraction includes the forms of nitrogen available for plant growth – nitrate and

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[2] Evans, B.M., 2002. Development of an Automated GIS-Based Modeling Approach to Support Regional Watershed Assessments. Ph.D. dissertation in the Dept. of Crop and Soil Sciences, Penn State University, 231 pp.
Vadas et, al. Relating Soil Phosphorus to Dissolved Phosphorus in Runoff: A Single Extraction Coefficient for Water Quality Modeling. Published in J. Environ. Qual. 34:572–580 (2005).
[3] Pennsylvania State Agronomy Guide, available at http://extension.psu.edu/agronomy-guide (as of July 5, 2012); Penn State Agricultural Analytical Services Laboratory (AASL) Handbook, http://www.aasl.psu.edu/ (as of July 5, 2012); USDA Plant-Crop Nutrient Tool, available at http://plants.usda.gov/npk/main (as of July 5, 2012)
[4] Understanding Nitrogen in Soils, Mike O'Leary, George Rehm and Michael Schmitt WW-03770-GO Reviewed 1994 Available at: http://www.extension.umn.edu/distribution/cropsystems/dc3770.html; Accessed July 5, 2012
[5] Wetzel, R. (2001). Limnology: Lake and River Ecosystems, Third ed. Academic Press, San Diego, CA.

ammonium[6]. Organic nitrogen becomes bioavailable over time as the particulate form of organic nitrogen is converted into DIN. The organic forms can be delivered to surface waters as eroded soil[7]. (See Attachment A of this memorandum for an additional discussion on bioavailability as applied to Santa Rosa credit proposals.)

When dealing with manure application on soils, total nitrogen testing focuses on Total Kjeldahl Nitrogen (TKN)[8]. This laboratory-measured nitrogen parameter is the sum of organic nitrogen and ammonium (NH_4^+)[9]. Additional laboratory procedures can be used to determine the ammonium concentration, which then can be used to calculate the organic nitrogen component from the TKN value[10]. The other forms of DIN – nitrite and nitrate –typically are present in smaller quantities in unsaturated soils, manure solids and/or biosolids. Therefore, the Beretta Dairy calculations can focus on TKN, which will release DIN components over time as organic matter decays.

Phosphorus is present in the environment in particulate attached and soluble forms[11]. Elemental phosphorus is extremely reactive and readily combines with oxygen when in contact with air to form phosphate[12]. Phosphate is a negatively charged ion and easily adsorbs to soil particles[13]. Therefore, substantial percentages of phosphorus are often attached to sediment, and eroded sediment can account for a large fraction of phosphorus loading to a water resource. Soluble phosphorus is released from sediments in increasing amounts when the soil content of phosphorus approaches the soil holding capacity[14]. In some settings, the soil holding capacity for phosphorus is approached or exceeded by the amount of phosphorus applied to a field and then soluble forms of runoff occur. The soluble fraction also can increase when inorganic and organically bound phosphorus has a weakened or broken ionic bond with the soil's key ionic bonding minerals. Iron, aluminum, magnesium and calcium are the three minerals that bind phosphorus to the largest extent[15]. The three ionic bonds can be broken with exposure to anoxic conditions or changes in pH (e.g., when iron oxidizes in anaerobic conditions) (Sims et al., 1998)[16], (Sharply et al., 1981)[17], (Warwick et al., 2004)[18].

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[6] USDA ARS (1995). Fate and Transport of Nutrients: Nitrogen. Working Paper No. 7. Available at: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/rca/?&cid=nrcs143_014202. Accessed July 5, 2012

[7] Id.

[8] UC Davis (2010). California Analytical Methods Manual. Accessed July 3, 2012, available on line at: http://anlab.ucdavis.edu/docs/uc_analytical_methods.pdf

[9] UC Davis, College of Agricultural and Environmental Sciences (2010). California Analytical Methods Manual. Available at http://anlab.ucdavis.edu/docs/uc_analytical_methods.pdf; Accessed July 5, 2012.

[10] Id.

[11] USDA ARS (1995). Fate and Transport of Nutrients: Phosphorus, Working Paper No. 8. Available at: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/rca/?&cid=nrcs143_014203; Accessed July 5, 2012

[12] Busman, L., J Lamb, G. Randall, G. Rehm, M. Schmitt, (2002) The Nature of Phosphorus in Soils. Available at: http://www.extension.umn.edu/distribution/cropsystems/dc6795.html; Accessed July 5, 2012

[13] Id.

[14] Id.

[15] Id.

[16] Sims, J.T., Simard, R.R., Joern, B.C. (1998). Phosphorus Loss in Agricultural Drainage: Historical Perspective and Current Research. J. Environ. Qual. 27:227-293 (1998)

Beretta Project Applications - Nitrogen

The credit equations used at the Beretta site require input values for:

- Current crop type (heavy use pad is comparable to a poor pasture stand)
- Acreage
- Soil type
- Field condition (poor, fair and good regarding density of stand)
- Hydraulic condition (Poor – greater than average rainfall runoff and less infiltration, Good – less than average rainfall runoff and more infiltration)
- RUSLE2 soil loss for one year period
- NRCS Curve Number
- Soil P test type
- Soil phosphorus test result
- Distance from the edge-of-field to the closest waterbody (feet)
- Number of 2-year, 24-hour storm events in 1 year (as provided by CA Water Gov website at ftp://ftp.water.ca.gov)
- Manure applications
    - Time of year (spring or summer/early fall/late fall or winter)
    - Animal type
    - Recent nitrogen concentration in manure analysis (lbs N/ton manure)
    - Manure application rate
    - Days between application and incorporation
- Residual nitrogen information
    - Frequency of past manure applications (<2 out of 5 years, 2-3 out of 5-years, 4-5 out of 5 years)
    - Soil series
- Sediment Delivery Ratio

The methodology for quantifying nitrogen reductions from nutrient management projects in the Beretta Dairy site is provided as follows. The edge-of-field loading calculations are performed twice – first for current conditions and then with the assumption that BMPs are implemented. The difference between these two values yields the load reduction.

The PA DEP calculator allows for consideration of minimum site expectations. In the North Coast Regional Water Quality Control Board jurisdiction, these expectations are provided by the General Discharge Requirements or the Waiver requirements. Some BMPs are not required by the GWDR or

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[17] Sharpley, A.N., Menzel, R.G., Smith, S.J., Rhoades, E.D., and Olness, A.E. (1981). The Sorption of Soluble Phosphorus by Soil Material during Transport in Runoff from Cropland and Grassed Watersheds. J. Envion.Qual. Vol. 10, no. 2, 1981

[18] Warwick, J.D., *Fleming, N.K., Cox, J.W., Chittleborough, D.J. (2004). Phosphorus Transfer in Surface Runoff from Intensive Pasture Systems at Various Scales: A Review. J. Environ. Qual. 33:1973-1988 (2004).

Waiver and could generate credits year after year for a length of time; others will be required after a reasonable establishment period and can only receive credits until a point of time that is defined in the GWDR or Waiver. Therefore, the three project sites where BMPs are proposed at the Beretta Dairy are separated into short-term credit generating BMPs and longer-term credit generation BMPs reflecting whether the Waiver requires the BMP or if the BMP is additional to the requirements, respectively.

Next, the PA DEP calculator addresses the total bioavailable nitrogen in commercial fertilizer applications. This step is performed for each application, and all applications are sequentially numbered. However, when working on an animal heavy use area, fertilizer is not applied and this step is not applicable. It is therefore not discussed here.

The PA DEP calculation method for estimating the total nitrogen from manure applications is calculated in Equation 1. The manure applications are sequentially numbered as well (e.g., the second manure application equals $_{m2}$). Nitrogen content in manure can be derived either by nitrogen manure testing (lbs/ton or lbs/1000 gallons of manure) or default values provided by the Midwest Plan Service (Midwest Plan Service, 2004) as shown in Table 1. (The sum of all manure applications is calculated in Equation 2.) Some of the following equations reference an "X", which allows either "B" for Before or "A" for After BMP conditions to be selected.

$$NA_{m1} = MAR_{m1} * ANC_{m1} \quad \textbf{(EQ. 1)}$$

Where:

NA_{m1} = Nitrogen Applied, manure application #1 (lbs/ac)
MAR_{m1} = Manure Application Rate, application #1 (tons/acre)
ANC_{m1} = Average Nitrogen Concentration, manure application #1 (lbs/ton); from Table 1 or test

And;

$$TNA_M = \Sigma NA_{m,\,1\text{-}n} \quad \textbf{(EQ. 2)}$$

Where:

TNA_M = Total Nitrogen Applied, manure applications (lbs/ac)
NA_m= Nitrogen Applied, manure application #X (lbs/ac); from Equation 1

The total available nitrogen from each manure application is calculated in Equation 3. This equation adjusts the TN applied by a nitrogen crop availability factor. The results of Equation 1 for each application must be multiplied by a coefficient for the crop available fraction. This coefficient is determined using Table 2, which considers the type of manure, season of application and the timing of incorporation (Penn State Cooperative Extension, 2011). Table 2 also takes into account the soil temperature and the period of time the manure remains on the surface, which affects exposure to soil bacteria, the bacteria's metabolic rate and the related conversion to and loss of ammonium. The

available nitrogen for a given manure application is calculated in Equation 3, and the sum of all available nitrogen from all applications is calculated in Equation 4.

$AN_{m1} = NA_{m1} * AF_{N1}$ **(EQ. 3)**

Where:

AN_{m1} = Available Nitrogen, from manure application #1 (lbs/ac)

NA_{m1} = Nitrogen Applied, in manure application #1 (lbs/ac); from EQ. 1

AF_{m1} = Available Fraction, in manure application #1 (ratio); from Table 2

And;

$TAN_M = \Sigma AN_{m,\,1\text{-}n}$ **(EQ. 4)**

Where:

TAN_M = Total Available Nitrogen, in manure applications (lbs/ac)

AN_m = Available Nitrogen, in manure application #X (lbs/ac); from Equation 3

In the next step, all of the nutrient applications are summed to estimate the total nitrogen applied and total available nitrogen (Equation 5 and Equation 6, respectively).

$TNA_X = TNA_F + TNA_M$ **(EQ. 5)**

Where:

TNA_X = Total Nitrogen Applied (lbs/ac)

TNA_F = Total Nitrogen Applied, all fertilizer applications (lbs/ac); not applicable

TNA_M= Total Nitrogen Applied, all manure applications (lbs/ac); from Equation 2

$TAN = TAN_f + TAN_M$ **(EQ. 6)**

Where:

TAN = Total Available Nitrogen (as calculated for Before and After BMP implementation)

TAN_f = Total Available Nitrogen, all fertilizer applications (lbs/ac); not applicable

TAN_M = Total Available Nitrogen, all manure applications (lbs/ac); from Equation 4

Residual nitrogen is calculated from data on previous manure application rates and legume crops. The frequency of manure applications within the past five years determines the residual nitrogen from previous manure applications. Organically bound nitrogen in manure is released based on the decay rate of the organic particles. A fraction of residual manure nitrogen is assumed to be released for the three years following application. Table 3 provides the results of a PA DEP and Penn State assessment using professional judgment regarding manure application residuals. Table 4 provides the residual nitrogen contribution from legumes (Penn State Cooperative Extension, 2011). Summing the residuals from both manure and legumes is performed in Equation 7, which calculates the residual manure available from previous applications. Table 6 is provided for informational purposes only, as it is based

on PA soils. Review of this table indicates that any "Somewhat Poorly Drained" soil or "Poorly Drained" soil receives a crop productivity rating of 4. Dairy operations within the Laguna de Santa Rosa are operating within the Santa Rosa plain and fall within these leaching and drain classifications. Therefore, a crop rating of 4 would be used on the Beretta fields included if they were cropped. This consideration does not apply to pastures or heavy use areas.

$$RN = RNM + RNL \quad \textbf{(EQ. 7)}$$

Where:

RN = Residual Nitrogen (lbs/ac)
RNM = Residual Nitrogen from Manure (lbs/ac; Table 3)
RNL = Residual Nitrogen from Legumes (lbs/ac; Table 4)

As noted previously, the above calculations are performed twice: once for the "before BMP" condition and again for the "after BMP" condition (Equation 8). Some of the following equations reference an X, which allows either B for Before or A for After BMP conditions to be selected.

$$RAN = AN_B - AN_A \quad \textbf{(EQ. 8)}$$

Where:

RAN = Reduction of Available Nitrogen (lbs/ac)
AN_B = Available Nitrogen (Before BMP)
AN_A = Available Nitrogen (After BMP)

The sum of the residual nitrogen and nitrogen available from commercial fertilizer and manure applications before and after implementing nutrient management measures provides an estimate of the total nitrogen available per acre as calculated in Equation 9 and 10. The field scale total available nitrogen is provided in Equation 11.

$$AN_B = RN + TAN_{m\Sigma x} + TAN_f \text{ (Before BMP)} \quad \textbf{(EQ. 9)}$$
$$AN_A = RN + TAN_{m\Sigma x} + TAN_f \text{ (After BMP)} \quad \textbf{(EQ. 10)}$$

Where:

AN_B = Available Nitrogen, Before BMP
AN_A = Available Nitrogen, After BMP
RN = Residual Nitrogen; from Equation 7
TAN_{FX} = Total Available Nitrogen from Fertilizer, not applicable for heavy use areas
TAN_{MX} = Total Available Nitrogen from Manure, for either Before or After; from EQ. 6

NLR = A * RAN **(EQ. 11)**

Where:

NLR = Nitrogen Load Reductions, applied in the field (lbs)
A = Acres in the field
RAN = Reduction of Available Nitrogen (lbs/ac); from EQ 8

Applying these calculations to heavy use areas requires several modifications. (Note that all three BMP sites at the Beretta Dairy are located in heavy use areas (the manure lagoon solids stacking area is located in the heavy use area for BMP #2, and BMP #3 provides further reductions at a remote heavy use area.) First, a heavy use area is not cropped. In the fall of each year, after the livestock access has been removed, the heavy use areas are scraped to remove the manure that remained on the surface. Mulch is then applied in preparation for the wet season. Therefore, the estimated amount of dry season manure applied by daily loafing of the milk cows prior to release into pastures must be adjusted by the changes that occur when implementing the two existing practices used to prepare for the winter wet season (i.e., scraping and mulching). These practices are representative of the current nutrient loading conditions prior to new BMPs being proposed in the City's Beretta Dairy crediting application.

To address how much manure remains on site associated with these current practices, and what then remains available to contribute to nitrogen loads, soil samples were collected in April of 2012. These soil samples represent the nitrogen content that remains available after the volatilization losses from non-incorporation during the dry season, the scraping that has been implemented, and any losses from wet season runoff has occurred. The soil test results from the three heavy use and lagoon solids stacking areas compare equally to fresh manure total nitrogen concentrations, after taking into account handling losses. When the BMP implementation does not change the field's intended use (i.e., the field remains a heavy use area for cows), a 5 percent increase in soil nitrogen concentration was added to estimate the fraction of applied nitrogen lost over the winter. This very low increase above the testing results acknowledges the many opportunities for winter season losses of the applied manure as described earlier and introduces a conservative safety factor into these calculations. One heavy use area (BMP #3) is being relocated to an interior field. The assumption to account for the wet season losses on this site uses 30 percent, which is less than the late fall, winter spring availability factor in the PA calculator of 40 percent. The soil nitrogen concentration was increased by 30 percent to adjust for the season's loss. An additional conservative safety factor for this site is applied in the buffer treatment efficiency estimate described below.

In summary, the Beretta Dairy edge-of-field loading calculations for current nitrogen applications include three conservative factors – spring-time sample collection, tests performed on the soil rather than manure, and a three-year averaging period allowed by the Nutrient Offset Program Resolution for crediting. The use of soil testing further dilutes the samples with inert materials (dirt). The three-year averaging period allows for mineralization (organic decay rates) to be taken into consideration. When the combination of all three factors are considered, (time of sample collection, soil tested instead of

manure, and the long-term period for organic decay) this process for estimating available nitrogen can be considered conservative.

To compute offset credits, the edge-of-field available nitrogen as calculated above is multiplied by other coefficients to account for additional site characteristics such as overland delivery, bioavailability, and in-stream channel processes (losses). Thus, the offset amount (i.e., credit) is the difference in the edge-of-field available nitrogen value with and without BMPs multiplied by these coefficients (which serve as credit "discounting factors"). Consideration of these factors ensures that credits are equal to or greater than the nutrients discharged in the City's wastewater. Each of these applicable factors are discussed as follows.

When a non-point source of nutrients is not adjacent to a receiving water, the edge-of-field loading can be adjusted by an upland delivery ratio to represent overland transport losses. The Beretta Dairy lagoon solid manure stacking area calculation (BMP Project #1) was adjusted for the upland transport losses by using the equation presented in Figure 1. The sediment delivery ratio (SDR) is taken from documentation discussing the development of the Minnesota Phosphorus Site Risk Index. The use of SDRs for upland field nutrient losses is considered a conservative assumption for nitrogen delivery. The fraction of soluble nitrogen lost in upland transport typically will be much lower on tight soils than the fraction of sediment loading lost in the same conditions. The nitrogen load reduction value for the field is multiplied by the delivery ratio to determine the edge-of-field delivered load per acre, as calculated in Equation 12. The calculation for the total field reductions is provided in Equation 13.

$$TNLREoF = NLR * SDR \qquad \textbf{(EQ. 12)}$$

Where:

TNLREoF = Total Nitrogen Load Reduction Edge-of-Field (lbs)
NLR = Nitrogen Load Reduction (lbs); from Equation 11
SDR = Sediment Delivery Ratio as provided by Figure 1 (ratio)

Equation 12 was applied to two of the Beretta BMPs. The first is BMP #1 for the manure lagoon solids stacking area. The second is BMP #3 where the remote heavy use area is being relocated to an interior field. The manure solid stacking area was 30 feet from the nearest water conveyance. The SDR discount factor resulted in a 50.5 percent reduction in the nutrient loading estimate from the current site conditions. BMP #3, the relocation of the remote heavy use area, also uses the SDR in its crediting computation. The SDR for relocating the area 200 feet away from Roseland Creek is 66.6 percent. Where a BMP is directly adjacent to a surface water body, the edge-of-field load is considered to be 100% delivered.

Though considered as an actual BMP and not a discount factor, additional nutrient reductions are expected at the Beretta dairy with the expected addition of vegetated buffers in the crediting proposal. These are introduced here as they are applied to the nitrogen loading AFTER the SDR discount factor is

applied to the edge-of-field load. A study by Zhang[19] *et al.,* (2010) presented the findings of a literature review focused on the treatment efficiency of vegetative buffers. In this review, nutrient loading reductions for 10-meter mixed grass setbacks were estimated to be 71 percent for nitrogen and 69 percent for phosphorus. A 30-meter buffer increased the percent reduction to 98 percent for nitrogen and 100 percent for phosphorus. The Beretta BMPs #1 and #2 have a 10-meter buffer as part of the treatment system. The remote heavy use area relocation (BMP #3) also benefits from a 200-foot grass buffer. However, to introduce a conservative estimate for this BMP site, the treatment efficiency for a 10-meter buffer was applied.

A literature review (see attachment A) was completed by K&A to address the nutrient bioavailability differences from various sources, as directed by the offset Resolution. Nutrients are present in the environment in a variety of forms, and not all of these forms are available for uptake by organisms. The fraction of the phosphorus or nitrogen that is or will become bioavailable for plant growth is the fraction of nutrient loading that is relevant to the Santa Rosa crediting project. However, different sources release different forms (or varying fractions) of nitrogen and phosphorus. In order to facilitate crediting, a bioequivalence factor should be applied to account for these differences. This helps ensure that the credited reductions are equivalent, in terms of environmental protection among all participating entities. The bioequivalence factor is a coefficient that accounts for the differences in bioavailability between two sources. This coefficient is determined by taking the percent of the offset loading that is or will become bioavailable and dividing it by the percent of the wastewater discharge that is or will become bioavailable.

Phosphorus in dissolved form is considered 100 percent bioavailable, but the bioavailable fraction of particulate-attached phosphorus varies depending on the source. For this non-point source, it is estimated that 60 percent of particulate-attached phosphorus will become bioavailable. Combined with the dissolved fraction, the weighted average result of bioavailable phosphorus is 80 percent. When the source is a domestic wastewater treatment plant, the particulate phosphorus fraction that will become bioavailable is higher and is estimated to be 70 percent. Combined with the dissolved fraction, the total is 85.5 percent. The bioequivalence factor for phosphorus from this source and a domestic wastewater treatment plant is calculated by 0.80/0.855. Therefore, the bioavailable coefficient is 93.5 percent. For nitrogen the dissolved inorganic forms (nitrate, nitrite and ammonia) are 100 percent bioavailable. The organic forms of nitrogen have variable bioavailability depending on the source. For agricultural non-point sources, the fraction of nitrogen that is or will become bioavailable has a weighted average of 80 percent. Domestic wastewater discharge has a higher fraction of nitrogen that is or will become bioavailable, with a weighted average of 94.5 percent. When these two fractions are entered into the bioavailable adjustment equation (0.80/0.945), the resulting nitrogen bioavailability coefficient is 85 percent. These bioavailability coefficients are used in the Beretta calculations.

[19] Zhang, X., Liu, X., Zhang, M., Dahlgren, R.A., and Eitzel. M. 2010. A review of vegetated buffers and a meta-analysis of their mitigation efficacy in reducing non-point source pollution. J Environ Qual. 2009 Dec 30; 39(1):76-84. Print 2010 Jan-Feb.

Finally, these credit calculations consider instream (channel) attenuation processes that occur between the location of the offset discharge from the Beretta dairy and the location of the City's Delta Pond discharge location. The Nutrient Offset Program Resolution allows for the use of spatial and temporal considerations to be factored in as a "margin of safety" when determining credits. A margin of safety effectively becomes another potential discounting factor for calculating credits. For spatial considerations, the Beretta Dairy is located above several summer low flow pools targeted for protection under a forthcoming Laguna de Santa Rosa nutrient TMDL. In comparison, the City of Santa Rosa discharges treated wastewater from its Delta Pond situated downstream of the low flow summer pools.

When considering the possible temporal differences between Beretta Dairy nutrient contributions and City wastewater discharges, there are three temporal Laguna flow regimes that must be considered for margin of safety considerations for timing of discharges including:

1. Discharges during the dry season (there may dairy runoff from summer rain events affecting low flow pools while there are no dry weather discharges of wastewater from Delta Pond)
2. Discharges during the wet season when the Russian River does not create flow reversals in the Laguna (the dairy-related loading pathway is still through the low flow pools, while the Delta pond discharge pathway does not travel through these pools)
3. Discharge during the wet season when the Russian River backs up into the Laguna (Delta Pond discharges under this condition could result in nutrients associated with wastewater being transported upstream of summer low flow pond locations; however, predicting the deposition of discharged nutrients becomes very complex as the area of deposition includes the entire floodplain and not necessarily just the low flow pool areas as is the case in the other two flow scenarios)

The City's Delta Pond discharge will only impact low flow pool areas under the third flow condition. This assumes that what is typically a two to three week winter discharge event by the City, occurs during a Laguna flow reversal period. In some years, the City has no discharge to the Laguna. In comparison, nutrient contributions from the Beretta Dairy will affect low flow pools under all flow regimes. Thus, no location discounts/margins of safety are applied in the credit proposal. An argument could be construed that reductions at the Beretta Dairy could infinitely exceed equivalence in years with no City discharge, or only discharges under the first two flow scenarios. However, the City has only proposed credits with discounting that includes various conservative assumptions in edge-of-field load calculations, as well as bioavailability and application of a sediment delivery ratio.

To illustrate how all these equations, assumptions and discounting factors are applied to calculate nitrogen credits for the proposed BMPs at the Beretta Dairy site, the following text box shows applicable calculations for BMP #2. Equations cited above and as derived from the PA DEP credit calculator are denoted as to where they apply in this example illustration.

Location Information:				Description of watershed location:	
Distance to nearest conveyance		1	feet		30
Delivery Ratio (Edge-of-Field)		100.00%	(Based on MN delivery ratio formula: distance$^{-0.2969}$)		49.47%
Area Served:	3.09	acres			
Soil Information:					
Classification:	Wright	(clay)	Woa		
Hydrologic Group:	D				
Fertilizer:	0 lbs N			0 lbs N	
	0 lbs N available			0 lbs N available	
Manure Application Rates					
(repeated as necessary to account for all applications)					
Season:	Spring and Summer				
Manure Type:	Dairy- Lactating Cows Solid				
Application Rate:	9.3	tons/acre			
Application Method:	No Incorporation				
N Availability Factor:	0.95	0.95 was selected based on the timing and results from the soil nutrient tests which were collected in late			
Before:	10	lbs N/ton	After	10	lbs N/ton
	9.5	lbs N available/ton		9.5	lbs N available/ton
	93	lbs N/acre		93	lbs N/acre
Equation 1	88.35	lbs N available/acre		88.35	lbs N available/acre
Equation 3					
Total Nitrogen Applied	93	lbs N/acre		93	lbs N/acre
Equation 5	88.35	lbs N available/acre		88.35	lbs N available/acre
Equation 6					
Residual Nitrogen	35	lbs acre every year becomes self canceling			
Equations 7 Nutrient Reductions from Manure Management					
	0	lbs/acre/year			
	0	lbs/acre/year			
Equation 11 Total N Loading	273	lbs/year			
Equation 12 Reduction from fencing	135	lbs per year			
Contributing Area for Buffer	0.9	acres			
Application of New Buffer:	Fenced	71%			
Site N Loading Reduction From New Buffer:	59	lbs N/yr			
Discount Factors			Description		
Edge-of-field delivery:	100.00%		Next to conveyance		
N Bioavailability:	85%		80% manure bioavailability/94.5% WWTP bioavailability		
Fencing Nitrogen Credits with Bioavailability		115	N credits		
Buffer Nitrogen Credits with Bioavailability		50	N credits		

Margin of Safety from implicit conservative assumptions (20% reduction in manure application rates and spatial and temporal location considerations for Delta Pond and Beretta Dairy)

Beretta Project Applications - Phosphorus

The proposed quantification methodology for phosphorus management practices at the Beretta Dairy is discussed here. Similar to nitrogen calculations, phosphorus computations for the edge-of-field loading are done twice; first for current site conditions and then for proposed nutrient management changes at the site. The edge-of-field reduction will reflect the impact of the changes in nutrient management. The PA DEP calculator has a variety of agricultural application calculations, including development of mass balances for applied nutrients, particulate phosphorus losses associated with soil erosion and dissolved phosphorus losses in runoff. The Beretta Dairy calculations only use equations for soil erosion sources and soluble phosphorus runoff estimates.

For manure applications, available phosphorus is determined by the timing, animal type, phosphorus concentration in the manure, rate of application and application method. Equation 13 calculates the available phosphorus per acre and is repeated for every manure application occurring in a year. Equation 14 is used to sum all of the manure applications to calculate total available phosphorus (lbs/acres).

$AP_{M1} = PC_{M1} * PSC * AR_{M1} * AF$ (lbs/ac) **(EQ. 13)**

Where:

AP_{M1} = Available Phosphorus, in manure application number 1 (lbs/ac)

PC_{M1} = Phosphorus Concentration, from manure test or Table 8 (Penn State Agronomic Guide)

PSC = Phosphorus Source Coefficient, Table 8 (PA P-Index)

AR_{M1} = Application Rate, for manure applied in application (lbs/ac)
AF = Availability Factor, phosphorus availability regarding surface proximity

And;

$TAP_m = \Sigma AP_{MX, 1\text{-}n}$ **(EQ. 14)**

Where:

TAP_m = Total Available Phosphorus, from all manure applications (lbs/ac)
AP_{MX} = Available Phosphorus, for each manure application event (lbs/ac)

Soil Phosphorus Loading Reductions

Discharge of soil phosphorus to waterways typically is controlled by reducing soil erosion and managing the soil phosphorus concentrations at levels well below the soil absorption capacity. As such, the RUSLE2 annual soil erosion equation results are combined with the sediment-bound phosphorus concentrations per ton of soil to predict the phosphorus load moving within the field. Equation 15 provides this assessment converted into pound and acre units[20].

ESP = SPC * SEDE * 2.205 * EF **(EQ. 15)**

Where:

ESP = Eroded Sediment Attached Phosphorus (lbs/yr)
SPC = Soil Phosphorus Concentration, from soil P test converted to total phosphorus (kg/ton)
SEDE = SEDiment Erosion, results for field from RUSLE2 calculation (tons/yr)
EF = Enrichment factor typical for the watershed, determined by GWLF modeling

The edge-of-field sediment-attached phosphorus load is calculated in Equation 16.

ESP-EoF = ESP * DR **(EQ. 16)**

Where:

ESP-EoF = Eroded Sediment Attached Phosphorus delivered to the Edge-of-Field (lb/yr)
ESP = Eroded Sediment Attached Phosphorus (Equation 21)
DR = Delivery Ratio (Figure 1)

The soil P test result conversion to total phosphorus has been modified to fit the Laguna setting. In Pennsylvania, the Mehlich – 3 test is used and applied in the PA DEP calculation spreadsheets. The soil

[20] Equation recommended by Beegle, D., Klineman, P., and Evans, B., from Penn State University as supported by Evans (Evans, 2002).

testing processed at the Beretta Dairy was for total phosphorus, and a back calculation can be made using the PA converter based on a regression for Mehlich 3 and TP soil samples.

SPC = SPT / 190 * 836 * 0.000909 [Mehlich - 3 TP] **(EQ. 17)**[21]

Where:

SPC = soil total phosphorus concentration (ppm)
SPT = soil phosphorus test results (ppm)

The constants in this equation reflect the PA DEP calculation of the Area Weighted Value of lbs/acre as calculated by Evans[20] and a mass conversion from pounds to kilograms.

Dissolved soil phosphorus stream loading considers an estimate of non-point source runoff volume by adapting the SCS Curve Number (CN) for the site. The CN calculation as quoted from the NRCS Technical Release 55 indicates:

Q = (P- 0.2S)2 / (P +0.8S)

S is related to the soil and cover conditions of the watershed through the CN. CN has a range of 0 to 100, and S is related to CN by:

S = 1000 / CN – 10

These equations allow the potential maximum retention to be removed from the runoff estimate for the Sonoma County 2-year, 24-hour historic rain event, as determined by the CA Water Gov records. Equations 18 and 19 calculate the volume runoff for the Laguna de Santa Rosa as an example using a CN equal to 86.

S = 1000 / 86 – 10 result = 1.63 **(EQ. 18)**
Q = (3.34 – 0.2(1.63))2 / (3.34 + 0.8 (1.63)) result = 1.96 **(EQ. 19)**

This runoff event volume can be multiplied by the estimated number of 2-year, 24-hour storm events in one year. According to Sonoma County records (gathered on CA Water Gov), the mean precipitation in the Santa Rosa Plain (where the Beretta Dairy is located) equals 30.98 inches per year. The number of 2-year, 24-hour rain events that would equal that amount of precipitation is 9.28. Entering 9.28 into Equation 20 provides the estimated average annual rainfall runoff.

AARR = Q * 9.28 **(EQ. 20)**

Where:

AARR = Average Annual Rainfall Runoff, in inches

[21] Vadas *et al*., 2005

Q = Annual Volume of Runoff, in inches

Equation 21 multiplies the total phosphorus concentration and the average annual runoff to obtain the total dissolved phosphorus loss from one acre.

TDP = STP * SPRF * 0.000227 **(EQ. 21)**

Where:

TDP = Total Dissolved Phosphorus, lost to runoff (lb/year)
STP = Soil Test Phosphorus
SPRF = Soluble Phosphorus Regression Factor[22]

SPRF = 2 * STP + 43.5 (*u*g/l), for the Mehilich test[23] **(EQ. 22)**

Equation 23 calculates the total dissolved phosphorus from manure delivered to the edge-of-field.

TDP-EoF = TDP * DR **(EQ. 23)**

Where:

TDP-EoF = Total Dissolved Phosphorus, to Edge-of-Field (lbs/ac)
TDP = Total Dissolved Phosphorus, lost to runoff (lbs/ac), from Equation 21
DR = Delivery Ratio (Figure 1)

The sum of the soil P loss from erosion, the total dissolved phosphorus loss, and the dissolved phosphorus from manure equals the phosphorus available in runoff, Equation 24

PFL = (TDP-EoF + ESP-EoF) * A **(EQ. 24)**

Where:

PFL = Phosphorus Field Loss (lbs/ac)
TDP-EoF = Total Dissolved Phosphorus at the Edge-of-Field, from Equation 21
ESP-EoF = Eroded Sediment Attached Phosphorus at the Edge-of-Field, from Equation 14
A = Acres, in the field

For Equation 24, the long-term presence of past phosphorus applications will stay with the soil for many years and a new soil P test would have to indicate a reduced available soil phosphorus reduction (ESP-EoF and TDP-EoF).

[22] Vadas *et al*., 2005 and Moncrief, 2002
[23] Vadas *et al*., 2005

To illustrate how all these equations, assumptions and discounting factors are applied to calculate phosphorus credits for the proposed BMPs at the Beretta Dairy site, the following text boxes show applicable calculations for BMP #2. Equations cited above and as derived from the PA DEP credit calculator are denoted as to where they apply in this example illustration.

Site Location Information:
Distance to nearest conveyance: 1 feet
Delivery Ratio (Edge-of-Field): 100.00% (Based on MN delivery ratio formula: distance^-0.2464)
Description of watershed location: 30 — 49.47%
Area Served: 3.09 acres
Soil Information:
Classification: Wright (clay) Wcw
Hydrologic Group: D
RUSLE estimate factors:
R Factor: 117.22 From EPA Rainfall Erosivity Factor Calculator for Small Construction Sites at: http://cfpub.epa.gov/npdes/stormwater/LEWferosivity_index-result.cfm
K Factor: 0.37 From NRCS Web Soil Survey at: http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm
LS Factor 0.15 From Guidelines for the Use of the Revised Universal Soil Loss Equation (RUSLE) Version 1.06 on Mined Lands, Construction Sites, and Reclaimed Lands
C Factor 0.42 From Guidelines for the Use of the Revised Universal Soil Loss Equation (RUSLE) Version 1.06 on Mined Lands, Construction Sites, and Reclaimed Lands
P Factor 1 (no erosion practice)
A= R*K*LS*C*P 2.73 tons/acre/year (if less than 1 ton/acre/year, use 1)

Erosion Rate: 2.73 tons/acre/year
Phosphorus Soil Test: 900 ppm Type: Mehlich - 3 As determined by TP soil test in cells I98:T104
Field Condition: Poor

Equation 19 — Calculating Rainfall Runoff using the SCS Curve Number: Runoff from one 2yr, 24 hr storm event (in) 1.96

COUNTY	Climate Zone	Mean Precip (in/yr)	2 year, 24 hour rainfall event (in)	# of these events in 1 year:
Sonoma	3	30.98	3.34	9.275443102

Equation 20 — County Sonoma
Number of 2 year, 24 hour storm events in 1 yr: 9.28
Average Annual Rainfall Runoff (in) 18.16 in
Hydrauliic Condition 0
Curve Number Based On: Pasture Poor Conditions
Curve Number: 89 S Value: 1.24 inches

2-year 24-hour rainfall event (in): gathered from CA Water Gov precipitation data available at:
Mean Precipitation (in/yr) is calculated from 30-yr record, missing data filled in using monthly long-term average.

Equations 18 & 25 — Manure Application Rates
Season: Spring and Summer
Manure Type: Dairy- Lactating Cows Solid
Application Rate: 9.3 tons/acre
Application Method: No Incorporation
N Availability Factor: 0.95 0.95 was selected based on the timing and results from the soil nutrient tests which were collected in
Before: 4 lbs P2O5/ton After
Equation 13 — 15.6 lbs P/acre
9.4 lbs P/acre; with potential to runo

Equation 14 — Phosphorus 15.6 lbs P/acre
9.4 lbs P/acre; with potential to runoff

Phosphorus Snapshot

Soil P 3.6 kg/ton P
Equations 15 & 17 — Background Soil P Loss from Erosion 43.4 lbs/acre
Soluble P Concentration 1943.50 ug/L (microgram/liter OR ppb)

Average Annual Runoff 1886200.54 L/ac
Background Dissolved P Loss 3440340704.03 ug/ac
Equation 21 — Background Dissolved P Loss 7.57 lbs/ac
P Load Available from Soils: 50.94 lbs/ac

Equation 24 — P Load Available from Soils and Nutrient Applications: 60.31 lbs/acre

Site P Loading Available: 186.36 lbs P/yr
Equations 16 & 23 — Reduction Due to Fencing 92.20

Buffer Contributing Area 0.9 acres
Application of New Buffer: Fenced 69%
Site P Loading Reduction From Application Changes: 36.33 lbs P/yr

Field Total P Reduction: lbs P/yr

List of Discount Factors — Description
P Edge-of-field delivery: 100.00% Next to conveyance
P Bioavailability: 93.5% 80% manure bioavailability/65.5% WWTP bioavailability
Bioavailability & Edge-of-Field
Phosphorus Credits using Fencing: 86 P credits
Phosphorus Credits using Buffer: 34 P credits

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Table 1. Manure Type and Average Nitrogen Concentrations.

Manure Type	Average N Concentration		Units
Dairy- Lactating Cows Liquid	28	lbs/1000 gallons	1000 gallons/ac
Dairy- Lactating Cows Solid	10	lbs/ton	tons/ac
Dairy- Dry Cow	9	lbs/ton	tons/ac
Dairy- Calf and Heifer	7	lbs/ton	tons/ac
Beef- Cow and Calf	11	lbs/ton	tons/ac
Beef- Steer	14	lbs/ton	tons/ac
Horse	12	lbs/ton	tons/ac

Table 2. Nitrogen Availability Factors.

Table 1.2-14. Manure nitrogen availability factors for use in determining manure application rates based on planning conditions.

A. Current Year

To use this table, find the ***planned manure application season*** in the left column, then move to the right in that row and select the ***target crop utilization***. Continue to the right in that row to find the ***nitrogen availability factor*** for the ***planned manure application management***.

			Nitrogen availability factor[1]		
Planned manure application season	*Planned manure target crop utilization*	*Application management*	*Poultry manure*	*Swine manure*	*Other manure*
Spring or summer	Spring utilization by grass hay and small grains. Summer utilization by corn, other summer annuals, and grass hay.	Incorporation the same day	0.75	0.70	0.50
		Incorporation within 1 day	0.50	0.60	0.40
		Incorporation within 2–4 days	0.45	0.40	0.35
		Incorporation within 5–7 days	0.30	0.30	0.30
		Incorporation after 7 days or no incorporation	0.15	0.20	0.20
Early fall[2]	Fall and spring utilization by grass hay and small grains.	Incorporation within 2 days	0.50	0.45	0.40
		Incorporation within 3–7 days	0.30	0.30	0.30
		Incorporation after 7 days or no incorporation	0.15	0.20	0.20
	Following summer utilization by corn and other summer annuals.	All situations	0.15	0.20	0.20
Late fall or winter[3]	Spring utilization by small grains and grass hay	All situations	0.50	0.45	0.40
	Following summer utilization by corn or other summer annuals	No cover crop	0.15	0.20	0.20
		Cover crop harvested for silage	0.15	0.20	0.20
		Cover crop used as green manure	0.50	0.45	0.40
Grazing	Late spring through early fall grazing	Manure deposited more or less continuously by grazing cattle	—	—	0.20
	Year-round grazing	Manure deposited more or less continuously by grazing cattle	—	—	0.30

1. Multiply this factor times the manure N content to estimate the manure N available for the planning conditions.
2. Early fall would be when it is still warm enough for plant growth and microbial activity to continue (soil temperature >50°F at 2 inches).
3. Late fall and winter is when it is so cold that there is no plant growth or microbial activity (soil temperature <50°F at 2 inches).

B. Historical Frequency of Manure Application on the Field

To use this table, determine the frequency of manure application and go across to the amount of residual N that is available from past manure applications. Deduct this amount of residual N from the basic N recommendation before determining any additional fertilizer or manure application rates.

Table 3. Available Nitrogen from Past Applications

Frequency of Past Manure Application (followed by manure type)	N Available (lbs N/ac)
Never received manure in past	0
Rarely received manure in past (<2 out of 5 yrs)	0
Frequently received manure (2-3 out of 5 yrs)	20
Continuously received manure (4-5 out of 5 yrs)	35

Table 4. Residual Nitrogen Contribution from Legumes[1].

Previous crop	Percent Stand	High-productivity fields	Moderate-productivity fields	Low-productivity fields
		Soil productivity group[2] 1	Soil productivity groups[2] 2 & 3	Soil productivity groups[2] 4 & 5
		Nitrogen credit (lb/A)		
First year after clover or trefoil	>50	90	80	60
	25–49	60	60	50
	<25	40	40	40
First year after alfalfa	>50	120	110	80
	25–49	80	70	60
	<25	40	40	40
First year after soybeans harvested for grain.		---- 1 lb N/bu soybeans ----		

1. When a previous legume crop is checked on the Penn State soil test information sheet, the residual nitrogen for the year following the legume is calculated and given on the report. This credit should be deducted from the N recommendation given on the soil test report.
2. See table 1.1-1 in the basic soils section for information on soil productivity groups.

Table 5. Legume Crop Residual Nitrogen.

Legume Crop (no nitrogen application recommended)	Pounds of N Removed/Unit of Yield	Pounds of N Removed/Ac
Alfalfa (5 tons/A)	50	250
Soybeans (40 bu/A)	3.2	130
Trefoil (3.5 tons/A)	50	175
Clover (3.5 tons/A)	40	140

Comment: Although legumes will use N from manure and other sources, applying N may increase the competition from weeds and grasses. If you apply manure, limit it to an application rate that balances the crop's P requirement.

Table 6. Selected Properties and Typical Capabilities of Major Pennsylvania Soils.

Table 1.1-1. Selected properties and typical capabilities of major Pennsylvania soils (continued).

Soil series	*Depth class*[1]	*Drain class*[2]	*Leaching potential*	*Crop prod. group*	*Corn grain (bu/A)*	*Corn silage (T/A)*	*Alfalfa (T/A)*	*Clover (T/A)*	*Wheat (bu/A)*	*Oats (bu/A)*	*Barley (bu/A)*	*Sorghum/sudan (T/A)*	*Soybeans (bu/A)*
Hublersburg	D	WD	2	1	150	25	6	4	60	80	75	25	45
Huntington	D	WD	2	1	150	25	6	4	60	80	75	25	45
Klinesville	S	WD	2	4	100	17	4[8]	2.5	40[8]	60	40[8]	17	30
Kreamer	D	MWD	1[7]	3	125	21	4	3	50	60	50	21	30
Lackawanna	D[5]	WD	1[7]	2	125	21	5	3.5	60	80	75	21	40
Laidig	D[5]	WD	1[7]	2	125	21	5	3.5	60	80	75	21	40
Langford	D[5]	WD	1[7]	3	125	21	4	3	50	60	50	21	30
Lansdale	D	WD	2	2	125	21	5	3.5	60	80	75	21	40
Leck Kill	D	WD	2	2	125	21	5	3.5	60	80	75	21	40
Lehigh	D	MWD	1[7]	4	100	17	4[8]	2.5	40[8]	60	40[8]	17	30
Letort	D	WD	2	1	150	25	6	4	60	80	75	25	45
Lewisberry	D	WD	2	2	125	21	5	3.5	60	80	75	21	40
Lordstown	MD	WD	2	3	125	21	4	3	50	60	50	21	30
Manor	D	WD	2	2	125	21	5	3.5	60	80	75	21	40
Mardin	D[5]	MWD	1[7]	3	125	21	4	3	50	60	50	21	30
Meckesville	D[5]	WD	1[7]	2	125	21	5	3.5	60	80	75	21	40
Melvin	D	PD	1[7]	4	100	17	4[8]	2.5	40[8]	60	40[8]	17	30
Mertz	D	WD	1	2	125	21	5	3.5	60	80	75	21	40
Monongahela	D[5]	MWD	1[7]	3	125	21	4	3	50	60	50	21	30
Morris	D[4]	SWPD	2	4	100	17	4[8]	2.5	40[8]	60	40[8]	17	30
Morrison	D	WD	2	2	125	21	5	3.5	60	80	75	21	40
Murrill	D	WD	2	1	150	25	6	4	60	80	75	25	45
Neshaminy	D	WD	2	1	150	25	6	4	60	80	75	25	45
Opequon	S	WD	2	4	100	17	4[8]	2.5	40	60	40	17	30
Oquaga	MD	WD	2	3	125	21	4	3	50	60	50	21	30
Penn	MD	WD	2	3	125	21	4	3	50	60	50	21	30
Philo	D	MWD	2[7]	2	125	21	5	3.5	60	80	75	21	40
Platea	D[5]	SWPD	1[7]	4	100	17	4[8]	2.5	40[8]	60	40[8]	17	30
Pope	D	WD	2	1	150	25	6	4	60	80	75	25	45
Rainsboro	D	MWD	1[7]	3	125	21	4	3	50	60	50	21	30
Ravenna	D[5]	SWPD	1[7]	4	100	17	4[8]	2.5	40[8]	60	40[8]	17	30
Rayne	D	WD	2	1	150	25	6	4	60	80	75	25	45
Readington	D[5]	MWD	1[7]	3	125	21	4	3	50	60	50	21	30
Reaville	D	SWPD	1[7]	4	100	17	4[8]	2.5	40[8]	60	40[8]	17	30
Red Hook	D	SWPD	1[7]	4	100	17	4[8]	2.5	40[8]	60	40[8]	17	30
Sheffield	D[5]	PD	1[7]	4	100	17	4[8]	2.5	40[8]	60	40[8]	17	30
Shelmadine	D[5]	PD	1[7]	4	100	17	4[8]	2.5	40[8]	60	40[8]	17	30
Swartswood	D[5]	MWD	1[7]	2	125	21	5	3.5	60	80	75	21	40
Tunkhannock	D	WD[6]	3	2	125	21	5	3.5	60	80	75	21	40
Tyler	D	SWPD	1[7]	4	100	17	4[8]	2.5	40[8]	60	40[8]	17	30
Upshur	D	WD	1	2	125	21	5	3.5	60	80	75	21	40
Venango	D[5]	SWPD	1[7]	4	100	17	4[8]	2.5	40[8]	60	40[8]	17	30
Volusia	D	SWPD	1[7]	4	100	17	4[8]	2.5	40[8]	60	40[8]	17	30
Washington	D	WD	2	1	150	25	6	4	60	80	75	25	45
Watson	D[5]	MWD	1[7]	3	125	21	4	3	50	60	50	21	30
Weikert	S	WD[6]	2	4	100	17	4[8]	2.5	40	60	40	17	30
Wellsboro	D[5]	MWD	1[7]	3	125	21	4	3	50	60	50	21	30
Westmoreland	D	WD	2	2	125	21	5	3.5	60	80	75	21	40
Wharton	D	MWD	1[7]	3	125	21	4	3	50	60	50	21	30
Wheeling	D	WD	2	1	150	25	6	4	60	80	75	25	45
Wurtsboro	D[5]	MWD	1[7]	3	125	21	4	3	50	60	50	21	30
Wyoming	D	WD[6]	3	3	125	21	4	3	50	60	50	21	30

1. Depth classes: D = deep (>40 inches); MD = moderately deep (20 to 40 inches); S = shallow (<20 inches)
2. Drainage classes: WD = well drained; MWD = moderately well drained; SWPD = somewhat poorly drained; PD = poorly drained
3. Leaching ratings—these are only a relative rating of leaching potential. The higher the number, the greater the relative leaching potential.
4. A fragipan is present at 10 to 16 inches (0.25 to 0.40 meters) below the surface of the soil.
5. A fragipan is present at 16 to 40 inches (0.40 to 1 meter) below the surface.
6. These soils are well drained to excessively well drained.
7. These soils have a seasonal high water table that is less than 6 feet from the surface. Leaching potential may be a consideration of water resource use and water table following pesticide application.
8. Crop is not well suited for this soil.

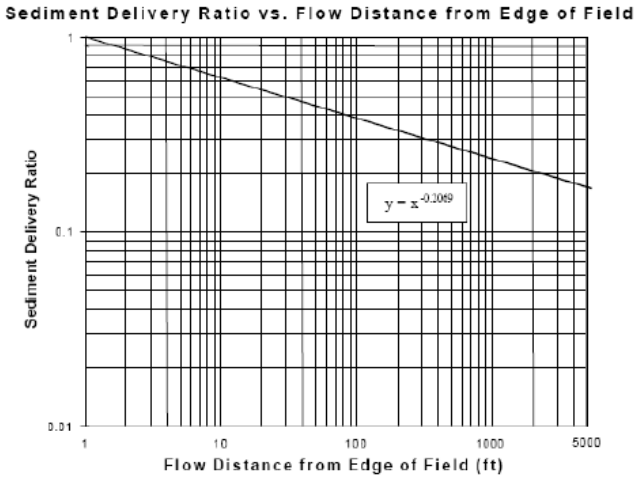
Table 7. Phosphorus Application Factors.

Application Method	April-Oct	Nov-March
	Phosphorus App Factor	
Placed or injected 2” or more deep	0.2	0.2
Incorporated less than 1 week following application	0.4	0.4
Incorporated more than 1 week following application	0.6	0.8
Not incorporated following application	0.6	0.8
Surface applied to frozen or snow-covered soil	1	1

Table 8. Nutrient Content of Manure and P Source Coefficients.

Manure Type	Average P Concentration				
	Phosphate	Phosphorus	Unit	P Source Coefficient	P Source Coefficient Applied[1]
Dairy- Lactating Cows Liquid	13	5.59	lbs P/1000 gallons	0.8	0.6
Dairy- Lactating Cows Solid	4	1.72	lbs P/ton	0.8	
Dairy- Dry Cow	3	1.29	lbs P/ton	0.8	
Dairy- Calf and Heifer	2	0.86	lbs/ton	0.8	

[1] 20 percent margin of safety introduced



The SDR equation is:

$$SDR = D^{-0.2069}$$

Where:
SDR = Sediment Delivery Ratio
D = Distance of sediment source to nearest hydrologically connected water body
[Note: For distances greater than 5000 feet use 5000 feet]

Figure 1. Sediment Delivery Ratio. (Delivery Ratio Explanation: To account for overland delivery of nutrients from the estimated edge-of-field location to an adjacent or nearby waterbody, Kieser & Associates, LLC recommends using information compiled by the University of Minnesota for sediment and particulate-attached nutrient reduction accounting. The University of Minnesota developed the Minnesota Phosphorus Site Risk Index in partial support of the Generic Impact Statement on animal agriculture (Moncrief, 2002). This method is applied in the Minnesota Phosphorus Index and water quality trading permits. The sediment delivery ratio (SDR) regression graph from the Minnesota Phosphorus Index is provided in Figure 1 above. The graph provides approximate SDRs based on distance from the edge-of-field to the nearest hydrologically connected water body.)

Attachment A

Santa Rosa Nutrient Offset Program Bioavailability Review

To: Lynn Small, City of Santa Rosa Control Board

Date: July 3, 2012

From: James A. Klang, PE, K&A

cc: Dave Smith, Merritt Smith

RE: Santa Rosa Nutrient Offset Program Bioavailability Review

Addressing Nutrient Bioavailability in Offsets

This memorandum provides a brief review of published literature and selected water quality trading programs, analyzing various approaches for addressing nutrient (phosphorus and nitrogen) bioavailability between sources. This background information forms the basis for recommended bioavailability factors included in equations for calculating Santa Rosa nutrient offset credits. For water quality offsets, discount factors are often applied to nutrient load reductions to ensure that the environmental outcome from the offset is equivalent to the protection that would be achieved under conventional methods of additional wastewater treatment. Such factors are used in crediting proposals to account for bioavailability equivalence in the Santa Rosa Nutrient Offset Program for loading between non-point sources and the City's treated wastewater discharge.

Phosphorus:

The State of Minnesota addressed phosphorus bioavailability issues in the Statement of Needs and Reasonableness (SONAR) document written to support Water Quality Trading rule promulgation[1]. The Minnesota Pollution Control Agency (MPCA) based this document on a study entitled, "Detailed Assessment of Phosphorus Sources to Minnesota Watersheds" (Barr, 2004). An appendix to the 2004 study compiles phosphorus bioavailability by source. The table from this appendix is reproduced below as Table 1.

The literature reviewed for this memo most commonly determined bioavailability using a one-month period after release to a water environment. Applying the results of these bioavailability studies to longer time periods (as would be the case in the Laguna de Santa Rosa setting), provides a conservatively low range. The nutrients in the Laguna setting have substantially more time to undergo chemical and biological changes. To address bioavailability, a coefficient can be calculated that reflects the bioavailability of the different phosphorus forms discharged by each source.

[1]MPCA. 2010. A Scientifically Defensible Process for the Exchange of Pollutant Credits under Minnesota's Proposed Water Quality Trading Rules. Accessed July 3, 2012, available at: http://kieser-associates.com/uploaded/MPCA_Defensible_Processs_Exchange_Credits_072809.pdf

K&A used Table 1 to calculate recommended equivalence factors that incorporate phosphorus bioavailability considerations for the Laguna de Santa Rosa. An equivalence factor accounts for differences in phosphorus bioavailability from each type of source. For point source domestic wastewater treatment plants (WWTPs) using agricultural nonpoint source offsets (without presence of manure), the recommended equivalence factor is 58/85.5 (or 0.68). When working on agricultural sites that are seeking to improve manure management, this factor becomes 80/85.5 (or 0.94).

Table 1. Estimates of phosphorus bioavailability fractions for specific source categories (from Barr, 2004).

Phosphorus Sources		Fraction of PP that is Bioavailable (Range)	Fraction of PP that is Bioavailable (Most Likely)	Fraction of DP that is Bioavailable (Most Likely)	Fraction of TP that is Particulate (Most Likely)	Estimate of TP that is Bioavailable (Most Likely)
Publicly Owned WWTP for domestic use (effluent)		**0.6 - 0.8**	**0.7**	**1.0**	**0.5**	**0.855**
Privately Owned WWTP for domestic use (effluent)		**0.6 -0.9**	**0.8**	**1.0**	**0.3**	**0.94**
Commercial/Industrial WWTPs (effluent)		**0.2 - 0.8**	**0.6**	**1.0**	**0.3**	**0.88**
Agricultural Runoff						
	Manure Management	**0.5 -0.7**	**0.6**	**1.0**	**0.5**	**0.8**
	Cropland Runoff	**0.2 - 0.7**	**0.4**	**1.0**	**0.7**	**0.58**
Urban Runoff						
	Turfed Surfaces	**0.2 - 0.7**	**0.4**	**1.0**	**0.7**	**0.58**
	Impervious Surfaces	**0.10 - 0.5**	**0.2**	**1.0**	**0.5**	**0.6**
Forested Land		**0.2 - 0.8**	**0.3**	**1.0**	**0.8**	**0.44**
Roadway and Sidewalk Deicing Chemicals						
	salt	**0.2 - 0.8**	**0.6**	**1.0**	**0.2**	**0.92**
	sand	**0.1 - 0.3**	**0.2**	**1.0**	**0.8**	**0.36**
Stream Bank Erosion		**0.1 - 0.5**	**0.3**	**1.0**	**0.8**	**0.44**

Nitrogen:

Total nitrogen (TN) consists of dissolved and particulate nitrogen. Dissolved nitrogen can be further subdivided into inorganic and organic forms. Organic forms of particulate nitrogen also can be present. The dissolved inorganic nitrogen (DIN) forms (NO_2, NO_3 and NH_4^+) are

commonly assumed to be 100 percent bioavailable (Berman, 1999). However, independent study findings regarding the bioavailability of organic nitrogen, dissolved organic nitrogen (DON) and particulate organic nitrogen (PON) suggest that the bioavailability of these forms might vary widely. The predictability of this range in bioavailability also might vary substantially, in part due to results based on algal bioassays (Seitzinger, 2002). DON in freshwater riverine systems was historically thought to be available only for bacterial uptake, rather than direct algal uptake. Research indicates that humic systems release more DON during summer periods than previously thought. Up to 20 percent of the DON can be photo-ammoniafied (Bushaw, 1996; Dagg, 2003).

The Laguna de Santa Rosa nitrogen loading affecting the low flow dissolved oxygen conditions, is likely in the forms of DON and PON that remain in the system for longer periods of time (e.g., when disconnected summer pools develop). These longer time periods likely expose the DON and PON to photochemical breakdown, zooplankton grazing and bacterial uptake resulting in NH_4-N or NO_3 release. Therefore, non-point source DIN is assumed to be 100 percent bioavailable (as discussed above) while DON and PON collectively are conservatively estimated at 20 percent bioavailable during the summer period for various Ag non-point sources. This is conservative because it does not include bacterial and zooplankton uptake. In the Laguna de Santa Rosa setting, the application of nitrogen bioavailability might be further complicated by limited laboratory or bioassay testing methods, which can use three-week incubation periods (Urgun-Demirtas *et al.*, 2008; Berman, *et al*. 1999). The use of this lab analysis is considered conservative due to the longer time periods and numerous chemical and biological activities that occur when the low flow polls trap nitrogen beyond the three-week timeframe of the lab tests.

Total Nitrogen to Dissolved Organic Nitrogen Ratios in Non-point Source Dominated Streams

Research indicates a broad range of ratios comparing stream TN to DON in non-point source dominated streams. Seitzinger (2004) conducted a literature review that suggested a range from 10 to 80 percent. Assessing the cropping and pasture runoff results from the Laguna de Santa Rosa TMDL source monitoring program, the 34-sample mean concentration was 2.6 mg/l TN. The dataset did not provide flow estimates. Therefore, a flow-weighted mean could not be generated. The mean concentration of the 34 samples of the total DIN fraction (NO_3- and NH_4-N) was 2.0 mg/l DIN.

A comparison of the two concentration means indicates approximately 76 percent of the total nitrogen is DIN. This can be roughly confirmed by solving for the DON fraction independently for each sampling event (TN - DIN = DON + PON) and then averaging the estimated percent of organic nitrogen results. The average organic nitrogen percentage of total nitrogen plus the 76 percent DIN fraction should be approximately 100 percent (not taking into account difficulties regarding sampling variability). The result of this calculation indicates approximately 29 percent of the total nitrogen is in the form of organic nitrogen. The 76 percent plus 29 percent is a reasonable indicator that these assumptions are within an acceptable range for the Laguna

de Santa Rosa setting. Therefore, using a 75 percent bioavailable fraction as DIN and 25 percent as organic nitrogen form in non-point source runoff was deemed reasonable for nitrogen offset credits.

After combining the stream fractions of inorganic and organic nitrogen (and bioavailability of each), the TN bioavailability of crop and pasture sources can be estimated as follows: DIN bioavailability (75 percent times 100 percent bioavailable) plus organic nitrogen bioavailability (25 percent times 20 percent bioavailable) equals 80 percent total nitrogen bioavailability. This estimate is used in Ag settings with high organic content as a conservative estimate. However, as previously mentioned, in settings where there is a substantial presence of particulate organic nitrogen, the estimate is unreasonably low because it is based on three week lab analysis methods. In settings where the credit estimation method is dominated by PON, a higher bioavailability factor will be used.

The bioavailability of WWTP nitrogen also must be determined. Assessing the same forms of nitrogen (e.g., particulate and dissolved, further subdivided into inorganic and organic) the inorganic fractions are assumed to be 100 percent bioavailable. Literature indicates that secondary effluent WWTPs that denitrify have DON percentages around 10 percent of the TN discharged (Pehlivanoglu, 2004). However, advanced treatment with low total nitrogen levels (below 3 mg/l) increases the fraction of DON to 40-50 percent of TN (Chandran, 2010). Therefore, an analysis of the Laguna WWTP pond storage system sampling was performed. The results provided in Table 2 indicated that average concentrations were:

Table 2. Average nitrogen concentrations from Delta Pond samples (City of Santa Rosa, Delta Pond monitoring results, 2006-2010).

Nutrient Form	Concentration (mg/l)	Number of Samples
Nitrate Nitrogen	8.19	20 samples
Organic Nitrogen	1.34	24 samples
Ammonia nitrogen	0.48	14 samples
Total Nitrogen	9.8	Sum of nitrate, organic and ammonia samples (same day) from Delta Pond

These values indicate that approximately 89 percent of the discharged pond effluent was DIN (assumed to be 100 percent bioavailable). A conservative assumption for the Santa Rosa offset program would be to use a 50 percent bioavailable fraction of DON, assuming algal uptake is enhanced by bacteria (Pehlivanoglu, 2004). Therefore, the contributing DON bioavailable fraction is assumed to be 5.5 percent of the total nitrogen loading. The estimated wastewater bioavailable fraction result is 94.5 percent. The nitrogen bioavailability discount factor for cropping and pasture land offsets is determined by 0.8 non-point source bioavailability/0.945 WWTP bioavailability, or a discount factor of 0.85 times the credited loading reduction.

References:

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