To: Lynn Small, Deputy Director
Environmental Compliance

Date: November 27, 2012

From: James A. Klang, PE, K&A
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cc: Dave Smith, Merritt Smith

RE: Nunes - Ocean View Dairy Summary of Best Management Practice Reduction Estimation Methods for City of Santa Rosa Nutrient Offset Program Credits

This memorandum provides details regarding the calculation methods used for estimating nitrogen and phosphorus credits from the Nunes - Ocean View Dairy site for the City of Santa Rosa Nutrient Offset Program. Credits were calculated for both current conditions as well as a future condition that includes the proposed Best Management Practices (BMPs). Tables and figures (located at the end of this memorandum) are provided for additional illustration and support of the crediting approaches.

Crediting methods were derived from approaches used by 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 Nunes - Ocean View Dairy site. Computed credit values are consistent with the City of Santa Rosa Crediting Proposal for the Nunes - Ocean View Dairy BMPs dated October 23, 2012 (and submitted to the North Coast Regional Water Quality Control Board—Regional Board on October 30, 2012).

The City of Santa Rosa Nutrient Offset Program defines the term “offset” as an equal or greater load reduction that is adjusted to account for differences in nutrient 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 implementing a BMP that results in reducing the nutrient load to a water body.

Calculation Method Selection

The PA DEP nutrient credit calculation method was selected after comparing multiple empirical methods. In addition to the Pennsylvania method, the EPA Region V model and the USDA-NRCS Nutrient Tracking Tool (NTT) were examined. The EPA and USDA methods were removed from further consideration due to their limited applicability to the characteristics of the Laguna de Santa Rosa setting.

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

The Region V model is limited in its ability to credit soluble nutrient parameters and lacks manure nutrient management considerations. NTT is expensive to calibrate for regional conditions, and without such calibration the local dairy BMP simulations cannot be adequately performed.

The strengths of the PA DEP method include ease of use, the ability to estimate load reductions for the soluble nutrient fraction, and the 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). These equations follow standard methods to estimate non-point source runoff. The calculations are performed on Microsoft Excel spreadsheets and a description of the calculation process is provided as follows.

Calculation Descriptions

The Nunes - Ocean View Dairy will be generating nutrient credits from three different BMP systems. The three systems described in the formal proposal are:

- Emptying manure lagoons and appropriately managing for future stormwater collection
- Implementing BMPs in heavy use areas to address accumulated manure
- Distributing 12,700 tons of manure solids for on-site land application

Credit calculation descriptions are provided for each of the three BMP systems. Each calculation process was based on the unique characteristics of the nutrient source.

BMP #1 – Manure Lagoon Cleanout and Management of Future Storage

BMP #1 addresses two full manure lagoons that have an imminent potential to contribute nutrients to Windsor Creek during precipitation events. As an interim measure, a berm will be established to prevent nutrient loading to Windsor Creek while cleanout is initiated. The crediting project will result in emptying the full lagoons and land applying the manure slurry at agronomic rates. The method used for emptying the lagoons will be either hauling the manure to forage fields on-site or land application on-site utilizing the reclaimed water irrigation system already available on the farm.

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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)

A typical lagoon cleanout process first empties the liquids in the lagoons by agitating the waste and pumping the liquid portion. The remaining solids then are stacked next to the lagoon to dewater. After dewatering, these solids will be similarly managed with the manure separated solids pile under BMP #3 of this crediting proposal. The production area contributing to the lagoons will be scraped and subsequently planted with cover crops in open areas. After manure removal, the lagoons will be temporarily closed allowing only Ag stormwater to enter.

To estimate the volume of runoff entering the lagoons, a local agricultural engineering firm was hired by the City of Santa Rosa to assess the Nunes Ocean View Dairy production area. Erickson Engineering, Inc. visited the site and developed runoff volume estimates based on the Soil Conservation Service Technical Release 55 (TR-55) method. The TR-55 runoff equation uses a coefficient called the Curve Number (CN), which is used to predict runoff from excess rainfall. The equation, as described in the TR- 55[4], is as follows:

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

S is the potential maximum retention after runoff begins, which is related to the soil and cover conditions of the watershed. The CN has a range of 0 to 100 and is selected based on rainfall and direct runoff. S is related to CN by:

$$S = 1000 / CN - 10$$

The runoff volume values applied by Erickson Engineering, Inc. were based on the 1983 isohyetal map provided by the Sonoma County Water Agency. The average annual rainfall applied was 36 inches a year. The results calculated by Erickson Engineering, Inc. are presented in Table 1. These estimates do not include dairy process water volumes because the milk parlor and barn flushing system will not be in use during the clean-up period as there will be no dairy herd onsite. Runoff estimates were divided into categories based on the surface characteristics of the contributing area. These categories include manured concrete, silage pad, manure storage (liquid), manured areas without concrete surfaces and crop/pasture areas.

[4]NRCS. 2009. Urban Hydrology for Small Watersheds, available at http://www.hydrocad.net/pdf/TR-55%20Manual.pdf pp. 2-1

Table 1. Runoff volume calculation based on SCS Technical Release - 55 runoff coefficients methods.

Surface Areas	Acres	Runoff coefficient Curve Number (CN)	Average Conditions (Acre-feet)	Wet Conditions (Acre-feet)
Manured Concrete	0.23	1.00	0.68	1.01
Silage Pad	0.52	1.00	1.57	2.33
Manure Storage, Liquid	2.09	1.00	6.26	9.33
Manured non-concrete	3.11	0.5	4.67	6.96
Crop/pasture	2.03	0.4	2.44	3.64
Totals	7.46	--	15.62	23.27

The results from the Erickson Engineering, Inc. assessment were used to estimate the credits generated by the proposed BMPs for the site. The crediting calculation used the volume estimate of 15.62 acre-feet of runoff expected under average conditions. This volume represents the flow into the two lagoons every year. The phosphorus and nitrogen load reduction was then calculated using this runoff volume combined with the manure lagoon nutrient concentrations. The 15.62 acre-feet value was first converted to 1,000-gallons in order for the units to correspond with those used in the nutrient concentration estimates provided by the Midwest Plan Service (Midwest Plan Service, 2004). This conversion is shown in EQ 1. The Midwest Plan Service provides estimates of dairy manure lagoon nutrient mass in lbs per 1,000 gallons (gals) of manure. The lagoon nutrient content is estimated to be 31 lbs of total nitrogen (TN) per 1,000 gallons and 15 lbs of phosphate (P_2O_5) per 1,000 gallons. Actual manure lagoon nutrient concentration samples have been collected and results are pending. Once available, calculations reported herein will be re-visited using site-specific information to adjust credit estimates.

15.62 (acre-ft) * 43,560 (sq ft/acre) * 7.48 (gals per foot^3) / 1,000 (gals) = 5,089 (1,000 gals) **[EQ 1]**

TN load reduction was calculated by combining the result from EQ 1 with the nutrient content estimates provided by the Midwest Plan Service, as shown in EQ 2.

5,089 (1,000 gals) * 31 (lbs TN/ 1,000 gals) = 157,773 (lbs) TN **[EQ 2]**

TP load reduction was calculated by first converting the P_2O_5 pounds into pounds of phosphorus, as shown in EQ 3. Next, the result from EQ 3 was converted to 1,000 gallon units, as shown in EQ 4.

15 (lbs) * 0.43 (molecular weight of P fraction in P_2O_5) = 6.5 (lbs / 1,000 gals) **[EQ 3]**

5,089 (1,000 gals) * 6.5 (lbs TP/ 1,000 gals) = 32,827 (lbs) TP **[EQ 4]**

A conservative assumption was added to address additional handling and storage losses after year one. Future stormwater directed to the ponds that are currently coming into contact with previously accumulated manure will also be addressed. Because the BMP system applied to the temporary closure of the lagoons includes removing the manure in the manured areas exposed to rainfall and providing a conservation cover. Without this aspect of BMP #1, the 5,089 1,000 gallon units of runoff would still be coming into contact with legacy manure in corrals and open manured areas and contribute to nutrient loading. To illustrate the potential loading associated with stormwater runoff from manured areas, two papers were reviewed. The first paper was a literature review conducted by Koelsch *et al.* (2006)[5]. In this paper, runoff originating in open lots with beef cattle was estimated to be 5,800 ppm of nitrogen and 1,200 ppm of phosphorus. However, dairy cattle have higher nutrient content in their manure than beef cattle[6]. The second research paper was a study of runoff nutrient loadings by Gilley et al, (2012)[7]. The results of this study found that nutrient loads in runoff events decreased when there was no additional manure added between events.

Based on these studies, it is logical to assume that stormwater directed into the lagoons would have been in contact with legacy manure without the proposed open lot BMPs, but the nutrient content would diminish over time. However, no equation exists to estimate the rate of decrease in nutrient concentration. To address this unknown rate of reduction, two conservative factors were incorporated into the credit estimation process. First, the estimate of nutrient concentrations in liquids entering the lagoon used in equations 2 and 4 is substantially less than the estimated concentration of runoff mixed with manure. This is shown by comparing the results of equation 2 with 2a and equation 4 with 4a. Equations 2a and 4a are loading rate equations based on volume estimates in million gallons and pollutant concentrations in parts-per-million (ppm) times the weight of a gallon of water. In these equations, the density of the water is assumed not to change with the addition of pollutants. Stormwater coming into contact with manured open lots has an estimated nutrient load of 246,165 lbs of TN and 50,931 lbs of TP, which is 1.56 times greater than the load estimates used in the credit calculation. Based on this conservative margin of safety, the nutrient content of the stormwater coming into contact with manured open lots could be reduced by 36 percent before the concentration would reach the inputs selected for this credit calculation. The second conservative factor incorporated into the credit calculation method is a discount of 40 percent for nitrogen loading and 30 percent for phosphorus loading, as shown in equations 5 and 6. Adding in this margin of safety results in an edge-of-field loading estimate that, in subsequent years, is 62 percent less than the initial load estimate for nitrogen, and 55 percent less for phosphorus.

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[5] Koelsch, R.K., Lorimer, J., Mankin, K. 2006. Vegetative Treatment Systems for Open Lot Runoff: Review of Literature. Conference Presentations and White Papers: Biological Systems Engineering. Paper 5. http://digitalcommons.unl.edu/biosysengpres/5

[6] Midwest Plan Service, 2004. Manure Characteristics: Manure Management System Series. Second Edition. MWPS-18 S-1. Iowa State University. http://www.mwps.org/index.cfm?fuseaction=c_Products.viewProduct&catID=719&productID=6421&skunumber=MWPS18S1. Accessed March 1, 2011.

[7] Gilley, J.E., Vogel, J.R, Eigenberg, R.A., Marx, D.B., Woodbury, B.L. 2012. Nutrient losses in runoff from feedlot surfaces as affected by unconsolidated surface materials. J. of Soil and Water Conservation. May-June 2012. Vol. 67, pp 211-217

5,800 (ppm) TN * 8.34 (mass of a gallon of water) * 5.089 (million gallons) = 246,165 lbs of TN **[EQ 2a]**

1,200 (ppm) TP * 8.34 (mass of a gallon of water) * 5.089 (million gallons) = 50,930.7 lbs of TP **[EQ 4a]**

157,773 (lbs) TN * (1-40%) = 94,664 (lbs) TN reduced in years 2, 3, and 4 **[EQ 5]**

32,827 (lbs) TP * (1-30%) = 22,979 (lbs) TP reduced in years 2, 3, and 4 **[EQ 6]**

Introduced margins of safety are incorporated to adjust for delivery losses and differences in bioavailability. When a non-point source of nutrients is not adjacent to receiving water, the edge-of-field loading can be adjusted by an upland delivery ratio to represent overland transport losses. The Nunes - Ocean View Dairy manure lagoon calculation for BMP #1 incorporates the upland transport losses by using the equation presented in Figure 1 (located at the end of this document). 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 under 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 7. Several additional equations are applied that allow the total offset reductions to be calculated in Equation 13.

DR = NLR * SDR **[EQ 7]**

Where:

DR = Nutrient Load Reduction Edge-of-Field (lbs)
NLR = Nutrient Load Reduction (lbs); from Equation 5 and 6
SDR = Sediment Delivery Ratio as provided by Figure 1 (ratio)

Equation 7 was then applied to equations 8 and 9 for nitrogen and 10 and 11 for phosphorus to account for the distance between the manure lagoons and Windsor Creek on the Nunes Ocean View Dairy site. The lagoons are approximately 85 feet from Windsor Creek. The SDR discount factor resulted in a 60 percent reduction in the nutrient loading estimate from the site.

157,773 (lbs of TN in year 1) * 0.3988 (SDR) = 62,927 (lbs TN in year 1) **[EQ 8]**

94,664 (lbs of TN in years 2, 3 and 4) * 0.3988 (SDR) = 37,756 (lbs TN in years 2, 3 and 4) **[EQ 9]**

32,827 (lbs of TP in year 1) * 0.3988 (SDR) = 13,093 (lbs TP in year 1) **[EQ 10]**

22,979 (lbs of TP in years 2, 3 and 4) * 0.3988 (SDR) = 9,165 (lbs TP in years 2, 3 and 4) **[EQ 11]**

To account for differences in the bioavailability of nutrient forms released from wastewater effluent and manure sources, K&A completed a literature review, as directed by the offset Resolution (see Attachment A). This review assessed the nutrient bioavailability differences associated with multiple sources in order to incorporate these differences in the credit calculation process. 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. 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 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 manure-related non-point sources, it is estimated that 60 percent of particulate-attached phosphorus will become bioavailable. Combined with the dissolved fraction, the weighted average of bioavailable phosphorus is 80 percent. When the source is a domestic wastewater treatment plant, the particulate phosphorus fraction that will become bioavailable is estimated to be 70 percent. Combined with the dissolved fraction, the total fraction of bioavailable phosphorus from a domestic treatment facility is 85.5 percent. The bioequivalence factor for phosphorus from this manure-related non-point 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 fraction of organic forms of nitrogen that are or will become bioavailable varies 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 bioavailability adjustment equation (0.80/0.945), the resulting nitrogen bioavailability coefficient is 85 percent. These bioavailability coefficients are used in the Nunes - Ocean View Dairy calculations.

Equations 12 through 15 present the final credit results after applying the bioavailability margin of safety.

62,927 (lbs TN in year 1) * 0.85 (ratio) = 53,488 TN credits in year 1 **[EQ 12]**

37,756 (lbs TN in years 2, 3 and 4) * 0.85 (ratio) = 32,093 TN credits in years 2, 3 and 4 **[EQ 13]**

13,093 (lbs TP in year 1) * 0.935 (ratio) = 12,242 TP credits in year 1 **[EQ 14]**

9,165 (lbs TP in years 2, 3 and 4) * 0.935 (ratio) = 8,569 TP credits in years 2, 3, and 4) **[EQ 15]**

BMP #2 – Heavy Use Area Restoration

For a 3.6-acre heavy use heifer loafing area situated adjacent to Mark West Creek Road, proposed activities will include scraping and closing this area, followed by the addition of a cover crop to increase nutrient uptake and reduce erosion. The heavy use area was historically used as a heifer loafing area. The heavy use history results in higher soil nutrient concentrations. Cows were released to this area daily and the cattle allowed to graze in the associated pasture. The total pasture is 19.4 acres, including the 3.6-acre loafing area. An adjacent 7.4-acre pasture also exists. Some 160 animals were kept 365 days per year in the open heifer barn and associated heavy use area and pastures. Animals were provided with supplemental feed bunkers and water near the barn.

The Pennsylvania Department of Environmental Protection (PA DEP) Chesapeake Bay Water Quality Trading Program[8] calculation method for pastures was adapted for heavy use areas here. The adjusted method calculates the reductions in phosphorus related to enriched soil concentrations from the past heavy use activities. The calculations estimate the reductions in phosphorus loading that result from implementation of a conservation cover BMP which will reduce surface erosion. This BMP will reduce both particulate and dissolved phosphorus loadings (but does not credit nitrogen). Site-specific credit calculations consider:

- Manure deposited in heavy use area
- Remnant manure after scraping
- Soil erosion rates for heavy use area
- Cover treatment efficiency

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 then are applied to calculate a final credit value eligible for offsetting City of Santa Rosa discharges.

To provide general background in preparation of the phosphorus calculation methods, a brief primer on phosphorus characteristics is provided here. Phosphorus is present in the environment in particulate attached and soluble forms[9]. Elemental phosphorus is very reactive and readily combines with oxygen

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

[9] 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

when in contact with air to form phosphate[10]. Phosphate is a negatively charged ion and easily adsorbs to soil particles[11]. 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[12]. 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 elements that bind phosphorus to the largest extent[13]. 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)[14], (Sharply et al., 1981)[15], (Warwick et al., 2004)[16].

The credit equations used at the Nunes - Ocean View Dairy 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 depending on the stand density)
- 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 one year (as provided by California Department of Water Resources website at ftp://ftp.water.ca.gov)
- Manure applications assumed to be zero
- Sediment Delivery Ratio

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[10] 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

[11] Id.

[12] Id.

[13] Id.

[14] 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)

[15] 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

[16] 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).

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 Waiver and could generate credits each year for an extended period of time. Others will be required after a reasonable establishment period and can only receive credits until a point in time defined in the GWDR or Waiver. Therefore, the proposed heavy use area BMPs at the Nunes Ocean View Dairy are being requested for short-term credit generation, even though the dairy will achieve GWDR compliance for long-term requirements.

The PA DEP calculator can also addresses the total bioavailable nitrogen in manure and commercial fertilizer applications. However, this portion of the credit estimation process was not applied because the cattle have been removed from the site.

Applying the PA calculations to heavy use areas requires several additional modifications to the calculation methods. First, a heavy use area is not cropped. When a dairy is in operation, in the fall the livestock are limited to barns or sacrificial heavy use areas and access to the largest portions of heavy use areas is restricted. This is done in preparation for the winter wet season to limit loss of vegetation in saturated conditions and the associated water erosion and erosion stemming from cow traffic in this sensitive period. In addition, the heavy use areas are scraped to remove the manure that remained on the surface. Mulch and grass seed are then applied in preparation for the wet season. However, the cattle at this site were removed in 2012. Therefore, the estimated amount of manure remaining from previous use, including daily loafing of the milk cows prior to release into pastures, must be adjusted. These adjustments should incorporate 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 represent the current nutrient loading conditions prior to implementation of the new BMPs proposed in the City's Nunes Ocean View Dairy crediting application.

The proposed quantification methodology for phosphorus management practices associated with proposed BMP #2 at the Nunes - Ocean View Dairy is described in the following narrative. 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 difference in the results from these two calculations will reflect the edge-of-field reductions and 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 Nunes - Ocean View 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. Because no additional manure is being applied during the crediting period, the only phosphorus losses that will be calculated are from sediment-attached phosphorus moving with eroded soil and soluble phosphorus releases during runoff events.

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 adsorption 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 16 provides this assessment converted into pound and acre units[17].

ESP = SPC * SEDE * 2.205 * EF **[EQ 16]**

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 17.

ESP-EoF = ESP * DR [**EQ. 17]**

Where:

ESP-EoF = Eroded Sediment Attached Phosphorus delivered to the Edge-of-Field (lb/yr)
ESP = Eroded Sediment Attached Phosphorus (Equation 16)
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 tests recently collected at another approved dairy offset site were used to estimate total phosphorus content of typical soils here, and a back calculation was made using the PA converter based on a regression for Mehlich 3 and TP soil samples. (Note: Nunes - Ocean View Dairy site samples have been collected and the results are pending.)

SPC = SPT / 190 * 836 * 0.000909 [Mehlich - 3 TP] **[EQ 18]**[18]

Where:

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

[17] Equation recommended by Beegle, D., Klineman, P., and Evans, B., from Penn State University as supported by Evans (Evans, 2002).
[18] Vadas *et al*., 2005

The constants in this equation reflect the PA DEP calculation of the Area Weighted Value of lbs/acre as calculated by Evans[19] 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 SCS Technical Release 55, indicates:

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

S is the potential maximum retention after runoff begins, which is related to the soil and cover conditions of the watershed. The CN has a range of 0 to 100 and is selected based on rainfall and direct runoff. S is related to CN by:

$S = 1000 / CN – 10$

These runoff 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 based on CA Water Gov records. Equations 19 and 20 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 19]**

$Q = (3.34 – 0.2(1.63))^2 / (3.34 + 0.8 (1.63))$ result = 1.96 **[EQ 20]**

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 long-term precipitation records (downloaded from CA Water Gov), the mean precipitation in the Santa Rosa Plain (where the Nunes - Ocean View Dairy is located) is 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 21 provides the estimated average annual rainfall runoff.

$AARR = Q * 9.28$ **[EQ 21]**

Where:

AARR = Average Annual Rainfall Runoff, in inches

Q = Annual Volume of Runoff, in inches

Equation 22 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 22]**

[19] Evans, 2002

Where:

TDP = Total Dissolved Phosphorus, lost to runoff (lb/year)

STP = Soil Test Phosphorus

SPRF = Soluble Phosphorus Regression Factor[20]

SPRF = 2 * STP + 43.5 (μg/l), for the Mehilich test[21] **[EQ 23]**

Equation 24 calculates the total dissolved phosphorus from manure delivered to the edge-of-field.

TDP-EoF = TDP * DR **[EQ 24]**

Where:

TDP-EoF = Total Dissolved Phosphorus, to Edge-of-Field (lbs/ac)

TDP = Total Dissolved Phosphorus, lost to runoff (lbs/ac), from Equation 22

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 25

PFL = (TDP-EoF + ESP-EoF) * A **[EQ 25]**

Where:

PFL = Phosphorus Field Loss (lbs/ac)

TDP-EoF = Total Dissolved Phosphorus at the Edge-of-Field, from Equation 24

ESP-EoF = Eroded Sediment Attached Phosphorus at the Edge-of-Field, from Equation 17

A = Acres, in the field

For Equation 25, 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 be conducted to indicate a reduction in available soil phosphorus (ESP-EoF and TDP-EoF).

To illustrate how all of these equations, assumptions, and discounting factors are applied to calculate phosphorus credits at the Nunes - Ocean View Dairy site, the following inserts 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.

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

[21] Vadas *et al*., 2005

Soil Information:					
	Classification:		Huichica	Loam	Htc
	Hydrologic Group:		D	Soil C; Manure pack D	
RUSLE estimate factors:					
	R Factor:	120	From EPA Rainfall Erosivity Factor Fact sheet		
	K Factor:	0.37	Construction Sites at: http://cfpub.epa.gov/npdes/stormwater/lew/lewcalculator.cfm		
	LS Factor	2.2	From NRCS Web Soil Survey at: http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm		
	C Factor	0.05	From Guidelines for the Use of the Revised Universal Soil Loss Equation (RUSLE) Version 1.06 on Mined Lands, Construction Sites and Reclaimed Lands, T.J. Toy and G. R. Foster, Co-editors J. R. Galetovic Publishing Editor. Accessed April 25, 2012 at: http://www.greenfix.com/Channel%20Web/pdfs/RUSLE%20Guidelines.pdf		
	P Factor	1	(no erosion practice)		
	A= R*K*LS*C*P	4.884	tons/acre/year	(if less than 1 ton/acre/year, use 1)	

	Soil P		3.0	kg/ton P
Phosphorus Snapshot	Background Soil P Loss from Erosion		64.6	lbs/acre
	Soluble P Concentration	1,544	ug/L (microgram/liter OR ppb)	
	Average Annual Runoff	1,866,201	L/ac	Average Annual Runoff Conversion
	Background Dissolved P Loss	2,880,480,541	ug/ac	
	Background Dissolved P Loss	6.3	lbs/ac	
	P Load Available from Soils:	70.9	lbs/ac	
	P Load Available from Soils and Nutrient Applications:		70.9	lbs/acre
	Site P Loading Available:		255.4	lbs P/yr

Introduced margins of safety are added to adjust for delivery ratio losses and differences in bioavailability.

When non-point sources of nutrients are not adjacent to receiving waters, the edge-of-field loading can be adjusted by an upland delivery ratio to represent overland transport losses. The Nunes - Ocean View Dairy heavy use area calculation (BMP #2) was adjusted for the upland transport losses by using the Minnesota Phosphorus Site Risk Index Sediment Delivery Ratio (SDR) equation presented in Figure 1, and as described in the calculations for BMP #1. The phosphorus 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 26. The calculation for the total field reductions is provided in Equation 27.

DR = NLR * SDR **[EQ 26]**

Where:

DR = Nutrient Load Reduction Edge-of-Field (lbs)
NLR = Nutrient Load Reduction (lbs); from Equation 5 and 6
SDR = Sediment Delivery Ratio as provided by Figure 1 (ratio)

Equation 26 was applied for the site in equation 27 to account for the distance between the heifer heavy use area and a roadside water conveyance on the west side of this area. This conveyance connects to Windsor Creek a short distance south of the dairy site. The average distance to the conveyance is 100 feet. Equation 27 provides the application of the SDR to the phosphorus loading estimate. The SDR discount factor is 38.57 percent reducing the credit value by 61.43 percent.

255.4 (lbs of TP) * 0.3857 (SDR) = 98.48 (lbs TP) **[EQ 27]**

In addition to excluding the dairy milk cows, a conservation cover BMP will be added to the Nunes - Ocean View Dairy heavy use area. The cover, calculated here as a buffer, further reduces erosion and assimilates both soluble and sediment-attached phosphorus. The heavy use area cover introduced here is applied AFTER the SDR discount factor to determine the edge-of-field load. A study by Zhang *et al.* (2010)[22] presented the findings of a literature review focused on the treatment efficiency of vegetative buffers. In this review, nutrient loading reductions for a 30-meter buffer increased the percent reduction to 100 percent for phosphorus. Equation 28 presents the application of the addition of perennial cover to equation 27.

98.48 (lbs TP) * 1 = 98.48 lbs of TP reduced **[EQ 28]**

As presented in BMP #1, K&A completed a literature review (see attachment A) to address the nutrient bioavailability differences associated with various sources, as directed by the offset Resolution. For this manure-related non-point source site, it is estimated that 60 percent of particulate-attached phosphorus will become bioavailable. Combined with the dissolved fraction, the weighted average of bioavailable phosphorus is 80 percent. When the source is a domestic wastewater treatment plant, the particulate phosphorus fraction that will become bioavailable is estimated to be 70 percent, for a total of 85.5 percent when combined with the dissolved fraction. The bioequivalence factor for phosphorus from this manure-related non-point source and a domestic wastewater treatment plant is calculated by: 0.80/0.855. Therefore, the bioavailable coefficient is 93.5 percent. Equation 29 applies this margin of safety.

98.48 (lbs TP) * 0.935 (ratio) = 92.1 TP credits **[EQ 29]**

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[22] 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.

In summary, the Nunes Ocean View Dairy edge-of-field loading calculations for nutrient applications include the following conservative assumptions: no further manure applications (of either nitrogen or phosphorus) will occur during the credit life and residual nitrogen releases from the site after dairy cows were excluded beginning in 2012 will not be credited. In addition, these credit calculations consider instream (channel) attenuation processes that occur between the Nunes - Ocean View Dairy site and the low flow pools in comparison with the relative location and timing of the Delta Pond discharges. The Nutrient Offset Program Resolution allows for the use of spatial and temporal considerations to be incorporated as an additional "margin of safety" factor when determining credits.

BMP #3 On-site Re-use of Stacked Manure Solids

The proposed credit-generating activity for BMP #3 will eliminate nutrient loading contributions to Windsor Creek by first constructing an interim containment berm, land applying on-site the manure separated solids, and then establishing a cover crop on exposed ground surfaces. During previous site visits, at least five areas were identified where manure stacking is persistent and nutrient and bacteria loading contributions to surface water are possible via runoff. The areas of activity will be consolidated into zones that provide protection against surface water nutrient loading with temporary berming until full land application of the solids is completed.

Three acres of manure separated solids are stacked on the dairy site. The stacking piles are estimated at 12,700 tons of solids. However, all of this manure is not expected to be released to Windsor Creek within the next four years. To calculate the credits for sediment-attached nutrient loading, the RUSLE equation was applied to the physical attributes of the stacking piles. The credit calculation insert below shows the application of RUSLE to the site. RUSLE supporting materials are listed alongside the applied coefficients. Using a topographic map of the site, the slope lengths of the manure stacking piles were found to average 12 feet, generating a LS factor of 1.84.

Area Served:		3	acres	
Soil Information:				
	Classification:	Huichica	Loam	Htc
	Hydrologic Group:	D		
RUSLE estimate factors:				
	R Factor:	**120**		**Soil identified as a C; manure pack/compaction assumed a D rating**
	K Factor:	**0.1**		**From EPA Rainfall Erosivity Factor Fact sheet**
	LS Factor	**1.84**	**12 foot length**	**Sites at: http://cfpub.epa.gov/npdes/stormwater/lew/lewcalculator.cfm**
	C Factor	**0.42**		**From NRCS Web Soil Survey at: http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm**
	P Factor	**1**	**(no practice)**	**From Guidelines for the Use of the Revised Universal Soil Loss Equation (RUSLE) Version 1.06 on Mined Lands, Construction Sites, and Reclaimed Lands**
	A= R*K*LS*C*P	**9.27**	**tons/acre/year**	**From Guidelines for th (if less than 1 ton/acre/year, use 1)**
	Erosion Rate:	**9.27**	**tons/acre/year**	
	Field Condition:	Poor		

Manure samples are pending at the site. However, dairy separated solids nutrient contents were estimated using the Pacific Northwest Extension publication PNW0533 (Pacific Northwest Extension, 2000). The nutrient content of manure separated solids is estimated to be 5 lbs per ton for nitrogen and 0.9 lbs per ton for phosphorus. In order to use the PA calculation method, the manure nutrient content was converted into metric units of 2.5 kg TN /ton and 0.45 kg TP /ton.

The eroded material is manure separated solids. Therefore, the sediment-attached nutrient calculations are derived by adjusting equation 16 to generate equation 16a, which can be used to calculate both nitrogen and phosphorus.

ESP = SPC * SEDE * 2.205 * EF **(EQ. 16a)**

Where:

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

Next, equations 18 through 23, presented in the calculation discussion for BMP #2, are used to predict the soluble phosphorus loss from the manure separated solids stacking piles. The calculation of equation 16a and 18 through 23 is presented in the following insert.

Eroded/Particulate Attached			
TN	**306.7**	**lbs per year**	
TP	**55.2**	**lbs per year**	
Soluble	**TP**		
Soluble P Concentration	269	ug/L (microgram/liter OR ppb)	
Average Annual Runoff	1,866,671	L/ac	Using 18.16 inches annual average runoff
Background Dissolved P Loss	501,243,054	ug/ac	
Background Dissolved P Loss	**1.1**	lbs/ac	
Total TP	**56**	lbs/ac	
		Additional conservative assumption; soluble nutrient loading not credited	

The sediment delivery ratio and bioavailability factors were applied as margins of safety to the crediting equations. The distance from the manure separated solids stacking piles and Windsor Creek is 85 feet. The sediment delivery ratio is 39.88 percent. The sediment delivery ratio equation 26 was applied to both nutrients in equations 30 and 31.

306.7 (lbs of TN) * 0.3988 (SDR) = 122.3 (lbs TN) **[EQ 30]**

56.3 (lbs of TP) * 0.3988 (SDR) = 22.5 (lbs TP) **[EQ 31]**

The final step in calculating the credits for BMP #3 is to apply the bioavailability factor for nitrogen and phosphorus. The differences in nitrogen bioavailability between wastewater effluent and manure can be addressed by applying the 0.85 ratio, as described in BMP #1. The difference in phosphorus bioavailability between wastewater effluent and manure can be addressed by applying the 0.935 ratio, as described in BMP #1

122.3 (lbs TN) * 0.85 (ratio) = 104.0 TN credits per year **[EQ 32]**

22.5 (lbs TP) * 0.935 (ratio) = 21.0 TP credits per year **[EQ 33]**

This BMP #3 calculation summary completes the descriptions for all three proposed BMPs for the Nunes - Ocean View Dairy Site as part of this memorandum.

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Table 2. Manure Type and Average Nitrogen Concentrations.

Manure Type	Average N Concentration		Units
Dairy- Lactating Cows Liquid	28	lbs/1,000 gallons	1,000 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 3. 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 >50ºF 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 <50ºF 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 4. 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 5. Phosphorus Application Factors.

Application Method	April-Oct	Nov-March
	Phosphorus Application 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 6. Nutrient Content of Manure and P Source Coefficients.

Manure Type	Average P Concentration			P Source Coefficient	P Source Coefficient Applied[1]
	Phosphate	Phosphorus	Unit		
Dairy- Lactating Cows Liquid	13	5.59	lbs P/1,000 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

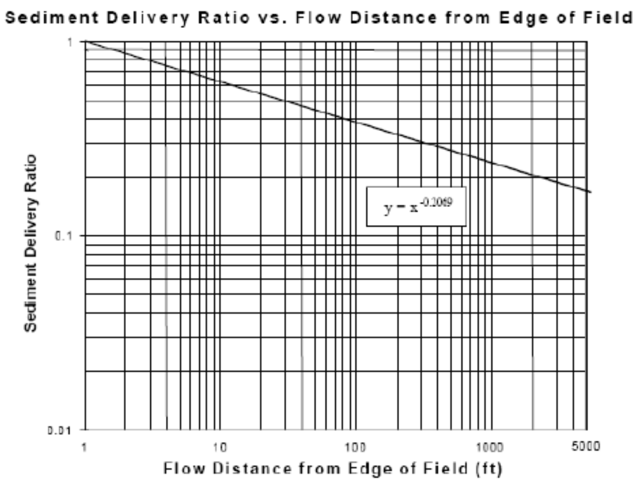

Figure 1. Sediment Delivery Ratio.

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]

(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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City of Santa Rosa RESPONSES (in RED) to Regional Board Request for Information for the City's Nutrient Offset Proposal for Nunes Ocean View Dairy. November 14, 2012

I have reviewed the City's Nutrient Offset Proposal for the Nunes Ocean View Diary. I have the following questions and requests:

1. The proposal mentions on page 3, paragraph 4, that a "detailed crediting summary" that is to be provided under separate cover. I did not receive any documents other than the Project Description.

   The Nunes Ocean View Dairy Summary of Best Management Practice Reduction Estimation Methods for City of Santa Rosa Nutrient Offset Program Credits is being submitted under separate cover.

2. The site assessment completed by Erickson Engineering is said to estimate that there are 3-5 five years of forage production in the manure stockpiles. Does this estimate account for the presence of only 6 dairy cows? Does the low number of dairy cows present over the minimum 4 year crediting period affect the nutrient balance (i.e., will the low number of grazing animals reduce the removal of nitrogen out of the system)?

   Manure stockpiles represent years of dairy production manure accumulation for an animal herd ranging between three hundred to four hundred head. Manure stockpiles were not adequately managed in a manner that accomplished annual land application of the produced manure either onsite or offsite. Thus, the large stockpiles are from historic production. Manure from the remaining six breeding stock to be left on-site will be managed appropriately and separately from proposed BMP crediting practices addressing remaining historic stockpiles.

   As such, the manure production from the six head is not factored into the credit life estimate, but will be land applied using agronomic rates. The minimum four-year time estimate accounts for on-site application at agronomic rates of only the historic/existing manure accumulated in the stockpiles. No credits are assigned to the six head. The proposed crediting period for the historic stockpiles represents a conservative credit life assumption. Application of this manure on available fields at agronomic rates will require portions to be applied across three to five years according to the Erickson Engineering, Inc., report. In addition, the calculations in the Erickson report do not include the land application of manure from the lagoons that will also need to be agronomically applied. Consideration of this additional manure makes the estimated credit life of four years a conservative estimate.

   The pasture uptake of nutrients from both the lagoons and separated solids piles will be adequate if operated for hay or silage production during the crediting period which is stated in the proposal to be a minimum of four years. Harvesting the biomass will remove the nutrients at rates similar to or greater than that of grazed pastures. The credit estimate does not include additional nutrient reductions for the continued site exclusion of a dairy herd during the project life. As such, 1) the credit life is a reasonable minimum period given the volume of separated solids, scraping the pens and emptying the manure lagoons; 2) the credit life will not be extended due to the additional amount of manure generated by the six head during the project period; and, 3) all credits awarded are based on historic applications and none are based on applications that will occur from the six head.

3. The 2012 site examination conducted by Erickson Engineering is used as a reference for rainfall runoff and information related to the nutrient balance. Can you provide a copy of the Erickson Engineering report, or the relevant parts of the report?

   The Erickson Engineering, Inc., site assessment report was based in part upon an Excel workbook entitled “20309 Ocean View” and this file accompanies this response. In this workbook, the worksheet “Ocean View” presents the rainfall calculations in columns A through J, rows 77 through 82. This workbook also provides the basis for the manure separated solids volume and lagoon capacity estimations.

4. Each year during the project the reduced accumulated volume of waste in the manure ponds lessens the potential that the remaining contents of the pond will discharge to surface waters. I note that there is a 40% discount factor for nitrogen and 30% for phosphorus for years 2-4. Do these discount factors account for the lower potential for discharge and wouldn’t the discount factors increase each year given the lower potential each year through the end of the project?

   Yes, the discount factors in years 2 through 4 acknowledge a reduction in nutrient concentrations. Although the concentrations are expected to diminish, there is no equation available to calculate the rate of decrease. Therefore, the same conservative factors were applied in years 2 through 4. However, additional margins of safety were built into the calculations to account for this uncertainty. Therefore, the discount factors and overall credit calculation method reflect a conservative credit estimate.

   Several factors contribute to the potential decrease in concentration, including the fact that no new manure will be added to the manured open lots during the credit generation period (the dairy will not be operating). In addition, the concentration could decrease due to the possibility of reduced solids transport and a reduction in the nitrogen concentration of the manure if the top of the lagoon becomes temporarily aerobic.

   With the cattle being excluded, the lagoons would only receive legacy manure from open lot facilities on the dairy site. The proposed project will remove manure from these open concrete and unpaved corrals, as well as establish appropriate perennial cover for protection of the lagoons during their temporary closure. The nutrient load reduction estimates consider the combination of open lot BMPs and the proper management of existing manure within the lagoons (removal and land application). Erickson Engineering estimated that stormwater flow from manured open lots (corrals and pens) contributes 71.9 percent of the total waste volume requiring lagoon storage. The current lagoons only provide 41 percent of the needed capacity to store a waste volume associated with the previous herd size. As a result, flow from the manured areas would enter the lagoon system and overtop the lagoons, even without the addition of the barn flushing system and parlor wash water.

Without cattle on the site, over time the nutrient concentration in the flow from manured open lots will diminish. A study by Gilley *et al*. (2012)[1] indicated that nutrients from consolidated feedlot surfaces exposed to stormwater runoff have a nearly constant rate of phosphorus loss. The same study found that total nitrogen loading increases in linear fashion with flow rates. Both of these findings assumed a constant source of manure. However, when runoff events occurred on plots where new manure was not added, this controlled study observed a reduction in loading. A literature review completed by Koelsch *et al*. (2006)[2] further characterized open lot runoff loading. This review found that runoff from open beef cattle lots averaged 5,800 ppm TN and 1,200 ppm TP. Waste from dairy cattle has a higher strength than waste from beef cattle. Using the average concentrations gathered in this review, the nutrient loading from open lot runoff associated with an operating Nunes dairy site would generate approximately 51,000 pounds of phosphorus and 246,000 pounds of nitrogen annually.

As stated earlier, with the cattle removed and no new manure inputs, this initial loading is expected to diminish over time. However, there are no reliable estimates regarding the rate of decrease and therefore 30 percent and 40 percent were applied to all years 2 through 4. This inability to estimate annual decreases in nutrient concentration from open lot runoff is compensated for by conservative estimates that were built into the reduction estimation and credit calculation process. The manure areas initially generate nutrient loading that is more than 1.55 times the load estimate provided in the proposal, before a discount is applied. The combined implicit and explicit margins of safety result in an edge-of-field loading estimate that in subsequent years is 62 percent lower for nitrogen and 55 percent lower for phosphorus compared to the initial nutrient loading estimates. Therefore, although the annual loading estimate does not reflect a reduced load each year, using the discount factors as an average for all three years remains conservative approach to crediting this BMP application.

In summary:

- The lagoon cleanout and land application will include removal of accumulated manure in open lots from the previous herd and establishment of conservation cover as appropriate
- Without the proper management provided by this project, the manured area would continue to generate stormwater that has come in contact with manure
- The nutrient content of the stormwater from these areas is expected to diminish over time as the herd has been removed
- An estimation method is not available to specifically calculate the annual decrease for years two, three and four
- A implicit margin of safety was applied to the stormwater loading entering the lagoon in years two, three and four
- An additional explicit discount factor of 40 percent further reduction for nitrogen and 30 percent further reductions of phosphorus is applied

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[1] Gilley, J.E., Vogel, J.R, Eigenberg, R.A., Marx, D.B., Woodbury, B.L. 2012. Nutrient losses in runoff from feedlot surfaces as affected by unconsolidated surface materials. J. of Soil and Water Conservation. May-June 2012. Vol. 67, pp 211-217

[2] Koelsch, R.K., Lorimer, J., Mankin, K. 2006. Vegetative Treatment Systems for Open Lot Runoff: Review of Literature. *Conference Presentations and White Papers: Biological Systems Engineering.* Paper 5. http://digitalcommons.unl.edu/biosysengpres/5

- The estimation process applies a cumulative reduction of 62 percent for nitrogen and 55 percent for phosphorus as an average result across all subsequent years

5. Is the proposal to completely empty the manure ponds and remove the stacks of manure? If all manure is not removed at the end of the project, can storm water contacting the manure remaining in the stacking area and collecting in the manure ponds still be considered agricultural storm water, as suggested on page 8, paragraph 2?

   The crediting is based on full removal of all liquids and solids in the lagoons, plus full removal of all separated solids in the stacking piles and establishment of a perennial cover in the stacking area. The six cows present on the site would generate a minor amount of additional solids that can be incorporated into the separated solids pile during the beginning of the operation. In future years, the site would switch to an approved solids management system based on the WMP and NMP requirements.

6. In credit calculations for BMP No. 3, the current condition is compared to an after-project condition, which includes the "natural re-establishment of the riparian corridor buffer." Because the City is not proposing to re-establish the riparian corridor, the City should not include the nutrient removal that results for the "natural" process.

   The credit calculations do not credit the benefits of a riparian corridor buffer. The project schedule will implement interim BMPs preventing a discharge of runoff that has been in contact with manure solids (e.g., berms, solids pile relocation to a safer area and/or perennial cover on the stacking area). The physical characteristics of the site create a riparian corridor. The features include the Windsor Creek flood plain area and adjacent bluff slope that rises up to the production area of the dairy. BMPs will protect this corridor during the crediting period. In addition, a Waste Management Plan (WMP) will be created within the project period that will specify adequate long-term operation of the dairy to prevent production area discharges. The owner will be responsible for compliance with the WMP. The proposal reference to "natural re-establishment of the riparian corridor buffer" refers to the natural occurrence of vegetation growth in setback areas even though the area does not have enhanced management for plantings and is not assigned any treatment value.

7. In crediting methods for BMP No. 3 (Attachment A), it's not clear to me how the values for "Eroded/Particulate Attached" are calculated. My calculation (tons/ac-yr)(kg/ton)(lb/kg)(acres) results values ½ the values calculated in the spreadsheet. Please explain.

   The calculation includes a nutrient enrichment ratio. In the Pennsylvania method, Evans (2002)[3], provides guidance that phosphorus enrichment should be a factor of two. Examining other approaches to enrichment factors shows that this is a conservative estimate. The PA enrichment equations are documented in CREAMS[4] (A Field Scale Model for Chemicals,

[3]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.

[4] Kinsel, W. G., et. al. 1980. CREAMS : Chemicals, Runoff, and Erosion from Agricultural Management Systems. Volume 1 Model Documentation.

Runoff, and Erosion from Agricultural Management Systems) model documentation. This documentation states that organic nitrogen forms associated with soils enrich at even higher rates than the phosphorus forms associated with soils. The Michigan DEQ document entitled "Pollutant Controlled Calculation and Documentation for Section 319 Watersheds Training Manual" (1999)[5] indicates the enrichment of nitrogen associated with soil erosion at 9 tons/acre to be three times that for peat soils. Peat is used in this comparison due to the high organic material content. The EPA Region 5 Load Estimation Spreadsheet Model (2009)[6] is based on this Michigan document. Based on this assessment of other enrichment factors, multiplying by a factor of two is considered conservative.

8. Can you provide an excerpt of the document "Manure Characteristics: Manure Management System Series" to verify that the values used in the spreadsheet and to document that any assumptions for using the numbers have been met.

The requested excerpts are provided below. The Nunes Ocean View proposal section entitled "Proposed Credit Generating Practices" provides the entire list of references used. In addition, nutrient content variability from site to site or time to time can be substantial. The potential for variation in nutrient concentrations has been acknowledged, and the City has collected representative site-specific soil and manure samples, as described in the proposal (and results are pending):

> "Attachment A to this document presents a summary of the credit calculations examined for these proposed practices at this dairy. These calculations assume nutrient content and concentration values based on published animal livestock research. The publications that were used to supply these estimates are widely recognized as the industry's leading source of accurate information and/or are developed for assessing and designing livestock environmental controls in other states. Site-specific sampling is being pursued by the City and thus, credit calculations may be adjusted and later communicated with the Regional Board."

The manure characteristics used in the calculations are provided in the following Tables 1, 6 and 7 from the Midwest Plan Service document.

Table 1. Variations in unagitated lagoons.
Case studies from one swine and one dairy single-stage lagoon. Sampling depths of 2 feet and 14 feet. Lagoon depth is 18 to 20 feet. Based on data presented in *Livestock Waste: A Renewable Resource*, 1980, pg. 254 to 256.

		Swine		Dairy	
Component	Unit	2 ft Depth	14 ft Depth	2 ft Depth	14 ft Depth
Total solids (TS)	lbs per 1,000 gal	20	170	135	265
Volatile solids (VS)	lbs per 1,000 gal	10	85	90	177
Nitrogen (N)	lbs per 1,000 gal	4	10	3	7
Ammonical Nitrogen (NH_4-N)	lbs per 1,000 gal	3	6	3	2
Phosphorus (P_2O_5)	lbs per 1,000 gal	2	15	4	7
Potassium (K_2O)	lbs per 1,000 gal	5	8	6	8

[5] Michigan Department of Environmental Quality. 1999. Pollutants Controlled Calculation and Documentation For Section 319 Watersheds Training Manual. Accessed November 14, 2012 at: http://www.michigan.gov/documents/deq/deq-wb-nps-POLCNTRL_250921_7.pdf
[6] US EPA. 2009. Region 5 Load Estimation Spreadsheet Model. Accessed November 14, 2012 at: http://it.tetratech-ffx.com/steplweb/models$docs.htm

Table 6. Daily manure production and characteristics, as-excreted (per head per day)[a].

Values are as-produced estimations and do not reflect any treatment. Use these values only for planning purposes. The actual characteristics of manure for individual situations can vary ± 30% or more from table values due to genetics, dietary options and variations in feed nutrient concentration, animal performance, and individual farm managment.

	Size[a]	Total manure[b]			Water[c]	Density[c]	TS[d]	VS[c]	BOD_5	Nutrient content		
Animal	**(lbs)**	**(lbs)**	**(cu ft)**	**(gal)**	**(%)**	**(lb/ft³)**	**(lb/day)**	**(lb/day)**	**(lb/day)**	**(lbs N)[d]**	**(lbs P_2O_5)[d]**	**(K_2O)**
Dairy												
Calf	150	12	0.18	1.38	88	65	1.4	1.2	0.19	0.06	0.01[c]	0.05
	250	20	0.31	2.30	88	65	2.4	2.0	0.31	0.11	0.02[c]	0.09
Heifer	750	45	0.70	5.21	88	65	6.7	5.7	0.69	0.23	0.08[c]	0.23
	1,000	60	0.93	6.95	88	65	8.9	7.6	0.92	0.30	0.10[c]	0.31
Lactating cow	1,000	111	1.79	13.36	88	62	14.3	12.1	1.67	0.72	0.37[c]	0.40
	1,400	155	2.50	18.70	88	62	20.0	17.0	2.34	1.01	0.52[c]	0.57
Dry cow	1,000	51	0.82	6.14	88	62	6.5	5.5	0.75	0.30	0.11[c]	0.24
	1,400	71	1.15	8.60	88	62	9.1	7.7	1.04	0.42	0.15[c]	0.33
	1,700	87	1.40	10.45	88	62	11.0	9.3	1.27	0.51	0.18[c]	0.40
Veal	250	6.6	0.11	0.79	96	62	0.26	0.11	0.04	0.03	0.02	0.05[d]
Beef												
Calf (confinment)	450	48	0.76	5.66	92	63	3.81	3.20	1.06	0.20	0.09	0.16
	650	69	1.09	8.18	92	63	5.51	4.63	1.54	0.29	0.13	0.23
Finishing	750	37	0.59	4.40	92	63	2.97	2.42[d]	0.60	0.27	0.08	0.17
	1,100	54	0.86	6.46	92	63	4.35	3.55[d]	0.89	0.40	0.12	0.25
Cow (confinment)	1,000	92	1.46	10.91	88	63	11.0	9.38	2.04	0.35	0.18	0.29
Swine												
Nursery	25	1.9	0.03	0.23	89	62	0.21	0.17	0.06	0.02	0.01	0.01
	40	3.0	0.05	0.37	89	62	0.33	0.27	0.10	0.03	0.01	0.02
Finishing	150	7.4	0.12	0.89	89	62	0.82	0.65	0.23	0.09	0.03	0.04
	180	8.9	0.14	1.07	89	62	0.98	0.78	0.28	0.10	0.04	0.05
	220	10.9	0.18	1.31	89	62	1.20	0.96	0.34	0.13	0.05	0.06
	260	12.8	0.21	1.55	89	62	1.41	1.13	0.41	0.15	0.05	0.08
	300	14.8	0.24	1.79	89	62	1.63	1.30	0.47	0.17	0.06	0.09
Gestating	300	6.8	0.11	0.82	91	62	0.61	0.52	0.21	0.05	0.03	0.04
	400	9.1	0.15	1.10	91	62	0.82	0.70	0.28	0.06	0.04	0.05
	500	11.4	0.18	1.37	91	62	1.02	0.87	0.35	0.08	0.05	0.06
Lactating	375	17.5	0.28	2.08	90	63	1.75	1.58	0.58	0.17	0.11	0.13
	500	23.4	0.37	2.78	90	63	2.34	2.11	0.78	0.22	0.15	0.18
	600	28.1	0.45	3.33	90	63	2.81	2.53	0.93	0.27	0.18	0.21
Boar[c]	300	6.2	0.10	0.74	91	62	0.57	0.51	0.20	0.04	0.03	0.03
	400	8.2	0.13	0.99	91	62	0.75	0.67	0.26	0.06	0.05	0.05
	500	10.3	0.17	1.24	91	62	0.94	0.84	0.33	0.07	0.06	0.06
Poultry												
Broiler	2	0.19	0.003	0.023	74	63	0.050	0.038	0.011	0.0021	0.0014	0.0010
Layer	3	0.15	0.002	0.017	75	65	0.037	0.027	0.008	0.0026	0.0008	0.0012
Turkey (female)	10	0.47	0.007	0.056	75	63	0.117	0.088	0.034	0.0078	0.0051	0.0034
Turkey (male)	20	0.74	0.012	0.088	75	63	0.186	0.139	0.054	0.0111	0.0074	0.0048
Duck	4	0.44	0.007	0.053	73	62	0.118	0.089	0.016	0.0043	0.0034	0.0026
Sheep												
Feeder lamb[c]	100	4.1	0.06	0.5	75	63	1.05	0.91	0.10	0.04	0.02	0.04
Horse												
Sedentary	1,000	54.4	0.88	6.56	86[d]	62	7.61	6.5	1.52	0.18	0.06	0.06[d]
Intense exercise	1,000	55.5	0.90	6.70	86[d]	62	7.78	6.6	1.56	0.30	0.15	0.23[d]

TS = total solids; VS = volatile solids; BOD_5 = the oxygen used in the biochemical oxidations of organic matter in five days at 68 F, which is an industry standard that shows wastewater strength.

[a] Use linear interpolation to obtain values for weights not listed in the table.

[b] Calculated using TS divided by the solids content percentage.

[c] Based on MWPS historical data.

[d] Values calculated or interpreted using diet based formulas being considered for the ASAE Standards D384: *Manure Production and Characteristics.*

Table 7. Estimated liquid pit manure characteristics.
Use only for planning purposes. These values should not be used in place of a regular manure analysis

Livestock Stages	Production						Concentration			
	Manure	Total N	NH_3-N	P_2O_5	K_2O	Units	Total N	NH_3-N	P_2O_5	K_2O
	(lb/yr)						lbs/1,000 gallons of manure			
Farrowing	11,500	21	11	17	15	per pig space	15	8	12	11
Nursery	1,000	3	2	2	3	per pig space	25	14	19	22
Grow-Finish (deep pit)	3,500	21	14	18	13	per pig space	50	33	42	30
Grow-Finish (wet/dry feeder)	2,500	17	12	13	12	per pig space	58	39	44	40
Grow-Finish (earthen pit)	3,500	13	10	9	8	per pig space	32	24	22	20
Breeding-Gestation	9,100	27	13	27	26	per pig space	25	12	25	24
Farrow-Finish	37,500 2,000	126 7	72 4	108 6	103 6	per production sow per pig sold per year	28 28	16 16	24 24	23 23
Farrow-Feeder	10,000	25	13	22	23	per production sow	21	11	18	19
Dairy Cow	54,000	200	39	97	123	per mature cow	31	6	15	19
Dairy Heifer	25,000	96	18	42	84	per head capacity	32	6	14	28
Dairy Calf	6,000	19	4	10	17	per head capacity	27	5	14	24
Veal Calf	3,500	11	9	9	17	per head capacity	26	21	22	40
Dairy Herd	73,000	271	53	131	193	per mature cow	31	6	15	22
Beef Cows	30,000	72	25	58	86	per mature cow	20	7	16	24
Feeder Calves	13,000	39	12	26	35	per head capacity	27	8	18	24
Finishing Cattle	25,500	89	24	55	79	per head capacity	29	8	18	26
Broilers	83	0.63	0.13	0.40	0.29	per bird space	63	13	40	29
Pullets	49	0.35	0.07	0.21	0.18	per bird space	60	12	35	30
Layers	130	0.89	0.58	0.81	0.51	per bird space	57	37	52	33
Tom Turkeys	282	1.79	0.54	1.35	0.98	per bird space	53	16	40	29
Hen Turkeys	232	1.67	0.56	1.06	0.89	per bird space	60	20	38	32
Ducks	249	0.45	0.24	0.36	0.33	per bird space	22	5	15	8

Rev 12.07.2011

Dairy Waste Management System Evaluation

Date: 17-Dec-12
Time: 1:16 PM
Rev: 10-Mar-12

Ocean View Dairy - Marvin L. Nunes
Dairy ranch

3975 Mark West Station Road, Windsor CA
Address

707.528.3545
Green boxes are for data entry
All cells are unprotected

1. Milk String Confinement Equivalent Days Estimation

Season	Weeks per year	Hours per Day: milk barn	Stall barn	inside feed bunk	outside feed bunk	pasture	
Winter	8.1	4	16	4	0	0	24 hr
Spring	20	4	16	4	0	0	24 hr
Summer	8	4	16	4	0	0	24 hr
Fall	16	4	16	4	0	0	24 hr
Total Weeks	52.1						365 days
Equiv Confined Days/year		61	243	61			
Manured/unconfined Days/year					0		
Equiv Unconfined Days/year						0	

2. Animal Waste Production

Animal Group		No. of Animals	Weight 1000 lb. un	Equivalent Days Confined	Equivalent Days Unconfined	Gallons Manure/ 1000lb./day	Annual Manure Prod Acre-feet Confined	Annual Manure Prod Acre-feet Unconfined	
Milk Cows	high string	230	322.0	365	0	**14.8**	5.33	0.00	
1400 lbs.	low strings	100	140.0	365	0	**14.8**	2.32	0.00	
Dry Cows (1.5/12 of mi 1400 lbs.		40	56.0	30	335	**10.0**	0.05	0.57	
2yr->springer 900-1500 lbs.		80	96.0	0	365	**7.0**	0.00	0.75	large heifers pastured
Med. Heifers 500-900 lbs.		80	56.0	0	365	**4.8**	0.00	0.30	pastured
Smal Heifers 250-500 lbs.		80	30.4	365	0	**1.7**	0.06	0.00	pastured
Baby Calves 100-250 lbs.		83	14.0	365	0	**1.7**	0.03	0.00	calf pen
On Site Totals		610	700				7.79	1.63	

3. Total Animal Waste

9.41 Acre Feet

4. Additions to the Confinement Waste Management System:

Notes:

3	20T loads/year sand
4	20T loads/year straw

Assume 0.5% of 50lb ration/day, milk strings
at 40 lb/cu ft

Imported manure, whey, other

	Units/Year	Acre Feet	
Animal Bedding Makeup sand	60.0 tons	0.02	recycled fron
Animal bedding Straw/organic	80.0 tons	0.09	assumed, pe
Damaged feed or silage	15.1 tons	0.02	40 lb/ft^3 der
External inputs	0 10 cy loads	0.00	
Dry lot scrapings plus imports to compost pile	20 10 cy loads	0.12	
Subtotal		0.26	

5. Wash and Process Water Produced Annually

			Rate Gal/min	Use Hr/day	Gal/Day	Ac/ft per yr	Percent of Total
Milking System Wash Water					200	0.22	21.3
Milking System Backflush @ .25 gal/unit					165	0.18	17.6
Milk Tank Wash Water					60	0.07	6.4
Milk claw Wash Water		Gal H2O/cow	0.25		165	0.18	17.6
		Milkings/day	2				
Sprinkler Pen Water					0	0.00	0.0
Milking Parlor Wash Water			5	1.00	300	0.34	31.9
Recycled wash water, per day			0	0.00	0	0.00	0.0
Vacuum Pump Water			0	0	0	0.00	0.0
Air Comp/Milk Cooler Water			0	0	0	0.00	0.0
Leaking troughs, other losses			0	24	0	0.00	0.0
Spring flows to manure storage			0	24	0	0.00	0.0
Flush System Added Water				Calf pen cleanup	50	0.06	5.3
				days/year	365		
Total Wash and Process Water					940	1.05	100.0
					Gal/day	Acre Feet	

Section IV. Rain Water Additions to Waste System

Rainfall Data for Discretionary Design

Local average annual rainfall, inches	36.0	Local average per SCWA isohyetal map, rev June 83.	**5.4**	25-year, 24-hr storm Inches @ 3.8*(local avg/25.5) @ Petaluma.
10-year Wet-Winter Annual Rainfall, inches	53.6	10-year wet winter prorated based on 46-year Petaluma data with 38.0" 10-year wet winter relative to 25.5" avg annual rainfall (O'Connor, 2000).		

Rainfall Runoff Entering Waste Management System

Surface areas from Areas tab	Acres	Runoff Coefficient	Average Acre-feet	Wet Acre-feet	
Manured Concrete	0.23	1.00	0.68	1.01	
Silage Pad Runoff	0.52	1.00	1.57	2.33	
Manure Storage, liquid	2.09	1.00	6.26	9.33	
Manured non-concrete	3.11	0.50	4.67	6.96	
Crop/pasture	2.03	0.40	2.44	3.64	
Total watershed area	7.46		15.62	23.27	10-year Winter Storage Required
				3.34	25 year, 24-hour Storage Required

Pump size required to handle 25 year, 24-hour storm:

Hours pumped per day	Days pumped	Required Pump size, Gal/min	Pump Size OK? Pump period available? (Y/N; caps only)
12	4	378	N

Section V. Total Annual Waste Flows

Total System Evaluation

Estimate Annual Waste Storage Requirement at Dairy

	Acre Feet	Percent of Total	
On-Site Animal Waste	7.79	24.1	
Off-site additions to system Bedding, feed, liquids	0.26	0.8	
Wash and Process Water	1.05	3.2	
Manured-area Rainfall, 10-year wet winter	23.27	71.9	
Subtotal - Annual wastewater volume	32.37	100.0	baseline

Storage Reduction Adjustments

	Unit	Input	Reduction Acre-Feet	Adjusted Storage Volume Acre-Feet	Adjusted Storage Volume % of Total
Evaporation	Feet	3.00	6.26	26.10	80.7
Pond drained before use?	Feet	0.0	0.00	26.10	80.7
Solids Separation Mech. Manure Separation? (Y/N; caps only)	12% reduction	Y	0.93	25.17	77.8
Slurry Transport	Gal/load	4000			
Daily drawdown of sump or pond	Load/day	0	0.00	25.17	77.8
independent of annual cleanout	Day/yr	180			
Solids Transport	Cu Yd/load	10	0 loads/year		
Compost or solids removal	Load/day	0	0.00	25.17	77.8
independent of annual cleanout	Day/yr	20			
Irrigation Disposal	Gal/min	200	0 loads/year		
Daily drawdown of sump or pond	Hr/day	0.0	0.00	25.17	77.8
independent of annual cleanout	Day/year	30.0			

	Acre-Feet	% of Total
Add 25-year, 24-hour storm runoff if insufficient pump capacity or cycle time	3.34	10.3
Total Annual Waste Flows **Requiring Storage Capacity**	28.51	88.1

Section VI. Evaluate Capacity of Existing Storage System

	Acre Feet
Waste Storage Capacity	
Design storage capacity of waste ponds. (from Areas worksheet)	18.00
Design storage capacity of other facilities. (add, if any)	
Total Storage Capacity (Add cells 19,21)	18.00
Waste Storage Capacity Reductions (Incomplete annual pond cleanout, etc)	15.00
Manure Handling and Storm Water Management Capability	
Working Storage Capacity (cell 3-cell 4)	3.00

Calculation indicates that: **Manure Production Exceeds Storage Capacity** Additional Capacity Required: **25.5** Acre-Feet	**Total Capacity Required** **28.5** Acre-Feet

Dairy Pond Size Estimation - Data Summary Sheet

Ocean View Dairy - Marvin L. Nunes 707.528.3545 17-Dec-12
3975 Mark West Station Road, Windsor CA 1:16 PM

Unconfined manure production		1.63 acre feet				
Confined manure production		7.79 acre feet			**7.79**	acre-feet
Total waste production		9.41 acre feet				
Additions to the Confinement Waste Management System						
Animal Bedding	Makeup sand	0.02 acre feet				
	Straw/organic	0.09 acre feet				
	External inputs	0.00 acre feet			**0.26**	acre-feet
	Damaged feed	0.02 acre feet				
	Milking System Wash Water	0.29 acre feet				
	Milking System Backflush @ .25 gal/unit	0.18 acre feet				
	Milk claw Wash Water	0.18 acre feet				
	Sprinkler Pen Water	0.00 acre feet				
	Milking Parlor Wash Water	0.34 acre feet	940 gal/day		**1.05**	acre-feet
	Recycled wash water, per day	0.00 acre feet				
	Vac Pump/Air Comp/Cooler	0.00 acre feet				
	Leaks/Springs	0.00 acre feet			**9.09**	af wastewate
	Flush System Added Water	0.06 acre feet			28	% of total

Rainfall Data for Discretionary Design	Acres	Coefficient	runoff, ac-ft		Design rain **53.6**	Avg rain 36.0
Manured Concrete	0.23	1.00	1.01			
Silage Pad Runoff	0.52	1.00	2.33			
Manure Storage, liquid	2.09	1.00	9.33			
Manured non-concrete	3.11	0.50	6.96			
Crop/pasture	2.03	0.40	3.64		ac ft	ac ft
Total Runoff	7.46	na	23.27		**23.27**	15.62
Subtotal - Annual wastewater volume				Total:	**32.37**	24.71
Evaporation:					-6.26	-6.26
Solids separator:					-0.93	-0.93
Pond drawdown:					0.00	0.00
Slurry Transport	4000	Gal/load	0 loads/yr		0.00	0.00
Solids Transport	10	Cu Yd/load	0 loads/year		0.00	0.00
Irrigation Disposal	200	Gal/min	0 hr/yr		0.00	0.00
Adjusted storage volume, acre-feet per year:				-7.19	**25.17**	17.52
5.36 inches	25-year, 24-hr storm	Inches @ 3.8*(local avg/25.5) @ Petaluma.				
	Pump size required to handle 25 year, 24-hour storm:				**3.34**	2.24
	12 hr/day					
	4 day/yr		378 gal/min			
Total Annual Waste Flows Requiring Storage Capacity					**28.51**	19.75

Waste Storage Capacity

Design storage capacity of waste ponds.	18.00	acre-feet
Design storage capacity of other facilities.	0.00	acre-feet
Waste Storage Capacity Reductions	15.00	acre-feet
Working Storage Capacity	**3.00**	acre-feet

Calculation indicates that:

Manure Production Exceeds Storage Capacity

Additional Capacity Required: **25.5** Acre-Feet

Total Capacity Required

28.5 Acre-Feet

Runoff and Pond Areas Calculation Worksheet

Ocean View Dairy - Marvin L. Nunes Date: 17-Dec-12
3975 Mark West Station Road, Windsor CA Time: 1:16 PM
Measure areas and report in the space provided. Rev: 11-Mar-12

1. Concrete Manured Areas; 100% runoff coefficient

Includes feed lots, alley ways, holding corrals, sick pens, calf lots, compost piles, solids storage areas, outside loafing areas, and similar hardened or manured areas with 100% runoff to manure storage

Area	Width	Length	Sq Ft	Location Notes	Acres
alley	20	492.5	9850	concrete alley between barns	0.23
			0		0.00
			0		0.00
			0		0.00
			0		0.00
			0		0.00
			9850 Square Feet	0.23 Acres	Used in Sec IV, Cell 4 Cell 3 / 43560.

2. Roof Areas; 100% runoff coefficient

Includes feed lots, alley ways, holding corrals, sick pens, calf lots, compost piles, solids storage areas, outside loafing areas, and similar hardened or manured areas with 100% runoff to manure storage

Area	Width	Length	Sq Ft	Location Notes	Acres
1	70	325	22750	silage pad, concreted	0.52
2			0		0.00
3			0		0.00
4			0		0.00
5					0.00
6			0		0.00
			22750 Square Feet	0.52 Acres	Used in Sec IV, Cell 4 Cell 3 / 43560.

3. Manure Pit and Liquid Storage Ponds: 100% catchment

Includes wastewater ponds, manure pits, flush water recycle ponds, manure sumps, etc.

Note: When measuring the waste storage capacity of ponds, include the capacity of pit(s) and other collection facilities. If more than one pond is used, measure all ponds. Allow for two feet of freeboard in the last pond when making measurements.

Pond/Pit	Width	Length	Sq Ft	**Avg** depth	Capacity	Location Notes	Acres
1	180	275.0	49500	8.8	10.00	Pond 1	1.14
2	150	276.0	41400	8.4	8.0	Pond 2	0.95
3			0		0.0		0.00
4			0		0.0		0.00
5			0		0.0		0.00
7			0		0.0		0.00
8			0		0.0		0.00
9			0		0.0		0.00
10			0		0.0		0.00
			90900 Square Feet	2.09 Acres	18.0 Acre-feet	Used in Sec IV, Cell 3, Section VI Cell 1	

Notes: Width and length adjusted to provide surface area per GPS and CAD-based aerial measurements
Average depth adjusted to provide spreadsheet-based capacity value based on surface area

4. Non-Concrete Manured Areas Draining to Storage

Includes tributary areas of clean water around barns and corrals that drain to manure ponds.

Area	Width	Length	Sq Ft	Location Notes		Acres
1	53.3	180	9600	corral 1		0.22
2	110.6	180	19900	corral 2		0.46
3	59.4	180	10700	corral 3		0.25
4	55.3	180	9950	corral 4		0.23
5	128.4	180	23120	manure storage 1		0.53
6	254.0	200	50800	manure storage 2		1.17
7	70	164.3	11500	manure storage 3		0.26
8			0			0.00
9			0			0.00
10						0.00
			135570 Square Feet	3.11 Acres	Cell 3 / 43560 Used in Sec IV, Cell 4	

5. Crop and Pasture Areas Draining to Manure Storage Areas

Includes tributary areas of clean water away from dairy that drain to manure ponds.

Area	Width	Length	Sq Ft	Location Notes		Acres
1	50	1062.8	53140	Pond tributary areas per CAD		1.22
2	100	355	35500	hillside west of barns		0.81
3			0			0.00
4			0			0.00
5			0			0.00
			88640 Square Feet	2.03 Acres	Cell 3 / 43560 Used in SecIV, Cell 9	

Nutrient Budgeting Worksheet

17-Dec-12 1:16 PM Rev: 10-Mar-12

This worksheet is intended to provide guidance for nutrient budgeting for management of manure produced by animals in both confined and unconfined conditions. It will partially fulfill facilities management plans as recommended by regulatory agencies.

Complete the **Producer** and **Area** worksheets prior to entering nutrient bugeting information. Provide inputs as required in empty green-shaded boxes in the Nutrient Bugeting worksheet. Calculation results are shown in non-shaded boxes.

Nutrient budgeting may include confined or unconfined animals, irrigated and non-irrigated land, fertilized or non-fertilized inputs, and may use lab or handbook data for stored manure nutrient values. **Several runs of this computer spreadsheet worksheet will be needed to evaluate confined animal manures, unconfined animal manures, and individual fields, either on-site or off-site, because of the large number of possible nutrient input combinations.** Take care when evaluating individual fields to include all inputs, and to eliminate duplicate accounting with such items as animals pastured elsewhere or fertilizer and irrigation water used elsewhere. Total ranch nutrient budgeting can be accomplished using total headcounts, acreages, etc., and will represent average conditions rather than site-specific conditions.

Results are based on a large number of input assumptions, and represent general nutrient budgeting trends, rather than an exact detail accounting of site-specific conditions. Detailed assessments will require concentration sampling and quantity measurements of soil, forage, crops, irrigation water, stored manure, and other inputs and outputs to the nutrient input, waste management, and nutrient consumption systems.

Section I. Producer Information

Ocean View Dairy - Marvin L. Nunes
3975 Mark West Station Road, Windsor CA 707.528.3545

Land Areas	On-Site Acres	Off-Site Acres	Total Acres
Total Property	172	0	172
Housing, corrals barn	17	0	17
Riparian, pond, swale, inaccessible	25		25
All Crop Lands	55		55
Pasture Lands Irrigated or dry	75	0	75

	Acres	Acres	Manure disposal Acres
Total Crop and Pasture	130	0	130

Section II: Pasture and Crop Nutrient Demand

Table 1. Plant Food Utilization by Various Crops

Total uptake in harvested portion. Reference: Table 4.1, Western Fertilizer Handbook

	Crop	Yield	N (Pounds per Acre)	P_2O_5 (Pounds per Acre)	K_2O (Pounds per Acre)
Field Crops	Corn - grain	5t/180bu	240	100	240
	Corn - silage	30t	250	105	250
	Grain sorghum	4t / 150bu	250	90	200
	Oats	1.6t/100bu	115	40	145
	Wheat	3t/100bu	175	70	200
	Barley	2.5t / 100bu	160	60	160
Fruit and Nut Crops	Apples	15t	120	55	215
	Grapes	15t	125	45	195
Forage Crops	Alfalfa	8t	480	95	480
	Bromegrass	5t	220	65	315
	Clover-grass	6t	300	90	360
	Orchardgrass	6t	300	100	375
	Sorghum-sudan	8t	325	125	475

Note: These paramete values may be adjustec as desired to best matc existing site conditions.

Change numbers in thi: table to adjust nutrient demands to reflect soils, slope, aspect, rainfall, other paramete affecting plant vigor an nutrient demand.

Timothy	4t	150	55	250
Vetch	7t	390	105	320
Coastal Dryland Pasture		200	80	175
Irrigated Pasture		275	90	300

Section III: Nutrient Composition of Manure

Nutrient concentration of manure depends on animal species and age, feed materials and additives, source of manure, storage method, length of storage, rainwater dilution, disposal method, and other factors. The most accurate nutrient budgeting estimates will be obtained if lab samples for nutrient concentration are taken from the storage area. A composite sample from several surface locations and depths within the storage is required for a representative value. The average table values shown from USDA-SCS Ag Waste Management Field Handbook are used for calculations if you do not provide site-specific nutrient concentrations.

Table 2. USDA-NRCS Ag Waste Handbook
Nutrients, lb/day/1000lb of animal

Nutrient Parameter	milking	dry	heifer
Nitrogen, N:	0.45	0.36	0.31
Phosphorous, P:	0.07	0.05	0.04
Potassium, K:	0.26	0.23	0.24
Copper, Cu:		22	

Table 3. Commercial Laboratory Analysis
of your stored liquid manure

	If available, enter data here	
Parameter	Milligrams/liter	Equivalent lb/gal
Nitrogen, N:		0.00000
Phosphorous, P:		0.00000
Potassium, K:		0.00000
Copper, Cu:		0.00000

Section IV. Annual Production of Animal Waste for All Livestock

Nutrient quantities stored in containment facilities are estimated in one of two ways:

1) USDA handbook N-P-K values are used with confined animal counts and manure production estimates obtained from the **Producer** worksheet.
2) If commercial lab analysis data for N-P-K is entered above, nutrient quantities are based on the lab concentration data times the pond storage volume obtained from the **Producer** worksheet.

Note that total nutrient quantity estimates in storage facilities may be significantly different using the two different approaches. Lab data from the storage pond will tend to be most accurate. This is because factors affecting nutrient concentration are taken into account, including seasonal dilution, process and wash water, actual manure quantities collected, external inputs to storage, changes during storage, and similar factors. Wide variation between individual facilities can be expected.

1. Handbook Method Animal counts from the companion **Producer worksheet** are multiplied by the appropriate table values for N, P, and K above to determine nutrient production.

Table 4. Unconfined Animal Nutrients
Production based on Handbook Values

	Unconfined	Total Pounds of Nutrients		
	Cubic Feet	N	P	K
Milk Cows	0	0	0	0
1400 lbs.	0	0	0	0
Dry Cows (1.5 1400 lbs.	25047	6754	938	4315
2yr->springer 900-1500 lbs.	32748	10862	1402	8410
Med. Heifers 500-900 lbs.	13099	6336	818	4906
Smal Heifers 250-500 lbs.	0	0	0	0
Baby Calves 100-250 lbs.	0	0	0	0
On Site Totals	70893	23952	3157	17630

Table 5. Confined Animal Nutrients
Production based on Handbook Values

Confined	Total Pounds of Nutrients		
Cubic Feet	N	P	K
232236	52889	8227	30558
100972	22995	3577	13286
2243	756	118	437
0	0	0	0
0	0	0	0
2518	4993	777	2885
1162	2304	358	1331
339131	83936	13057	48497

2. Lab Data Method: Laboratory nutrient analysis of existing storage liquid is multiplied by existing pond storage volume to estimate total nutrient quantities in storage. Only for CONFINEMENT manure.

Note: If ponds are pumped to maintain adequate winter storage, or if storage encroaches into freeboard requirements, the working storage capacity is not a true measure of animal manure production and storage. Indicate additional storage in the box provided to account for total annual production.

Working storage capacity, from Producer Worksheet, Section VI: Acre-feet	Storage Additons, Acre-feet
-22.51	0.00

Cells G130+g134-F159 main sheet

Table 6. Confined Animal Manure Storage Nutrients		
Based on lab sampling data, lb.		
N	P	K
0	0	0

3. Calculation Method for Acreage Requirments:

The remainder of this worksheet is used to determine the acres required for consumption of N - P - K nutrients in keeping with good crop management practices. Application rates consistent with crop uptake needs will maximize economic benefits of applied manures and will reduce chance of impairing surface water runoff quality.

Area requirement calculations are based on total nutrients produced. Indicate in the box below if the calculations for stored liquid and solid manures should be based on : 1 = Handbook values, or 2 = Lab Data values. Unconfined animal nutrient values are based on handbook information, because lab data for grazed animal manures is difficult to obtain.

CONFINED ONLY Animal Manure Nutrient Calculation Method 1

1 = Handbook Values
2 = Lab Data Values

Section V: Manure Nutrient Quantity Adjustments

1. Manure Storage Method

Nutrient losses from manure occur during collection, storage, application, and after land application. Losses can vary widely, depending on collection method, collection frequency, temperature, precipitation, type of handling system, duration, type, and location of storage, and other factors.

About half the N in fresh manure is inorganic, and subject to significant losses.
The table from Oregon State University publication EC1094 provides an estimate of NPK retained by various storage systems. Lab nutrient analyses of manure take these storage losses into account. Use these adjustment values in Table 14 and Table 16

Table 7. Percentage of Original Manure Nutrient Content Retained by Storage System

	N	P	K
Daily Spread	80	90	90
Dry, under roof	70	90	90
Earth storage	55	60	70
Lagoon/flush	30	40	60
Open lot	60	70	65
Pits under slats	75	95	95
Scrape/storage tank	70	90	90
None (grazing)	100	100	100

2. Manure Spreading Method

Nitrogen nutrient losses from manure can occur during spreading (Fresh manure odor is mostly volatized ammonia). Essentially all phosphorus and potassium applied will be available to the crop. The table from OSU publication EC1094 summarizes percent nutrient delivered to cropland and available for plant uptake, based on application and preutilization losses. Use these adjustment values in Table 14 and Table 16 below.

Table 8. Percentage of Original Manure Nutrient Content Delivered to Crop and Available for Uptake

	N	P	K
Injection	95	100	100
Broadcast	80	100	100
Broadcast/cultivate	95	100	100
Sprinkling	75	100	100
Grazing	85	100	100

Section VI: Additional Nutrient Inputs

1. Commercial Fertilizer

Many ranchers provide supplemental fertilizer to pasture or silage crops, on an annual or other intermittent basis. These nutrients should be accounted for in a complete nutrient budget. Fertilizer may be applied in pastures where unconfined animals are grazed, in irrigated pastures, where manure is disposed, and in crop areas. This section estimates total nutrients available based on the fertilizer formulation used, the application rate, and the application frequency. Fertilizer composition data is from Western Fertlilzer Handbook, Table 5-5.

Table 9. Nutrient Value of Selected Commercial Fertilizers

Western Fertilizer Handbook Table 5-5 Fertilizer Formulation	Total Nitrogen N%	Available Phosphoric Acid P_2O_5%	Water-soluble Potash K_2O%
Ammonium nitrate	34		
Monoammonium phosphate	11	48	
Ammonium phosphate 1	13	39	
Ammonium phosphate 2	16	20	
Ammonium phosphate 3	27	12	
Diammonium phosphate	17	47	
Ammonium sulfate	21		
Anhydrous ammonia	82		
Aqua ammonia	20		
Sodium nitrate	16		
Urea	45		
Urea ammonium nitrate	32		
Single superphosphate		18	
Triple superphosphate		45	
Phosphoric acid		53	
Superphosphoric acid		80	
Potassium chloride			61
Potassium nitrate	13		44
Potassium sulfate			51
Sulfate of potash-magnesia			22

Indicate tons of fertilizer applied, area covered in acres, and how many years between applications for the commercial fertilizers noted. Formulations in Table 9 are used to estimate NPK application rates by fertilizer classification, using multipliers for elemental nutrients NPK.

You will need to rerun the spreadsheet to determine effects on individual fields, if all fields are not treated the same. Entering two kinds of fertilizer on a single field will result in acreage duplication in the Table 10 summary and errors in the nutrient budget summary in Table 14.

For simplicity, fertilizer nutrient values are included in both confined and unconfined animal manure disposal area evaluations, further down the spreadsheet. You will need to rerun the spreadsheet to individually evaluate confined and unconfined manure disposal areas, if both are not treated with equal amounts of commercial fertilizer.

Table 10. Commercial Fertilizer Application

Fertilizer Formulation	Fertilizer Application Data: Amount applied Tons	Area covered Acres	Application frequency Years	Nutrient Summary Pounds/acre/year: Total Fertilizer	N	P	K
Ammonium nitrate				0	0		
Monoammonium phosphate				0	0	0	
Ammonium phosphate 1				0	0	0	
Ammonium phosphate 2				0	0	0	
Ammonium phosphate 3				0	0	0	
Diammonium phosphate				0	0	0	
Ammonium sulfate				0	0		
Anhydrous ammonia				0	0		
Aqua ammonia				0	0		
Sodium nitrate				0	0		
Urea				0	0		
Urea ammonium nitrate				0	0		
Single superphosphate				0		0	
Triple superphosphate				0		0	
Phosphoric acid				0		0	
Superphosphoric acid				0		0	
Potassium chloride				0			0
Potassium nitrate				0	0		0
Potassium sulfate				0			0
Sulfate of potash-magnesia				0			0
Subtotals:		0	Acres	0	0	0	0

Average pounds per acre per year

2. Irrigation Water

Some dairy ranches utilize reclaimed water for irrigation purposes. This water may contain significant amounts of nutrients that must be included in the nutrient budget in order to obtain accurate results. This section estimates total nutrient availability based on lab data for the water and total application rate, in inches of water per year.

Enter nutrient concentrations in mg/l for N, P, and K. If nutrient concentrations are reported in other units, provide appropriate conversions before entering data. For example, multiply P_2O_5 by .4365 to obtain P and multiply K_20 by .8301 to obtain K.

For simplicity, irrigation water nutrient values are included in both confined and unconfined animal manure disposal area evaluations, further down the spreadsheet. You will need to rerun the spreadsheet to individually evaluate confined and unconfined manure disposal areas, if both are not treated with equal amounts of irrigation water.

Irrigated Area: 39 Acres per Year

Irrigation application: 6 inches per acre/year

Table 11. Irrigation Water Nutrients

Commercial Laboratory Analysis of your irrigation water (City of Santa Rosa typical data, 1995)

Nutrient Parameter	If available, enter data here Milligrams/liter	Equivalent lb/gal
Nitrogen, N:	30.6	0.00026
Phosphorous, P:	1.2	0.00001
Potassium, K:	2.0	0.00002
Copper, Cu:	0.02	0.00000

Table 12. Irrigation Water Nutrient Application Rate

Based on lab concentrations and inches/year

	Pounds/acre/year
N:	42
P:	2
K:	3
Cu:	0.0

Section VII: Manure Management on Available Acreage

1. Unconfined Animals on Seasonal Pastures:

Unconfined animals are grazed on pasture or crop stubble, with manure spread naturally by the animals. All manure nutrient content is retained by the system, and the only losses are due to denitirfication prior to plant uptake. Evaluate nutrient budgeting for unconfined animals by comparing annual NPK production to recommended NPK uptake for forage production on available acreage.

Indicate grazed acreage in Table 13 below. Nutrient demand is estimated based on published values in Table 1 above. Compare your yield values to those stated in Table 1. If your yields are significantly higher or lower, adjust the Table 1 nutrient demand values up or down to reflect actual crop demand based on local productivity.

Table 13. Grazed acreage for unconfined animals.

	On-Site Acres		Nutrient Demand, Pounds N	P_2O_5	K_2O
Field Crops					
Corn - grain			0	0	0
Corn - silage			0	0	0
Grain sorghum			0	0	0
Oats			0	0	0
Wheat			0	0	0
Barley			0	0	0
Fruit and Nut Crops					
Apples			0	0	0
Grapes			0	0	0
Forage Crops					
Alfalfa			0	0	0
Bromegrass			0	0	0
Clover grass	75.0		22500	6750	27000
Orchardgrass			0	0	0
Sorghum-sudan			0	0	0
Timothy			0	0	0
Vetch			0	0	0
Dryland Pasture			0	0	0
Irrigated Pasture			0	0	0
Subtotals:	75.0	acres pastured	22500	6750	27000

Table 14. Unconfined Animal Nutrient Balance Estimation

Note: This evaluation for grazed pasture areas is based on **handbook nutrient values**, since lab data for animal-distributed manure is difficult to obtain. It assumes that common acreage is used for livestock pasture and application of both commercial fertilizer and irrigation water. Unconfined animal counts are reported in the **Producer** worksheet. Return to previous sections if necessary to adjust animal counts, acreages, irrigation application, and commercial fertilizer application so that a valid evaluation may be made for pastured areas where unconfined animals are kept. Acre counts for Pastured, Irrigated, and Fertilized should be the same. Acres used for nutrient consumption should be equal to or less than total available on-site and off-site acres.

Acreage Check:	75.0	Pastured acres (Table 14)	130	On-site acres (Section 1)
		Irrigated acres (Table 11)	0	Off-site acres (Section 1)
	0	Fertilized acres (Table 10)	130	Total acres (Section 1)

irrigated acres = d281

1. Nutrient Inputs:

	N	P	K	
Table 4: NPK Production, lb:	23952	3157	17630	lb/yr
Table 7: Storage adjustment (grazing)	1.00	1.00	1.00	
Table 8: NPK delivery adjustment (grazing):	0.85	1.00	1.00	

Revise these adjustments to match your operation.

Estimated manure application rate by grazing animals:
29 tons/acre — Based on Table 5 animal production quantities, pastured acres.

		N	P	K	
Available from manure:	Manure NPK available , lb:	20360	3157	17630	lb/yr
	Manure NPK available , lb/ac:	271	42	235	lb/ac
External Inputs:	**Table 10**: Comm'l Fert, lb NPK/ac:	0	0	0	lb/ac
	Table 12: Irrig Water, lb NPK/ac:				
	Subtotal Inputs:	271	42	235	lb/ac
2. Crop Nutrient Demands:		N	P	K	
	Adjustment factor for elemental nutrient:	1.0000	0.4365	0.8301	
	Table 13: Adjusted NPK requirement, lb:	300	39	299	lb/ac
3. Nutrient Balance:					
	Subtotal Manure, Fertilizer, Irrigation Inputs, lb/yr:	271	42	235	lb/ac
	Subtotal Crop and Pasture Consumption, lb/yr:	300	39	299	lb/ac
	Difference, Inputs minus Outputs, lb/yr:	-29	3	-64	lb/ac

42

4. Nutrient Application Recommendations

Analysis based on total pastured acres.
cows on clover grass pasture

271	lb/ac N applied. Additional N permissible.	29	lb/ac additional N permissible.
42	lb/ac P applied. Reduce P inputs or increase acres.	3	lb/ac excess P application.
235	lb/ac K applied. Additional K permissible.	64	lb/ac additional K permissible.

2. Confined Animal Manure Disposal on Remote Fields:

Manure from confined animals is normally applied to pasture or crop stubble. The nutrient budget evaluation may be completed using either handbook values or lab analysis values. Manure nutrient quality may be adjusted for storage losses and application losses. Evaluate nutrient budgeting for seasonally-confined animals by comparing annual N-P-K production in storage to recommended N-P-K uptake for forage production on disposal acreage.

Table 15. Manure disposal acreage for confined animals.

	On-Site Acres		Nutrient Demand, Pounds N	P_2O_5	K_2O
Field Crops					
Corn - grain			0	0	0
Corn - silage			0	0	0
Grain sorghum			0	0	0
Oats			0	0	0
Wheat			0	0	0
Barley			0	0	0
Fruit and Nut Crops					
Apples			0	0	0
Grapes			0	0	0
Forage Crops					
Alfalfa			0	0	0
Bromegrass			0	0	0
Clover-grass	55.0		16500	4950	19800
Orchardgrass			0	0	0
Sorghum-sudan			0	0	0
Timothy			0	0	0
Vetch			0	0	0
Dryland Pasture			0	0	0
Irrigated Pasture			0	0	0
Subtotals:	55.0	acres spread	16500	4950	19800

Table 16. Confined Animal Nutrient Balance Estimation

Note: This evaluation for pasture and crop areas assumes that common acreage is used for stored manure disposal and application of both commercial fertilizer and irrigation water. Confined animal counts are reported in the **Producer** worksheet. Return to previous sections if necessary to adjust animal counts, confinement season, acreages, irrgation amounts, and commercial fertilizer amounts so that a valid evaluation may be made for pasture or crop areas where confined animal manures are disposed. Acre counts for Pastured, Irrigated, and Fertilized areas should be the same. Acres used for nutrient consumption should be equal to or less than total available on-site and off-site acres.

Acreage	55.0	manure disposal acres (Table 15)		130	On-site acres	(Section 1)
Check:	39	irrigated acres	(Table 11	0	Off-site acres	(Section 1)
	0	fertilized acres	(Table 1(	130	Total acres	(Section 1)

Handbook values used for Liquid Manure nutrient estimation.

1. Nutrient Inputs:

	N	P	K	
Table 4: NPK Production, lb:	83936	13057	48497	lb/yr
Table 7: Storage Adjustment (Earthen):	0.55	0.60	0.70	
Table 8: Delivery Adjustment (Broadcast):	0.80	1.00	1.00	

Revise these parameters to match your operation.
(All storage adjustments = 1.00 for lab data approach)

Required manure application rate for disposal:
185 tons/acre Based on Table 5 animal production quantities, spread acres.

		N	P	K	
Available from manure:	Manure NPK available , lb:	36932	7834	33948	lb/yr
	Manure NPK available , lb/ac:	671	142	617	lb/ac
External Inputs:	**Table 10**: Comm'l Fert, lb NPK/ac:	0	0	0	lb/ac
	Table 12: Irrig Water, lb NPK/ac	42	2	3	lb/ac
	Subtotal Inputs:	713	144	620	lb/ac

2. Crop Nutrient Demands:

	N	P	K	
Adjustment factor for elemental nutrient:	1.0000	0.4365	0.8301	
Table 15: Adjusted NPK requirement, lb:	300	39	299	lb/ac

3. Nutrient Balance:

Subtotal Manure, Fertilizer, Irrigation Inputs, lb/yr:	713	144	620	lb/ac
Subtotal Crop and Pasture Consumption, lb/yr:	300	39	299	lb/ac
Difference, Inputs minus Outputs, lb/yr:	413	105	321	lb/ac

4. Nutrient Application Recommendations Analysis based on total manure disposal acres.

713 lb/ac N applied. Reduce N inputs or increase acres. 413 lb/ac excess N application.
144 lb/ac P applied. Reduce P inputs or increase acres. 105 lb/ac excess P application.
620 lb/ac K applied. Reduce K inputs or increase acres. 321 lb/ac excess application

Table 17. Fertilizer Economic Value

Relative value of animal manure and irrigation water nutrients may be determined by comparison to commercially available bulk grannular fertilizer. Enter comparative retail costs for Ammonium sulfate (16-20-0)and for Potassium Chloride KCl (0-0-60) below for use as benchmark values. Handling and spreading costs vary for each producer and are not considered in the evaluation.

Animal manures as fertlizer provide additional intangible benefits such as micronutrients, microbial populations, and organic matter for soil building.

1. Benchmark economic values

	Enter current fertilizer costs	
Ammonium Sulfate (16-20-0), bulk grannular delivered to ranch:	$ 700.00	per ton
Potassium Chloride (0-0-60), bulk grannular delivered to ranch:	$ 600.00	per ton

	N	P	K		
Equivalent value, $/lb:	$ 0.0560	$ 0.0306	$ 0.1494		
Unconfined animal manure	$1,140	$96	$2,634	$3,871	unconfined
Confined animal manure	$2,068	$239	$5,073	$7,380	confined
Irrigation water	$91	$2	$16		
Applied Nutrient Values:	$3,299	$338	$7,723	Total Values	

Total Applied Nutrient Value: 11,360

This Nutrient Budgeting worksheet was developed to assist dairy ranch operators in evaluating waste management facilities and non-point source nutrient loading on their property, in order to better manage manures and protect fresh water resources. Developing and implementing a waste management plan based on appropriate management strategies will aid in preventing code violation through discharge of nutrient-laden materials into the waters of the region. The plan is the effort of the Gold Ridge Resource Conservation District, in cooperation with the University of California Cooperative Extension, Sonoma Marin Animal Waste Committee, North Coast Regional Water Quality Control Board, Natural Resource Conservation Service, and Western United Dairymen. The plan is a self-monitoring aid and may be used by anyone. The document may be copied and used freely. No warranty is expressed or implied and the authors are not responsible for facilities construction or operation or management decisions made on the basis of program outputs. Credit to the authors will be appreciated. L.R. Erickson Ph.D. Gold Ridge

Stage-Capacity Data
Erickson Engineering Inc.
Data from CAD

File: c:xl2k\project\Ocean View Pond 1
Property: Nunes Dairy
Project: Pond Volume Estimate
Location: Mark West Station Road
Date: 17-Dec-12 01:16 PM
Revised: 10-Mar-12

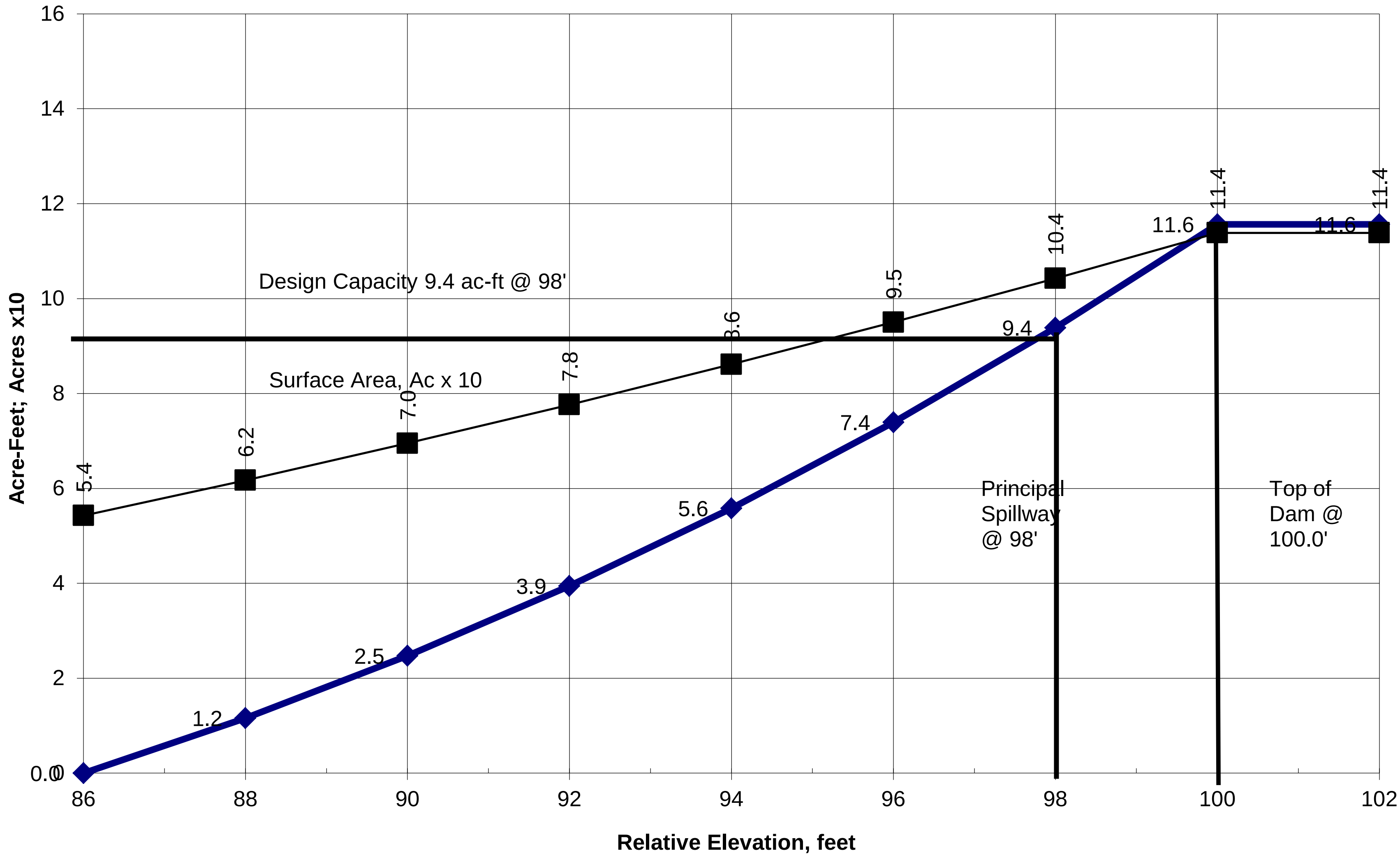
Elevation	Water Sq Ft	Avg SF	Volume Cu Ft	Cumulative Cu Ft	Water Acre-Feet	H2O Area, Acres x 10	Water Gal x 10^6
112					11.57	11.38	
110			0	503870	11.57	11.38	3.774
108		0	0	503870	11.57	11.38	3.774
106		0	0	503870	11.57	11.38	3.774
104		0	0	503870	11.57	11.38	3.774
102			0	503870	11.57	11.38	3.774
100	49590	47500	95000	503870	11.57	11.38	3.774
98	45410	43400	86800	408870	9.39	10.42	3.062
96	41390	39460	78920	322070	7.39	9.50	2.412
94	37530	35675	71350	243150	5.58	8.62	1.821
92	33820	32050	64100	171800	3.94	7.76	1.287
90	30280	28583	57165	107700	2.47	6.95	0.807
88	26885	25268	50535	50535	1.16	6.17	0.379
86	23650		0	0	0.00	5.43	0.000
84			0	0	0.00	0.00	0.000
82		0	0	0	0.00	0.00	0.000
80		0	0	0	0.00	0.00	0.000
78		0	0	0	0.00	0.00	0.000
76		0	0	0	0.00	0.00	0.000
74		0	0	0	0.00	0.00	0.000
72		0	0	0	0.00	0.00	0.000
70		0	0	0	0.00	0.00	0.000
68		0	0	0	0.00	0.00	0.000
66		0	0	0	0.00	0.00	0.000
64		0	0	0	0.00	0.00	0.000
62		0	0	0	0.00	0.00	0.000
		0	0	0	0.00	0.00	0.000
		0	0	0	0.00	0.00	0.000
	288555	251935					

Elevation	Cut SF	Avg SF	Volume Cu Ft	Cumulative Cu Ft	Tot Excav Acre-Feet	Cum Cuts Cu Yd/1000
112			0	0	0.0	0.000
110		0	0	0	0.0	0.000
108		0	0	0	0.0	0.000
106		0	0	0	0.0	0.000
104		0	0	0	0.0	0.000
102		0	0	0	0.0	0.000
100		0	0	0	0.0	0.000
98		0	0	0	0.0	0.000
96		0	0	0	0.0	0.000
92		0	0	0	0.0	0.000
88		0	0	0	0.0	0.000
86		0	0	0	0.0	0.000
84		0	0	0	0.0	0.000
82		0	0	0	0.0	0.000
80		0	0	0	0.0	0.000

78		0	0	0	0.0	0.000
76		0	0	0	0.0	0.000
74		0	0	0	0.0	0.000
72		0	0	0	0.0	0.000
70		0	0	0	0.0	0.000
68		0	0	0	0.0	0.000
66		0	0	0	0.0	0.000
64		0	0	0	0.0	0.000
62		0	0	0	0.0	0.000
0		0	0	0	0.0	0.000
0		0	0	0	0.0	0.000
0						

Elevation	Fill Cu Ft	Avg Cu Ft	Volume Cu Ft	Cumulative Cu Ft	Fill Acre-Feet	Cum Fill Cu Yd/1000
112			0	0	0.0	0.000
110			0	0	0.0	0.000
108		0	0	0	0.0	0.000
106		0	0	0	0.0	0.000
104		0	0	0	0.0	0.000
102		0	0	0	0.0	0.000
100		0	0	0	0.0	0.000
98		0	0	0	0.0	0.000
96		0	0	0	0.0	0.000
92		0	0	0	0.0	0.000
88		0	0	0	0.0	0.000
86		0	0	0	0.0	0.000
84		0	0	0	0.0	0.000
82		0	0	0	0.0	0.000
80		0	0	0	0.0	0.000
78		0	0	0	0.0	0.000
76		0	0	0	0.0	0.000
74		0	0	0	0.0	0.000
72		0	0	0	0.0	0.000
70		0	0	0	0.0	0.000
68		0	0	0	0.0	0.000
66		0	0	0	0.0	0.000
64		0	0	0	0.0	0.000
62		0	0	0	0.0	0.000
0			0	0	0.0	0.000
0		0	0	0	0.0	0.000
0		0	0	0	0.0	0.000
	0	0	0	cut/fill ratio:		#DIV/0!

Ocean View Dairy
Pond 1 Estimated Capacity
2.5:1 slopes, 14' depth, surface area per GE aerial photo



Stage-Capacity Data
Erickson Engineering Inc.
Data from CAD

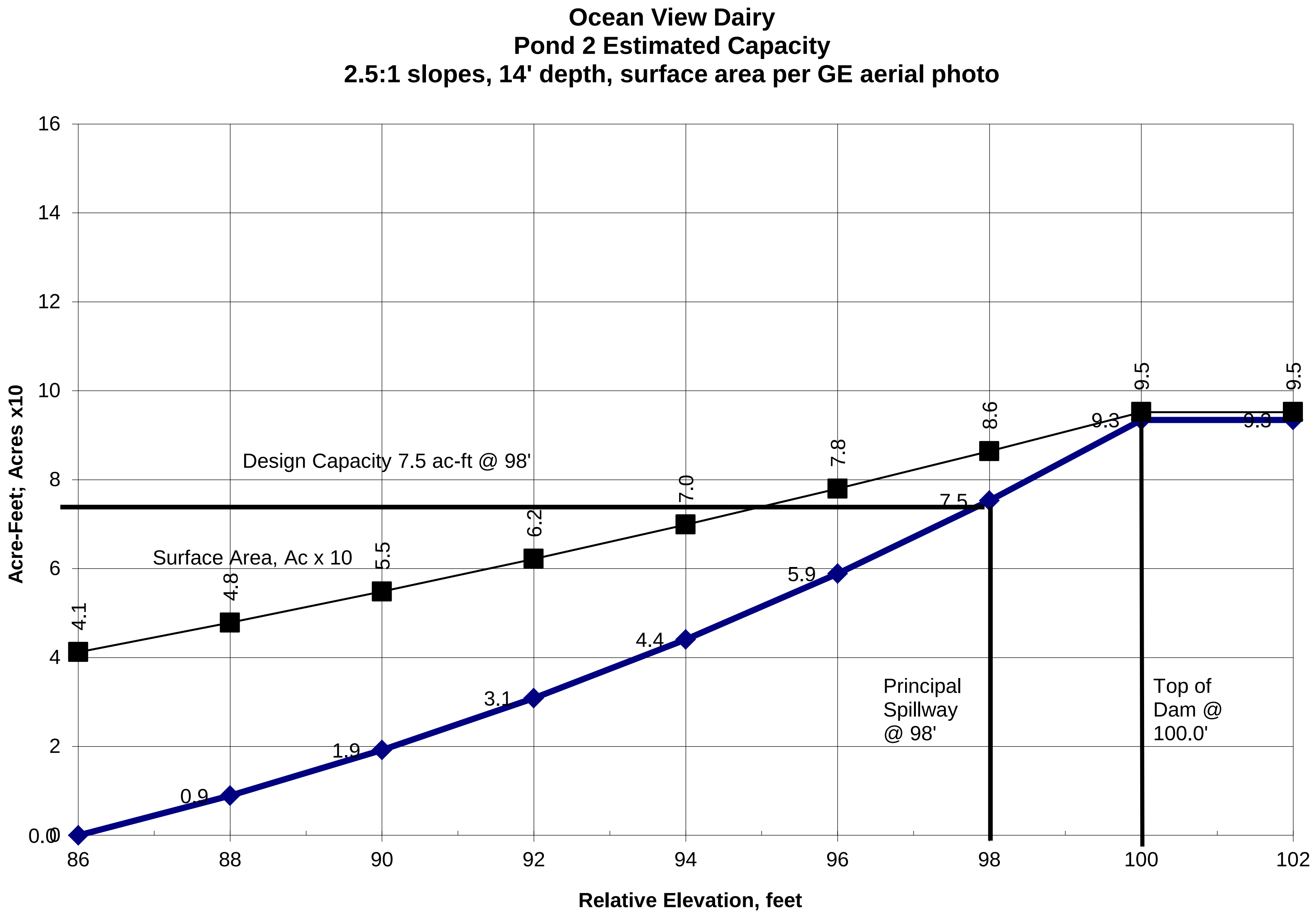
File: c:xl2k\project\Ocean View Pond 1
Property: Nunes Dairy
Project: Pond Volume Estimate
Location: Mark West Station Road
Date: 17-Dec-12 01:16 PM
Revised: 10-Mar-12

Elevation	Water Sq Ft	Avg SF	Volume Cu Ft	Cumulative Cu Ft	Water Acre-Feet	H2O Area, Acres x 10	Water Gal x 10^6
112					9.35	9.52	
110			0	407100	9.35	9.52	3.049
108		0	0	407100	9.35	9.52	3.049
106		0	0	407100	9.35	9.52	3.049
104		0	0	407100	9.35	9.52	3.049
102			0	407100	9.35	9.52	3.049
100	41470	39555	79110	407100	9.35	9.52	3.049
98	37640	35800	71600	327990	7.53	8.64	2.457
96	33960	32200	64400	256390	5.89	7.80	1.920
94	30440	28760	57520	191990	4.41	6.99	1.438
92	27080	25480	50960	134470	3.09	6.22	1.007
90	23880	22360	44720	83510	1.92	5.48	0.625
88	20840	19395	38790	38790	0.89	4.78	0.291
86	17950		0	0	0.00	4.12	0.000
84			0	0	0.00	0.00	0.000
82		0	0	0	0.00	0.00	0.000
80		0	0	0	0.00	0.00	0.000
78		0	0	0	0.00	0.00	0.000
76		0	0	0	0.00	0.00	0.000
74		0	0	0	0.00	0.00	0.000
72		0	0	0	0.00	0.00	0.000
70		0	0	0	0.00	0.00	0.000
68		0	0	0	0.00	0.00	0.000
66		0	0	0	0.00	0.00	0.000
64		0	0	0	0.00	0.00	0.000
62		0	0	0	0.00	0.00	0.000
		0	0	0	0.00	0.00	0.000
		0	0	0	0.00	0.00	0.000
	233260	203550					

Elevation	Cut SF	Avg SF	Volume Cu Ft	Cumulative Cu Ft	Tot Excav Acre-Feet	Cum Cuts Cu Yd/1000
112			0	0	0.0	0.000
110		0	0	0	0.0	0.000
108		0	0	0	0.0	0.000
106		0	0	0	0.0	0.000
104		0	0	0	0.0	0.000
102		0	0	0	0.0	0.000
100		0	0	0	0.0	0.000
98		0	0	0	0.0	0.000
96		0	0	0	0.0	0.000
92		0	0	0	0.0	0.000
88		0	0	0	0.0	0.000
86		0	0	0	0.0	0.000
84		0	0	0	0.0	0.000
82		0	0	0	0.0	0.000
80		0	0	0	0.0	0.000

78		0	0	0	0.0	0.000
76		0	0	0	0.0	0.000
74		0	0	0	0.0	0.000
72		0	0	0	0.0	0.000
70		0	0	0	0.0	0.000
68		0	0	0	0.0	0.000
66		0	0	0	0.0	0.000
64		0	0	0	0.0	0.000
62		0	0	0	0.0	0.000
0		0	0	0	0.0	0.000
0		0	0	0	0.0	0.000
0						

Elevation	Fill Cu Ft	Avg Cu Ft	Volume Cu Ft	Cumulative Cu Ft	Fill Acre-Feet	Cum Fill Cu Yd/1000
112			0	0	0.0	0.000
110			0	0	0.0	0.000
108		0	0	0	0.0	0.000
106		0	0	0	0.0	0.000
104		0	0	0	0.0	0.000
102		0	0	0	0.0	0.000
100		0	0	0	0.0	0.000
98		0	0	0	0.0	0.000
96		0	0	0	0.0	0.000
92		0	0	0	0.0	0.000
88		0	0	0	0.0	0.000
86		0	0	0	0.0	0.000
84		0	0	0	0.0	0.000
82		0	0	0	0.0	0.000
80		0	0	0	0.0	0.000
78		0	0	0	0.0	0.000
76		0	0	0	0.0	0.000
74		0	0	0	0.0	0.000
72		0	0	0	0.0	0.000
70		0	0	0	0.0	0.000
68		0	0	0	0.0	0.000
66		0	0	0	0.0	0.000
64		0	0	0	0.0	0.000
62		0	0	0	0.0	0.000
0			0	0	0.0	0.000
0		0	0	0	0.0	0.000
0		0	0	0	0.0	0.000
	0	0	0	cut/fill ratio:		#DIV/0!


Ocean View Dairy
Pond 2 Estimated Capacity
2.5:1 slopes, 14' depth, surface area per GE aerial photo
Acre-Feet; Acres x10
Relative Elevation, feet
Design Capacity 7.5 ac-ft @ 98'
Surface Area, Ac x 10
Principal Spillway @ 98'
Top of Dam @ 100.0'
16
14
12
10
8
6
4
2
0.0
0
86
88
90
92
94
96
98
100
102
4.1
4.8
5.5
6.2
7.0
7.8
8.6
9.5
9.5
0.9
1.9
3.1
4.4
5.9
7.5
9.3
9.3

Stage-Capacity Data
Erickson Engineering Inc.
Data from CAD

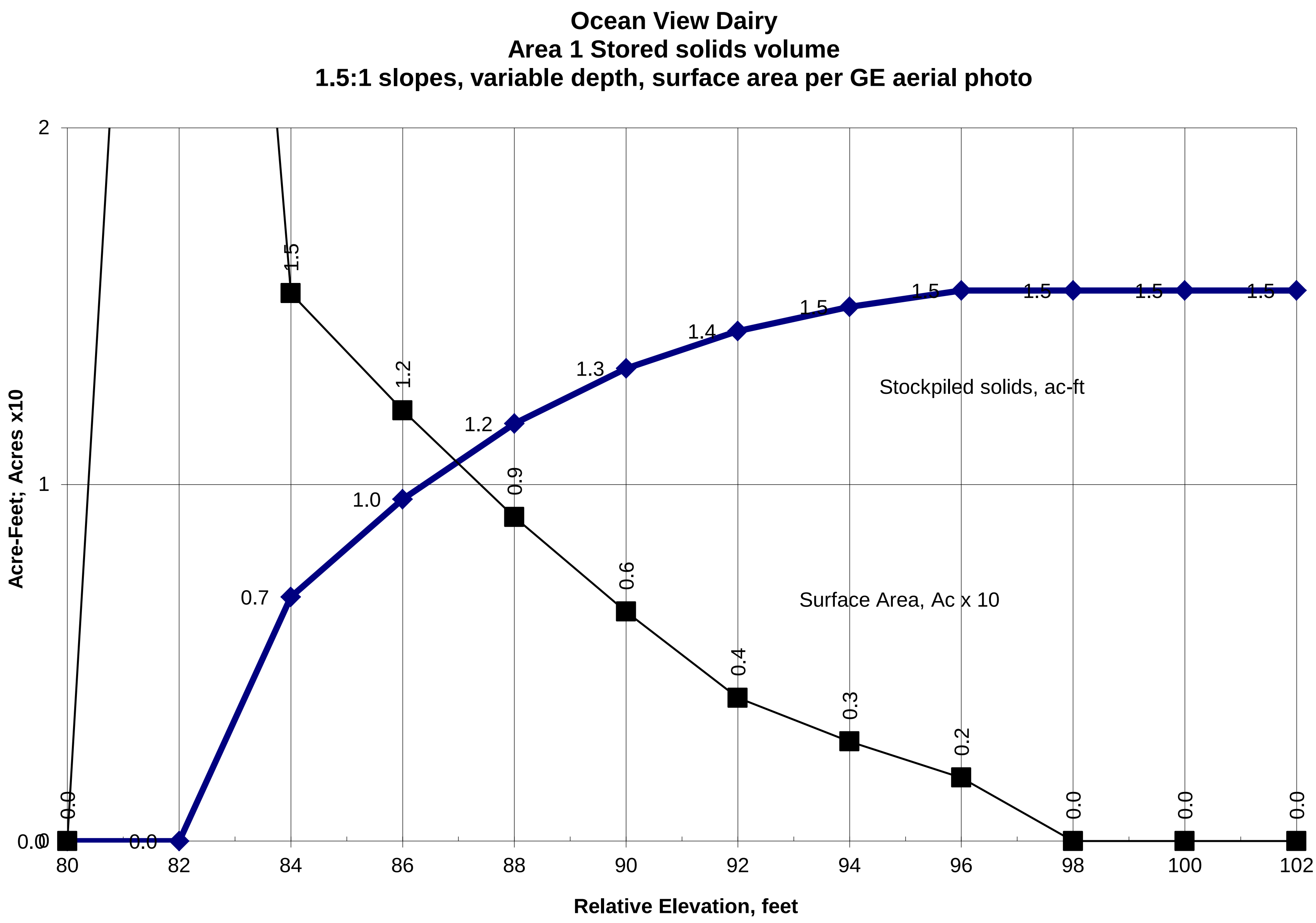
File: c:xl2k\project\Ocean View Stored 1
Property: Nunes Dairy
Project: Storage Volume Estimate
Location: Mark West Station Road
Date: 17-Dec-12 01:16 PM
Revised: 10-Mar-12

Elevation	Stored Sq Ft	Avg SF	Volume Cu Ft	Cumulative Cu Ft	Manure Acre-Feet	Area, Acres x 10
112					1.54	0.00
110			0	67249	1.54	0.00
108		0	0	67249	1.54	0.00
106		0	0	67249	1.54	0.00
104		0	0	67249	1.54	0.00
102			0	67249	1.54	0.00
100		0	0	67249	1.54	0.00
98			0	67249	1.54	0.00
96	775	996	1991	67249	1.54	0.18
94	1216	1483	2966	65258	1.50	0.28
92	1750	2276	4552	62292	1.43	0.40
90	2802	3380	6760	57740	1.33	0.64
88	3958	4610	9219	50980	1.17	0.91
86	5261	5976	11951	41761	0.96	1.21
84	6690	14905	29810	29810	0.68	1.54
82	23120		0	0	0.00	5.31
80		0	0	0	0.00	0.00
78		0	0	0	0.00	0.00
76		0	0	0	0.00	0.00
74		0	0	0	0.00	0.00
72		0	0	0	0.00	0.00
70		0	0	0	0.00	0.00
68		0	0	0	0.00	0.00
66		0	0	0	0.00	0.00
64		0	0	0	0.00	0.00
62		0	0	0	0.00	0.00
		0	0	0	0.00	0.00
		0	0	0	0.00	0.00
	45572	33625				

Elevation	Cut SF	Avg SF	Volume Cu Ft	Cumulative Cu Ft	Tot Excav Acre-Feet	Cum Cuts Cu Yd/1000
112			0	0	0.0	0.000
110		0	0	0	0.0	0.000
108		0	0	0	0.0	0.000
106		0	0	0	0.0	0.000
104		0	0	0	0.0	0.000
102		0	0	0	0.0	0.000
100		0	0	0	0.0	0.000
98		0	0	0	0.0	0.000
96		0	0	0	0.0	0.000
92		0	0	0	0.0	0.000
88		0	0	0	0.0	0.000
86		0	0	0	0.0	0.000
84		0	0	0	0.0	0.000
82		0	0	0	0.0	0.000
80		0	0	0	0.0	0.000

78		0	0	0	0.0	0.000
76		0	0	0	0.0	0.000
74		0	0	0	0.0	0.000
72		0	0	0	0.0	0.000
70		0	0	0	0.0	0.000
68		0	0	0	0.0	0.000
66		0	0	0	0.0	0.000
64		0	0	0	0.0	0.000
62		0	0	0	0.0	0.000
0		0	0	0	0.0	0.000
0		0	0	0	0.0	0.000
0						

Elevation	Fill Cu Ft	Avg Cu Ft	Volume Cu Ft	Cumulative Cu Ft	Fill Acre-Feet	Cum Fill Cu Yd/1000
112			0	0	0.0	0.000
110			0	0	0.0	0.000
108		0	0	0	0.0	0.000
106		0	0	0	0.0	0.000
104		0	0	0	0.0	0.000
102		0	0	0	0.0	0.000
100		0	0	0	0.0	0.000
98		0	0	0	0.0	0.000
96		0	0	0	0.0	0.000
92		0	0	0	0.0	0.000
88		0	0	0	0.0	0.000
86		0	0	0	0.0	0.000
84		0	0	0	0.0	0.000
82		0	0	0	0.0	0.000
80		0	0	0	0.0	0.000
78		0	0	0	0.0	0.000
76		0	0	0	0.0	0.000
74		0	0	0	0.0	0.000
72		0	0	0	0.0	0.000
70		0	0	0	0.0	0.000
68		0	0	0	0.0	0.000
66		0	0	0	0.0	0.000
64		0	0	0	0.0	0.000
62		0	0	0	0.0	0.000
0			0	0	0.0	0.000
0		0	0	0	0.0	0.000
0		0	0	0	0.0	0.000
	0	0	0		cut/fill ratio:	#DIV/0!


Ocean View Dairy
Area 1 Stored solids volume
1.5:1 slopes, variable depth, surface area per GE aerial photo
Acre-Feet; Acres x10
2
1
0.0
0
Stockpiled solids, ac-ft
Surface Area, Ac x 10
Relative Elevation, feet
80
82
84
86
88
90
92
94
96
98
100
102

Stage-Capacity Data
Erickson Engineering Inc.
Data from CAD

File: c:xl2k\project\Ocean View Stored 2
Property: Nunes Dairy
Project: Storage volume estimate
Location: Mark West Station Road
Date: 17-Dec-12 01:16 PM
Revised: 10-Mar-12

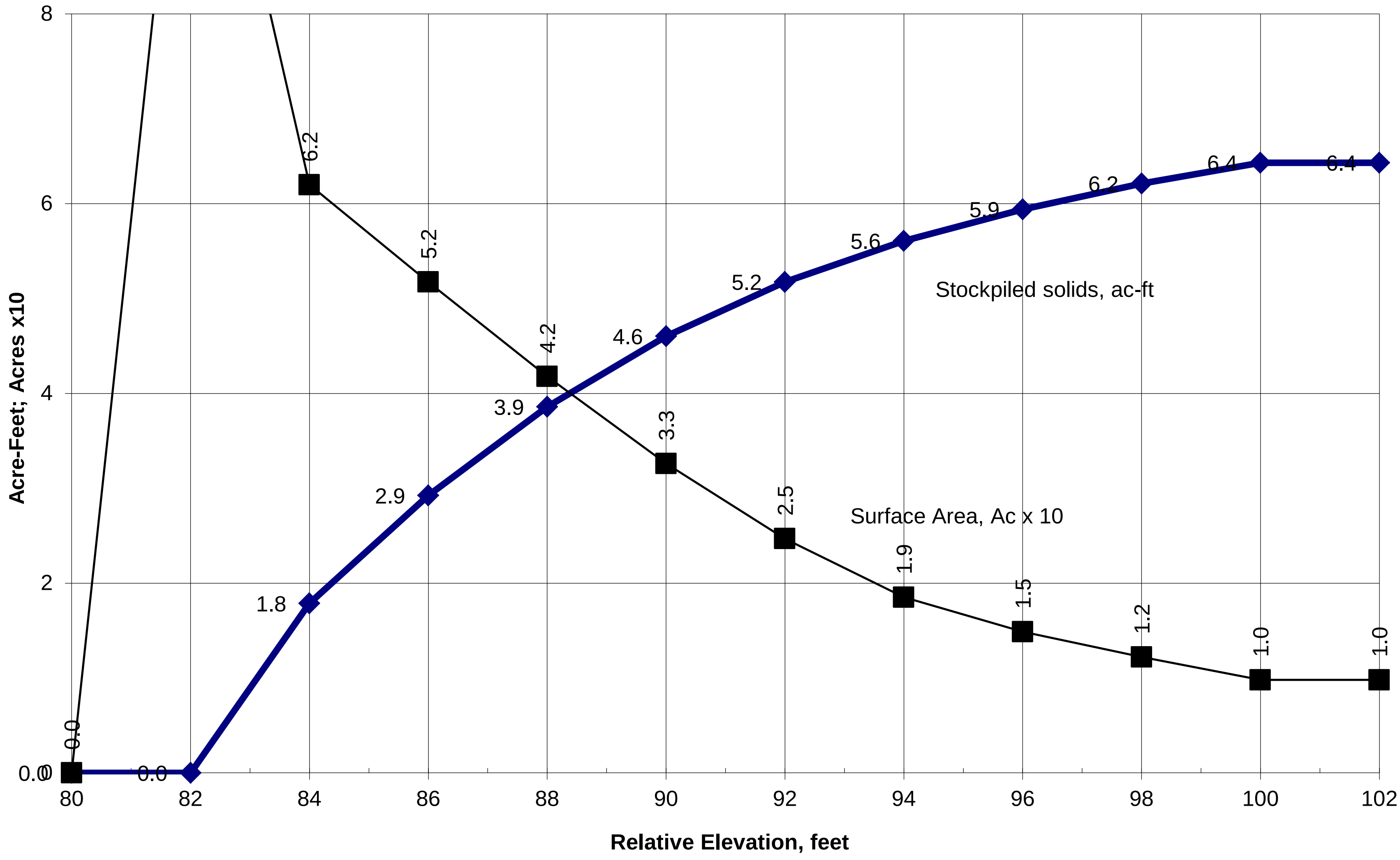
Elevation	Stored Sq Ft	Avg SF	Volume Cu Ft	Cumulative Cu Ft	Manure Acre-Feet	Area, Acres x 10
112					6.43	0.98
110			0	280142	6.43	0.98
108		0	0	280142	6.43	0.98
106		0	0	280142	6.43	0.98
104		0	0	280142	6.43	0.98
102			0	280142	6.43	0.98
100	4266	4792	9584	280142	6.43	0.98
98	5318	5898	11796	270558	6.21	1.22
96	6478	7270	14539	258762	5.94	1.49
94	8061	9406	18811	244223	5.61	1.85
92	10750	12475	24950	225412	5.17	2.47
90	14200	16202	32404	200462	4.60	3.26
88	18204	20368	40735	168058	3.86	4.18
86	22531	24764	49527	127323	2.92	5.17
84	26996	38898	77796	77796	1.79	6.20
82	50800		0	0	0.00	11.66
80		0	0	0	0.00	0.00
78		0	0	0	0.00	0.00
76		0	0	0	0.00	0.00
74		0	0	0	0.00	0.00
72		0	0	0	0.00	0.00
70		0	0	0	0.00	0.00
68		0	0	0	0.00	0.00
66		0	0	0	0.00	0.00
64		0	0	0	0.00	0.00
62		0	0	0	0.00	0.00
		0	0	0	0.00	0.00
		0	0	0	0.00	0.00
	167604	140071				

Elevation	Cut SF	Avg SF	Volume Cu Ft	Cumulative Cu Ft	Tot Excav Acre-Feet	Cum Cuts Cu Yd/1000
112			0	0	0.0	0.000
110		0	0	0	0.0	0.000
108		0	0	0	0.0	0.000
106		0	0	0	0.0	0.000
104		0	0	0	0.0	0.000
102		0	0	0	0.0	0.000
100		0	0	0	0.0	0.000
98		0	0	0	0.0	0.000
96		0	0	0	0.0	0.000
92		0	0	0	0.0	0.000
88		0	0	0	0.0	0.000
86		0	0	0	0.0	0.000
84		0	0	0	0.0	0.000
82		0	0	0	0.0	0.000
80		0	0	0	0.0	0.000

78		0	0	0	0.0	0.000
76		0	0	0	0.0	0.000
74		0	0	0	0.0	0.000
72		0	0	0	0.0	0.000
70		0	0	0	0.0	0.000
68		0	0	0	0.0	0.000
66		0	0	0	0.0	0.000
64		0	0	0	0.0	0.000
62		0	0	0	0.0	0.000
0		0	0	0	0.0	0.000
0		0	0	0	0.0	0.000
0						

Elevation	Fill Cu Ft	Avg Cu Ft	Volume Cu Ft	Cumulative Cu Ft	Fill Acre-Feet	Cum Fill Cu Yd/1000
112			0	0	0.0	0.000
110			0	0	0.0	0.000
108		0	0	0	0.0	0.000
106		0	0	0	0.0	0.000
104		0	0	0	0.0	0.000
102		0	0	0	0.0	0.000
100		0	0	0	0.0	0.000
98		0	0	0	0.0	0.000
96		0	0	0	0.0	0.000
92		0	0	0	0.0	0.000
88		0	0	0	0.0	0.000
86		0	0	0	0.0	0.000
84		0	0	0	0.0	0.000
82		0	0	0	0.0	0.000
80		0	0	0	0.0	0.000
78		0	0	0	0.0	0.000
76		0	0	0	0.0	0.000
74		0	0	0	0.0	0.000
72		0	0	0	0.0	0.000
70		0	0	0	0.0	0.000
68		0	0	0	0.0	0.000
66		0	0	0	0.0	0.000
64		0	0	0	0.0	0.000
62		0	0	0	0.0	0.000
0			0	0	0.0	0.000
0		0	0	0	0.0	0.000
0		0	0	0	0.0	0.000
	0	0	0		cut/fill ratio:	#DIV/0!

Ocean View Dairy
Area 2 Stored solids volume
1.5:1 slopes, variable depth, surface area per GE aerial photo



Manure Stockpile Volumentric Estimation

Ocean View Dairy - Marvin L. Nunes
3975 Mark West Station Road, Windsor CA

Date: 17-Dec-12
Time: 1:16 PM
Rev: 11-Mar-12

Area matches CAD

Visual estimate

	Width	Length	Sq Ft	**Avg** depth	ft^3	Location Notes	Acres
	100.0	143	14300	3.0	42900	manure storage 0	0.33
	128.4	180	23120	3.0	69360	manure storage 1	0.53
	254.0	200	50800	6.0	304800	manure storage 2	1.17
	10	158	1580	2.0	3160	manure storage 3	0.04
	70	164.3	11500	2.0	23000	manure storage 4	0.26
	100	108	10800	4.0	43200	manure storage 5	0.25
		Totals	112100		486420		

52 lb/ft^3 18016 cy
12647 tons Use these for planning purposes

Contour method

ft^3	Location Notes
41540	manure storage 0
67250	manure storage 1
280140	manure storage 2
3160	manure storage 3
23000	manure storage 4
43200	manure storage 5
458290	

52 lb/ft^3 16974
11916 tons

Pacific Northwest Extension Service
http://cru.cahe.wsu.edu/cepublications/pnw0533/pnw0533.pdf

NPK range of values in storage lb per ton as-is[3]

Type	N		P		K		Solids		
	lb/ton	lb	lb/ton	lb	lb/ton	lb	percent	lb/cy	lb/ft^3
Dry stack dairy	9	113822	1.8	22764	1.6	20235	35	1400	51.9
Separated dairy solids	5	49684	0.9	8943	2.4	23848	19	1100	40.7
Range, tons		57		11		10			
		25		4		12			

Area and volume matches CAD

	Width	Length	Sq Ft	**Avg** depth	ft^3	Location Notes	Acres
	180	275.0	49500	8.8	435600	Pond 1	1.14
	150	276.0	41400	8.4	348480	Pond 2	0.95
	20	60.0	1200	5.0	6000	Pond 3	0.03
		Totals	92100		790080		

62.4 lb/ft^3 18.1 acre feet
24650 tons 217.7 acre inches

Liquid storage, total nutrient values

Table 2 Average nutrient levels in dairy waste

Waste type	Total N	Organic	Ammonium	P2O5	K2O
Lagoon lb/ac-in	69	23	46	79	144

lb N	lb P2O5	lb K2O
1502	12036	21939

Table 5 Typical nutrient losses during handling and storage

System	N lost %		P lost %		K lost %
Lagoon, 365 day storage	90		50 to 80[5]		30 to 80[5]