FALL CREEK ENGINEERING, INC.
Civil • Environmental • Water Resource Engineering and Sciences
Tel. (831) 426-9054 1525 Seabright Ave, Santa Cruz, Ca 95062 www.fallcreekengineering.com

February 29, 2016

Scott Armstrong
California Water Boards
Central Valley Regional Water Quality Control Board
11020 Sun Center Drive #200
Rancho Cordova, CA 95670
sarmstrong@waterboards.ca.gov

Subject: **Comments on Tentative Waste Discharge Requirements Order and Monitoring and Reporting Plan, Bear Creek Winery, Lodi, California**

Dear Mr. Armstrong:

On behalf of Bear Creek Winery (BCW), Fall Creek Engineering, Inc. (FCE) has prepared this letter to provide comments on the Tentative Waste Discharge Requirements (WDRs) and Monitoring and Reporting Plan (MRP) for the process water system improvements at the facility. Based on our review of the WDRs and MRP, FCE offers the following comments.

Tentative Waste Discharge Requirements (WDR)

1. Page 3, Finding 11: Please change this finding to read "Historically, the Winery discharged process water from the Winery and distillery operation to over 45 acres of land disposal area. In the early 1990's when the distillery was closed the Winery continued to discharge winery related process water to 9.2 acres of rapid infiltration basins as described above in Finding 10. The balance of the 45 acres was converted to vineyard areas (Vineyards 1 and 2), which seasonably received process wastewater as irrigation water for the grape vines. Over the past several years the organic loading rates to the rapid infiltration basins have been excessive and have exceeded generally accepted loading rates for land disposal systems, especially during the crush season.

2. Page 5, Finding15: Please revise the following sentences pertaining to the proposed trickling filters of this finding to read "The trickling filter system will be sized based on an organic loading rate of 35 lb BOD/cf/day and the number and size of trickling filters will be determined and presented in the final engineering plans and construction documents as part of the *Pond Design Work Plan and Construction Quality and Assurance Plan*."

3. Page 5, Finding 16: Please revise this finding to read: "The Discharger is required to submit a *Solids and Leachate Management Plan* to the Executive Office that will identify solids and leachate handling, storage and disposal measures that protect groundwater quality at the facility".

   The analysis of leachate (presented in Table D-8) from the diatomaceous earth spent filter media is very similar to the characteristics of the process wastewater and can be expected to contain high concentrations of sugars and potassium characteristic of grape juice. Given the very low volume of leachate discharged on an interim basis, as compared to the relatively high volume of processed water discharged on a daily basis, the continued discharge of this waste stream to the rapid infiltration basin as an interim management measure does not pose a threat to groundwater quality. Given the low threat to groundwater quality posed by the spent filter waste leachate, FCE requests that the winey continue to discharge this waste to the rapid infiltration basins until the new wastewater treatment facility is installed.

4. Page5, Finding 17: Please revise the first sentence of this finding to read 'total nitrogen concentration will also decrease from current flow weighted average of 8.6 to 7 mg/L". this is based on the effluent quality data presented in Finding 13, Page 4.

5. Page 7, Finding 26: This finding indicates that after completion of Phase 1 improvements and Vineyards 3 and 4 are put into use that MW2D and MW4D will no longer be upgradient from the vineyards. The location of MW4D on the northeast corner of Vineyard 3 will remain upgradient of Vineyard 3 and the other disposal areas on the site. FCE agrees that MW2D will need to be replaced. Based on this finding, FCE recommends that the last two sentences of this finding be revised as follows: "After completion of Phase I improvements, Vineyard 3 and 4 will be used as LAAs, and well MW2D will be a compliance well. This Order requires the Discharge to install at least one well that will be upgradient of Vineyard 4 and the other LAAs.

6. Page 8, Finding 33: FCE has prepared an updated table presenting groundwater average concentrations for key constituents (EC, bicarbonate, sodium, nitrate, chloride, sulfate, dissolved iron, and dissolved manganese) including data collected for all four quarters of testing through 2015. This data set is based on eight (8) sampling events completed from October 2014 through November 2015. Examining this longer data record allows for a better interpretation of the groundwater conditions up and downgradient of the winery wastewater facilities.

		EC (umhos/cm)	Bicarbonate (mg/L)	Sodium (mg/L)	Nitrate-N (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Dissolved Iron (ug/L)	Dissolved Manganese (ug/L)
Potential Water Quality Objective	Well	***900***		***69***	***10***	***250 - 600***	***250***	***300***	***50***
Background Wells	MW2D	1244	334	62	31.7	96	68	157	25
	MW4D	1034	291	82	18.9	102	64	78	14
Downgradient Wells	MW3D	1238	306	70	43.9	75	95	98	25
	MW5D	1790	886	73	5.4	87	57	142	127
	MW6D	1075	424	51	16.1	79	56	88	17
	MW7D	836	276	48	15.8	59	56	98	16

FCE requests that this updated table replace the table presented in this finding. Based on our review of this data set, FCE finds the following:

a. On several occasions the water quality lab appeared to measure and report the total concentration of iron and manganese instead of the dissolved concentration and FCE considers these values to be outliers and not representative of the groundwater quality at the site. FCE has attached Table 1, which presents the entire data set and highlights the suspected outliers.

b. Including the outlier data in the calculations, as presented in the Tentative Order, does not accurately reflect groundwater conditions at the site and overstates the extent of groundwater degradation occurring at the site. FCE requests that these data be omitted from the calculated groundwater average concentrations presented in the tentative Order.

c. The heading "Potential MUN Water Quality Objectives" should be revised and "MUN" should be removed from the heading given that some of the water quality objectives presented are for agricultural water quality goals.

d. FCE has omitted total Kjeldahl nitrogen (TKN) from the table. TKN has not been detected in any all of the groundwater monitoring wells at the site over the past four quarters of testing and FCE recommends that it be removed from the Monitoring and Reporting Program for the winery.

7. Page 9, Finding 34: Please revise this finding to read as follows: "Downgradient well MW5D has the highest electrical conductivity concentration attributed primarily to the high concentration of bicarbonates. Elevated levels of iron and manganese are also observed in MW5D, immediately adjacent to the rapid infiltration basins as a result of the reduced groundwater conditions resulting from the long-term discharge of high organic loading rates to the basins. The concentration of bicarbonate, iron and manganese in the remaining downgradient monitoring wells is similar in quality to the two up gradient wells, indicating that impacts to groundwater quality are localized in close proximity to the rapid infiltration basins and taking corrective measures to reduce the quantity of organic matter discharged to the infiltration basins should reduce impacts to groundwater conditions at the site.

8. Page 10, Finding 38: Please remove the second sentence of this finding that pertains to numeric objectives for total coliform organisms. This finding is not relevant to the process wastewater discharge.

9. Page 10, Finding 39: Please remove this finding from the Order. This finding references Basin Plan's water quality objectives for bacteria, which are not a constituent of concern at the winery and as such should not be included in the Order.

10. Page 11, Finding 47: FCE recommends that the constituents of concerns presented in this table be revised to include electrical conductivity, bicarbonates, iron and manganese. As previously noted in Comment 4 above, TKN is not a constituent of concern in groundwater at the site. The table presented in this finding does not accurately represent groundwater quality across the site and FCE requests that it be omitted. A summary of this data is already presented in Findings 27 and 33.

11. Page 12, Finding 47.b: FCE requests that Finding 47. b. Nitrate be revised to more accurately describe groundwater quality conditions at the winery with respect to nitrates. FCE recommends that a portion of this finding be revised as follows: "Background groundwater quality is poor with respect to nitrate-nitrogen and exceeds the primary MCL of 10 mg/L. Nitrate-N concentrations immediately downgradient of the rapid infiltration basins is significantly lower than the upgradient wells with average concentrations measurements at 5.4 mg/L due to denitrification resulting from anaerobic groundwater conditions at this site. Similarly, nitrate-nitrogen levels are lower in the wells further downgradient from the rapid infiltration basins as compared to the background wells.

Nitrate-nitrogen levels measured in MW3D are higher than levels observed in background wells; however, it is important to note that MW3D is located downgradient of vineyards and not the rapid infiltration basins and the vineyards receive a combination of process water and irrigation water over the year. It is also unknown if the source of the nitrate-nitrogen is due to past or present nitrogen fertilizer applications at the vineyard or from adjacent agricultural lands upgradient of the subject vineyards. What is important is that the application of process water to land, as evidenced by the three monitoring wells downgradient of the site (MW5D, MW6D and MW7D) has caused nitrate-nitrogen levels in the groundwater underlying the winery to decrease, which has been a beneficial outcome of the land disposal practices at the winery."

12. Page 12, Finding 47.c: FCE requests that the first paragraph of the finding be revised as follows: "Based on the character of water supply and the nature of typical winery operations, wastewater at the site is not expected to contain elevated manganese concentrations. However, as noted in previous findings, excessive organic loading rates can result in anoxic conditions in groundwater that can solubilize naturally occurring manganese in soils. Elevated manganese concentrations have been measured in groundwater samples collected from MW5D immediately downgradient of the rapid infiltration basins at the site. The past eight rounds of groundwater testing clearly indicate that the ongoing discharge of untreated process water has degraded groundwater quality in the immediate vicinity of the rapid infiltration basins."

13. Page 13, Finding 47.d: FCE requests that the first paragraph of this finding be revised as follows: "Based on the character of water supply and the nature of typical winery operations, wastewater at the site is not expected to contain elevated iron concentrations. However, as noted in previous findings, excessive organic loading rates can result in anoxic conditions in groundwater that can solubilize naturally occurring iron in soils. Elevated iron concentrations have been measured in groundwater samples collected from MW5D immediately downgradient of the rapid infiltration basins at the site. The past eight rounds of groundwater testing clearly indicate that the ongoing discharge of untreated process water has degraded groundwater quality in the immediate vicinity of the rapid infiltration basins."

14. Page 13, Finding 49: FCE requests that this finding be revised as follows: "With respect to TDS, un unacceptable degree of groundwater degradation has occurred. Therefore this Order does not authorize any continued degradation as a result of the discharge or other activity at the winery which exists today for those constituents. The Groundwater Limitations are effective immediately and allow no degradation beyond groundwater quality in any compliance monitoring well and this Order requires intrawell analysis of compliance well groundwater monitoring data to determine compliance with the Groundwater Limitations."

15. Page 16, Finding 59: Please add the word Act after the "California Environmental Quality".

16. Page 17, Discharge Prohibitions 6: FCE recommends changing the word "disrupted" to "inhibited and/or impacted".

17. Page 21, Discharge Specifications 13: FCE requests that this specification be revised as follows: "Wastewater discharged to the LAAs shall not have a pH less than 4.0 or greater than 9.0."

    In 2004, FCE completed a baseline soil characterization study to assess the long-term impacts to the LAA from the continued discharge of process water to the rapid infiltration basins. A key aspect of this study was to determine if the soils in the rapid infiltration basins had excess buffering capacity to neutralize the low pH effluent discharged to them after 70 years of continuous use. The results of the study indicated that there was evidence of temporal soil pH reductions immediately following process water application; however, the soil pH was found to be higher in treated soils in comparison to the "control" or non-treated soil location. Process water applications were observed to increase soil pH in 2 to 5 foot depth intervals and overall soil pH buffering capacity appeared to be maintaining favorable condition for organic matter mineralization and crop uptake. A copy of the Baseline Soil Characterization study is attached for your reference and review. Based on these findings, FCE believes that the discharge of low pH process water to the LAA does not pose a threat to groundwater quality at the site.

    To comply with this Discharge Specification would require the Winery to add a water treatment chemical to the wastewater for pH adjustment and this would require the use of strong basic solution, such as sodium hydroxide solution, which would significantly increase the total dissolved solids concentration in the wastewater, which would increase the degradation of groundwater at the site.

18. Page 21, Discharge Specification 14: FCE is concerned that the current specification is unclear and does not provide the Winery a period to transition from the current residual waste management practices to an upgraded system. There is no evidence that the current residual management practice has contributed to the degradation of groundwater quality at the site. Based on these two reasons, FCE recommends that the Discharge Specifications be revised as follows: "As an interim measure, the Discharger shall improve the existing paved storage area of residual solids to effectively control leachate and rainfall runoff so that area is either covered by a roof to prevent rainfall from coming into contact with the residual wastes and any liquid discharged from the area is conveyed directly to a rapid infiltration basin and/or the Winery proposes to make other improvements that effectively control leachate and runoff from the site in a manner that does not degrade groundwater at the site. If ongoing monitoring indicates that these interim improvements are not sufficient to protect water quality, the Winery shall submit a *Solid Waste Management Plan* as part of the *Phase II Wastewater System Improvement Plan*. As part of the Phase II wastewater treatment improvements planned at the winery, a runoff and leachate collection system shall be installed in the solid wastewater storage area to convey leachate and/or runoff to the new treatment system."

19. Page 22, Discharge Specification 16: Please remove "a. Reverse Osmosis reject and e. Evaporative Cooling Water" from the list of prohibited wastewater streams. The Winery does not operate a Reverse Osmosis system on a regular basis, but on rare occasions the Winery may utilize a portable reverse osmosis (RO) unit to improve the quality of a wine. The use of a small RO unit may occur for a short period of time (two weeks or less) every two or more years. The water from the cooling towers (evaporative cooling water) has historically (and is currently) collected and comingled with the process water. This volume

of water from the cooling water has been accounted for within the daily flow rates reported in the monthly wastewater reports. Based on the relatively low volume of RO reject and cooling water in the discharge the contribution of fixed dissolved solids from these waste streams are not considered to be significant and as such should not be prohibited.

20. Page 23, Vineyard Land Application Area Specifications 1: FCE recommends that this specification be revised as follows: "Wastewater shall be applied to either the vineyard LAAs or the rapid infiltrations in compliance with the effluent loading rates and in a manner that does not create a nuisance or degrade groundwater at the site. The Winery shall apply the maximum amount of wastewater to the vineyard LAAs as possible to minimize the amount discharged to the rapid infiltration basins on an annual basis."

21. Page 23, Vineyard Land Application Area Specifications 5: FCE recommends that this specification be revised to state that "irrigation of the LAAs shall occur only when appropriately trained personnel are monitoring the system."

    Typically the winery is closed on the weekends, unless they are in a crush period. During these times the Winery does not always maintain personnel on the premises on the weekends, but there are occasions when the discharge of wastewater to the LAAs can occur if irrigation water is called for. In these instances the winery staff can be monitoring the system via a telemetry based system and be able to respond to an alarm condition to prevent the overflow or unregulated discharge of wastewater.

22. Page 24, Solids Disposal Specifications 4. Presently, the Winery contracts with a local farmer who removes residual solids and uses it as animal feed. The residual waste is an agricultural waste, primarily composed of pressed grape skins and seeds. This has been an ongoing practice for several decades and the farmer does not have waste discharge requirements for this arrangement. It is unclear why the beneficial reuse of this residual as an animal feed requires the issuance or coverage under Waste Discharge Requirements. FCE recommends that a *Solid Waste Management Plan* be developed to provide a thorough description of how all of the residual waste is being managed on and off site. The Plan should describe when, where and how much residual waste is being removed from the site and how it is being reused at the final destination. FCE recommends that the specifications be revised to allow for the transport and reuse of agricultural residual wastes for animal feed or other beneficial reuse schemes, and be allowed without the issuance of waste discharge requirements, so long as it is done in a manner that is approved by the Executive Officer.

23. Page 24, Provisions 1.b: FCE requests that this provision be revised so that the submittal for the *Groundwater Monitoring Well Installation Report* is extended to 15 January 2017. The tentative WDR stipulates that this report be due by 1 October 2016; however, this is during the crush period at the Winery and it would be very difficult to complete this report during this period of operation.

24. Page 25, Provision 1.c: FCE requests that this provision be revised so that the submittal for the *Salinity Evaluation and Minimization Plan is extended to 28 February 2017*. The tentative WDR stipulates that this report be due by 1 October 2016; however, this is

during the crush period at the Winery and it would be very difficult to complete this report during this period of operation.

25. Page 26, Provision 1.d: FCE requests that this provision be revised so that the submittal for the *Groundwater Limitations Assessment Plan is extended to 15 March 2017*. The tentative WDR stipulates that this report be due by 1 October 2016; however, this is during the crush period at the Winery and it would be very difficult to complete this report during this period of operation.

26. Page 26, Provision 1.g: FCE requests that this provision be revised so that the submittal for the *Wastewater System Improvement Phase II Completion Report is extended to 15 January 2019*. The tentative WDR stipulates that this report be due by 1 October 2018; however, this is during the crush period at the Winery and would it be very difficult to complete this report during this period of operation.

27. Once the wastewater treatment system is installed the Winery would like to be able to reuse the treated water for other beneficial purposes on the property. The reuse of treated effluent for beneficial purposes is important to meet the State's water conservation goals. The primary reuse of the water would be for dust control on farm roads around the vineyards. Currently, the Winery utilizes high quality groundwater for dust control purposes. FCE requests that a finding be added to Section F. Vineyard Land Application Area Specifications that states the following: "The Discharger may reuse treated process water for other beneficial purposes, such as dust control, only after the Executive Officer has approved an Effluent Reuse plan submitted by the Winery. The Effluent Reuse Plan shall describe how and where water will be reused and for what purposes and how it will be managed to prevent discharge of the water off site or into surface water drainage courses. The Effluent Reuse Plan should include a map delineating the areas water will be reused on the site. The Winery should report the volume of water reused on the site on a daily basis and include this information in the monthly report.

Tentative Monitoring and Reporting Plan (MRP)

1. FCE requests that the sample frequency for influent BOD be reduced to monthly sampling.

2. FCE requests that the first paragraph of section "RAPID INFILTRATION BASIN AND LAND APPLICATION AREA MONITORING" on page 3 be removed. As long as the Winery complies with the discharge requirements and operates the rapid infiltration and LAA areas in a manner that is protective of groundwater quality and does not create conditions of nuisance then this language is not necessary. The Winery shall have the flexibility to operate their facility as necessary to manage the discharge and to comply with the waste discharge requirements.

3. FCE requests that removing "field saturation" from the list of required report notations in the second paragraph of section "RAPID INFILTRATION BASIN AND LAND APPLICATION AREA MONITORING" on page 3. By design, the rapid infiltration basins will have standing water, and the vineyards treated water is applied to the vineyards by furrow irrigation, both of which will be considered as saturated conditions.

4. FCE requests that the constituent list for groundwater monitoring be revised to include bicarbonate and electrical conductivity and to remove fixed dissolved solids and total Kjeldahl nitrogen. Measuring both total dissolved solids (TDS) and fixed dissolved solids (FDS) in groundwater is redundant. It is very unlikely that any residual organic matter is reaching groundwater and FCE expects that the concentration of TDS and FDS should be very close if not the same. To date the ongoing monitoring program has not measured any TKN in the groundwater up or down gradient of the disposal areas. Based on this observation FCE does not believe it should be included in the monitoring program.

This concludes our comments on the tentative WDRs and MRP. Thank you for the opportunity to review these documents. Please contact me if you have any questions or require any additional information.

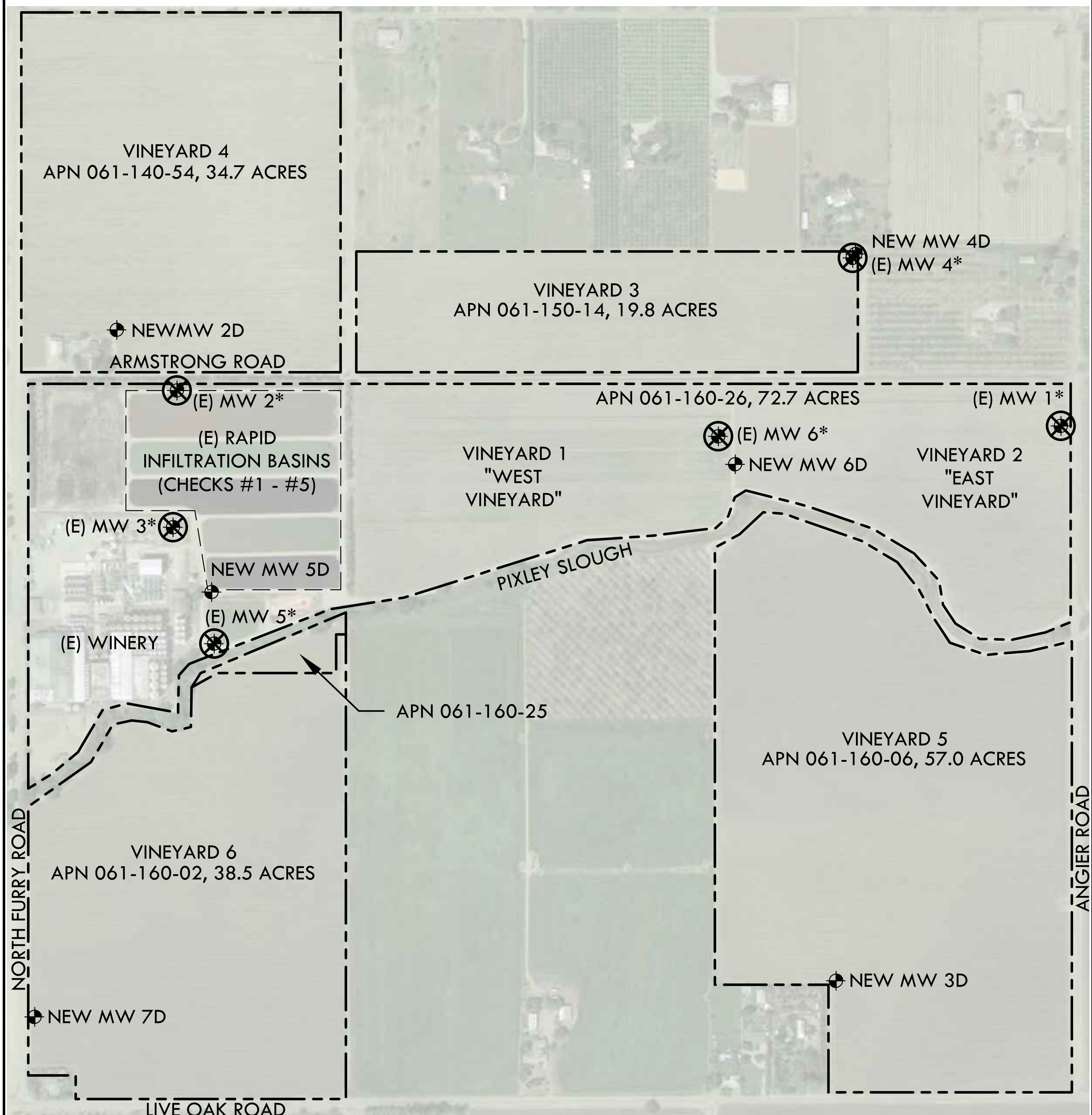
Sincerely,

PETER HAASE, M.S., P.E.
Principal Engineer

Attachments

Attachment 1 - Groundwater Quality Data - October 2014 through November 2015

Date	Well	Calcium	Magnesium	Sodium	Potassium	Bicarbonate	Chloride	Sulfate	Nitrate-N	Alkalinity	Iron	Manganese	TKN
10/16,24/2014	2D	182	94	108	47	378.2	109	83	35.5	310	0.253	0.006	<1
11/7/2014	2D	113	54	64	3	366.0	107	69	35.1	300	0.100	0.000	<1
1/19/2015	2D	109	54	54	4	329.4	86	56	16.8	270	***8.46***	***0.16***	<1
3/6/2015	2D	104	50	51	2	317.2	102	70	34.0	260	0.120	0.001	<1
4/20/2015	2D	112	51	52	2	329.4	100	70	26.9	270	***2.38***	0.050	<1
5/8/2015	2D	126	60	63	3	329.4	89	63	35.9	270	***5.33***	0.100	<0.5
8/21/2015	2D	93	48	53	2	305.0	79	75	35.1	250	0.030	0.010	<0.5
11/13/2015	2D	108	51	52	2	317.2	97	61	34.6	260	0.280	0.010	<0.5
Average		**118**	**58**	**62**	**8**	**334.0**	**96**	**68**	**31.7**	**274**	**0.157**	**0.025**	**<1**
10/16,24/2014	4D	285	147	154	51	219.6	186	108	15.7	180	0.306	0.009	<1
11/7/2014	4D	74	25	91	4	305.0	107	68	16.1	250	0.050	0.010	<1
1/19/2015	4D	82	33	67	3	317.2	104	66	34.4	260	0.070	0.010	<1
3/6/2015	4D	80	34	63	2	305.0	88	58	16.8	250	0.030	0.010	<1
4/20/2015	4D	83	35	71	3	317.2	90	59	17.4	260	0.030	0.010	<1
5/8/2015	4D	90	39	76	3	305.0	82	51	16.8	250	***2.18***	0.040	<0.5
8/21/2015	4D	82	34	65	2	292.8	79	53	16.8	240	0.030	0.010	<0.5
11/13/2015	4D	77	33	66	2	268.4	80	52	17.1	220	0.030	0.010	<0.5
Average		**107**	**48**	**82**	**9**	**291.3**	**102**	**64**	**18.9**	**238.75**	**0.078**	**0.014**	**<1**
10/16,24/2014	3D	265	137	170	31	341.6	124	110	42.0	280	0.137	0.011	<1
11/7/2014	3D	102	46	66	4	317.2	83	97	43.5	260	0.110	0.050	<1
1/19/2015	3D	105	46	52	3	305.0	68	90	44.0	250	0.070	0.040	<1
3/6/2015	3D	106	47	51	3	305.0	71	95	45.2	250	0.130	0.040	<1
4/20/2015	3D	114	49	57	3	305.0	68	94	44.6	250	0.030	0.020	<1
5/8/2015	3D	112	46	54	3	317.2	64	85	44.0	260	0.180	0.020	<0.5
8/21/2015	3D	101	47	53	2	268.4	53	101	43.6	220	0.030	0.010	<0.5
11/13/2015	3D	107	47	54	2	292.8	66	85	43.9	240	0.100	0.010	<0.5
Average		**127**	**58**	**70**	**6**	**306.5**	**75**	**95**	**43.9**	**251.25**	**0.098**	**0.025**	**<1**
10/16,24/2014	5D	431	223	85	137	902.8	108	71	4.9	740	0.705	0.013	1
11/7/2014	5D	171	81	80	5	927.2	96	64	3.9	760	0.100	0.260	<1
1/19/2015	5D	181	84	73	4	939.4	89	56	5.9	770	0.070	0.230	<1
3/6/2015	5D	184	86	70	3	927.2	82	56	6.1	760	0.030	0.150	<1
4/20/2015	5D	177	82	75	4	878.4	81	56	5.1	720	0.140	0.120	<1
5/8/2015	5D	185	85	70	4	939.4	78	51	5.5	770	0.030	0.130	<0.5
8/21/2015	5D	55	84	65	3	634.4	83	57	5.9	520	0.030	0.100	<0.5
11/13/2015	5D	180	85	68	3	939.4	77	42	5.5	770	0.030	0.010	<0.5
Average		**196**	**101**	**73**	**20**	**886.0**	**87**	**57**	**5.4**	**726.25**	**0.142**	**0.127**	**<1**
10/16,24/2014	6D	218	113	74	42	488.0	97	65	16.5	400	0.300	0.010	<1
11/7/2014	6D	123	54	56	4	536.8	78	57	18.3	440	0.070	0.040	<1
1/19/2015	6D	99	43	45	3	402.6	74	48	14.6	330	0.070	0.020	<1
3/6/2015	6D	101	44	42	11	402.6	76	62	13.9	330	***31.7***	***1.17***	<1
4/20/2015	6D	104	44	47	3	402.6	80	56	15.3	330	0.030	0.010	<1
5/8/2015	6D	119	50	51	3	414.8	69	47	14.0	340	***4.21***	***0.16***	<0.5
8/21/2015	6D	81	49	47	2	341.6	79	59	18.4	280	0.030	0.010	<0.5
11/13/2015	6D	104	45	46	2	402.6	75	53	17.4	330	0.030	0.010	<0.5
Average		**119**	**55**	**51**	**9**	**424.0**	**79**	**56**	**16.1**	**347.50**	**0.088**	**0.017**	**<1**
10/16,24/2014	7D	300	155	110	47	292.8	106	82	18.1	240	0.267	0.011	<1
11/7/2014	7D	78	34	42	3	305.0	47	53	16.0	250	***3.74***	***0.21***	<1
1/19/2015	7D	74	32	37	1	292.8	48	45	14.8	240	0.190	0.020	<1
3/6/2015	7D	75	34	36	1	292.8	51	64	14.3	240	0.030	0.010	<1
4/20/2015	7D	74	32	42	2	256.2	58	56	16.8	210	0.030	0.010	<1
5/8/2015	7D	72	31	40	2	256.2	58	54	16.3	210	0.110	0.040	<0.5
8/21/2015	7D	70	34	37	1	231.8	55	51	14.5	190	0.030	0.010	<0.5
11/13/2015	7D	73	33	38	1	280.6	49	45	15.5	230	0.030	0.010	<0.5
Average		**102**	**48**	**48**	**7**	**276.0**	**59**	**56**	**15.8**	**226.25**	**0.098**	**0.016**	**<1**



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NORTH

LEGEND

- MONITORING WELL
- DESTROYED MONITORING WELL
- PROPERTY LINE

NOTES:

1. * INDICATES THAT THE MONITORING WELL HAS BEEN DESTROYED.

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FIGURE 4
DESTROYED MONITORING WELLS
BEAR CREEK WINERY, LODI, CALIFORNIA

TECHNICAL REPORT

Baseline Characterization of Soils

Main Disposal Area and Vineyard Blocks 1 and 2
Bear Creek Winery, Lodi, San Joaquin County

May 2004

FALL CREEK ENGINEERING, INC.

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TEL. (831) 426-9054 P.O. BOX 7894, SANTA CRUZ, CA 95061 FAX. (831) 426-4932

FALL CREEK ENGINEERING, INC.
Civil • Environmental • Water Resource Engineering and Sciences
Tel. (831) 426-9054 P.O. Box 7894, Santa Cruz, CA 95061 Fax. (831) 426-4932

May 27, 2004

Tim O'Brien
Central Valley Regional Water Quality Control Board
11020 Sun Center Drive #200
Rancho Cordova, CA 95670-6114

Transmittal: **Baseline Characterization for Vadose Zone Monitoring Program**
Bear Creek Winery, Lodi, San Joaquin County

Dear Mr. O'Brien:

On behalf of Bear Creek Winery, Fall Creek Engineering, Inc. (FCE) respectively submits the enclosed technical report. The report presents the results of the soil characterization study required by your office. The technical report has been prepared in accordance with Section 13267 Order for Technical reports, dated 28 April 2003.

In general, the results of the characterization study indicate that the application of process water to the LTU is within acceptable agronomic rates and is not resulting in any significant impacts to soil and groundwater conditions at the winery. Based on the results of this study, FCE has prepared a proposed soil monitoring program, which is presented as the final section of the enclosed study report.

FCE looks forward to your review of the subject report. Thank you for your ongoing cooperation on this project. If you have any questions or comments, please do not hesitate to contact me at (831) 426-9054.

Sincerely,

PETER HAASE, P.E.
Principal Engineer

Enclosure

cc+encl: Vince Westphal, Lodi
Craig Rous, Lodi
San Joaquin County Public Health Services

TECHNICAL REPORT

Baseline Characterization of Soils

Main Disposal Area and Vineyard Blocks 1 and 2
Bear Creek Winery, Lodi, San Joaquin County

Prepared For:

Bear Creek Winery
Attn: Craig Rous & Vince Westphal
Furry Road
Lodi, CA

Prepared By:

MARC BUCHANAN, PhD.
Soil Scientist

&

PETER HAASE, P.E.
Principal Engineer

REGISTERED PROFESSIONAL ENGINEER
PETER H. HAASE
No. 055605
Exp. 12/31/04
CIVIL
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1. Introduction

Fall Creek Engineering, Inc. and Buchanan Associates has conducted a soil investigation at the Land Disposal Facility at Bear Creek Winery. The soil investigation pursuant to the requirements of the California Regional Water Quality Control Board and according to a work plan prepared by FCE and dated, July 1, 2003.

The Winery applies process water to several locations on the 92 acre property. A majority of the process water is discharged to a 12-acre land disposal area and a portion of process water is applied to vineyards.

FCE conducted a soil investigation to evaluate and compare current conditions in the Main Disposal and Vineyard treatment units adjacent to the facility. The soil sampling program was conducted to evaluate the areal and vertical variation in soil chemistry in the various land disposal areas.

The results of the preliminary analysis of soil indicate variation in soil chemical properties from process water applications.

The following summarizes the findings from the initial sampling:

1. No significant physical restrictions to plant rooting depth and treatment volume were encountered.

2. There is some evidence of poor process water distribution uniformity across the Main Disposal Unit due primarily to an open ditch delivering the water to the checks.

3. Spatial variation of some properties in Main Disposal Unit may also be influenced by inherent soil properties and past land leveling activities.

4. There is evidence of an accumulation of potassium in the upper soil profiles in all units; however, this may not be directly related to process water applications, but rather land spreading of residual solids from the winery (i.e. land spreading of lees and filter cake on the soils).

5. There is some evidence of temporal soil pH reductions immediately following process water application; however, the soil pH was found to be higher in treated soils in comparison to the “control” or non-treated soil location. Process water applications may be increasing soil pH in 2 to 5 foot depth interval and overall soil pH buffering capacity appears to be maintaining favorable condition for organic mater mineralization and crop uptake

6. Organic matter is accumulating in upper soil profile due primarily to bi-annual incorporation of plant residues

7. The results indicate that nitrate-nitrogen may be accumulating in the upper foot of vineyard soils. It is unclear at this time if the nitrogen is present due to process water application or from irrigation water containing elevated nitrogen levels. Due to the relatively infrequent application of process water to the vineyards it is unlikely that the process water will provide

an adequate amount of organic matter to support biochemical reduction (denitrification) of nitrate. It is assumed that the grapevines will take up and use available nitrate nitrogen.

8. Nitrate-Nitrogen is not accumulating in the non-vineyard soils used for process water disposal.

9. Overall, under current operational conditions, process water percolation depths in the Main Disposal Unit may average 3.5 to 4.5 feet, however deeper percolation likely occurs in areas closest to the inlet and the distribution ditch.

2. STUDY METHODOLOGY

Samples were collected from the 0 to 1, 1 to 2, and 2 to 5 foot depth intervals of soil in the Main Disposal Area, and Vineyard Blocks #1 and 2. The sampling protocol for the Main Disposal area was designed to assess the degree of spatial variation in soil chemical properties as influenced by historical and recent process water loading. Composite sample collection was utilized for the vineyard blocks in order to develop comparative data.

2.1. Sampling Protocol – Main Disposal Area

Soil samples were collected from the three depth intervals at ten (10) locations in the area (Figure 1). These sample locations were selected to include a control (1 sample location) outside of the current treatment zone, sample points at varying distance from the sump inlet, and to include locations that had recently received fall season “crush” effluent and areas that had not yet received effluent (total of 9 sample locations). Each sample was collected with a manual auger, homogenized, then quartered, remixed, and sub-sampled into labeled two quart plastic bags. All samples were immediately stored on ice, in the dark until delivery to a certified analytical laboratory.

2.2. Sampling Protocol – Vineyard Blocks

Soil samples were collected from the three depth intervals at six (6) locations in each block (as shown in Figure 1). These sample locations were selected to provide a composite interpretation of soil conditions. Each sample was collected with a manual auger, homogenized and sub-sampled into labeled two quart plastic bags. All samples were temporarily stored on ice in the field. Following collection of all samples in each block, the sub-samples from each depth interval were mixed thoroughly in a clean plastic bucket, quartered, then re-mixed. A sub-sample was then placed in a two quart plastic bag, placed on ice, in the dark until delivery to a certified analytical laboratory.

Each sample was analyzed for the following parameters:

Soluble Ions Determined in Distilled Water Extracts	Additional Parameters Determined
• Calcium • Magnesium • Sodium • Potassium • Chloride • Sulfate • Nitrate	• Exchangeable Cations Calcium Magnesium Sodium Potassium Ammonium • Cation Exchange Capacity (CEC) • Iron • Manganese • pH • Soluble Salts (ECe) • Sodium Absorption Ratio (SAR)

3. SOIL CHARACTERISTICS

The soils in the Main Disposal and Vineyard blocks include two distinct soil series (USDA 1975) and have been formed under the dominant influences of parent material and fluvial deposition. The Main Disposal area is mapped as being predominantly on the Tokay fine sandy loam (0-2 percent slopes), with the southeastern corner (approximately 20 percent of area) occurring on Stockton clay (0-2 percent slopes). In reality, FCE found very little evidence to suggest the presence of Stockton clay in visual observations of soil borings from that portion of the site.

Vineyard #1 is also mapped to have approximately 60 percent Stockton clay and the remaining portion on Tokay fine sandy loam, but visual evidence suggests a much lower percentage of Stockton clay. Vineyard #2 is mapped as being all Stockton clay, however visual observations do not support this as well, although generally the soil generally found in the lower portions of the 2 to 5 foot depth interval do conform to expected characteristics of Stockton clay. As one would expect the Stockton clay series does occur in low lying landscape positions adjacent to Pixley Slough, it is likely that past land leveling for crop production may have buried portions of the Stockton clay series to varying degrees in all of the treatment units.

<u>Tokay fine sandy loam (0 to 2 percent slopes)</u>
Taxonomy – Coarse-loamy, mixed, thermic, Typic Haploxeroll

The soils of this series are very deep, well drained, and are found on low alluvial fan terraces. Soils in these areas are typically dissected by intermittent sloughs (e.g. Pixley). Typically the surface soil is grayish brown fine sandy loam to a depth of 19 inches, while the subsoil intergrades to pale brown fine sandy loam to a depth of 60 inches.

<u>Stockton clay (0 to 2 percent slopes)</u>
Taxonomy – Fine, montmorillonitic, thermic, Typic Pelloxererts

This soil is somewhat poorly drained and formed in alluvium from mixed sources. Soils in these areas are typically dissected by intermittent sloughs (e.g. Pixley) and mottles are typically found in the subsoil profile Typically the surface soil is dark gray clay to a depth of 29 inches. A zone of light brownish gray clay loam approximately 5 inch thickness is found below surface soil, while the subsoil may be weakly to strongly cemented (hardpan) clay loam or silty clay.

4. SOIL SAMPLE CHARACTERIZATION

In the following section, the chemical analysis of the soil samples collected from the Main Disposal Area and Vineyard Blocks 1 and 2 will be compared. Visual observations of soil samples are referenced occasionally in order to provide additional background information to support the interpretation of the chemical properties.

4.1. Main Disposal Area

Samples collected in the 10 sample locations provide a reasonable assessment of spatial variation in soil properties. Most of the following data is referenced by sample location number, but is grouped by their relative position to the sump inlet at the eastern portion of the disposal area. Therefore locations 2, 4 and 6 are closest, followed by 3 and 5, then 1, 7, 8, and 9 on the western edges of the area (Figure 1).

At the time of sample collection, effluent had been recently distributed over a number of checks, starting at the north end. Over approximately a week period each group of checks had sequentially received daily process water. This included sample locations 1,2,3, and 9 (see Figure 1).

Variations in Soil Physical Properties

After review of field notes and chemical data, a discussion of apparently inherent variation in soil properties should precede the discussion of the influence of process water applications on soil chemistry. As indicated above, this treatment unit is situated upon two distinct soil types as mapped in the San Joaquin County Soil Survey. Typical and historical soil-irrigation management practices in this area included large scale leveling of fields that, in some cases, required significant grading, which is common practice noted in the discussion of soil series in the survey.

Selected physical observations made during soil sampling are provided in Table 1 where "odor" is defined as the detection of anaerobic odors indicative of recent wastewater contact; "mottles" refer to presence of fresh localized concentrations of oxidized and/or reduced iron (Fe) and manganese (Mn); and "gley" refers to signs of a seasonally perched water bearing zone and fine textured soil (clay and silt versus sand). The data in Table 1, grouped based on proximity to Pixley Slough and the approximated boundary for Stockton clay (and as shown in Figure 1), will indicate those areas where it appears that the Stockton clay or an inter-grade of the tow soil series may have been buried (south near the slough) and areas that had recent contact with process water (north).

The data, particularly from the 2 to 5 foot depth interval suggest that some inherent chemical properties more likely associated with Stockton clay (e.g. CEC, soluble salt concentration, exchangeable cations, sulfate) are contributing to some of the spatial variation in chemical properties in the treatment unit.

There was evidence of seasonally perched water and fine-textured soil (silty clay to sandy clay loam) in the 2 to 5 foot depth intervals in locations 5, 6, and 7. Location 4 had gley and finer texture only at the 56 to 60 inch depth, while location 3 appeared to be more strongly influenced by recent process water application and soil texture was largely sandy loam at the depth where gley colors were found. All of the locations most recently in contact with process water had evidence of recent re-dox fluctuations (fresh, bright mottles) and slight to strong anaerobic odor.

Table 1. Subjective ranking of sample attributes odor, mottles, and gley

LOCATION #	Odor		Mottles		Gley	
	1-2	2-5	1-2	2-5	1-2	2-5
	--------------------------depth interval (ft) -----------------------					
North						
Control	--	--	--	+	--	--
1	--	--	+	++	--	--
2	--	+	+	+++	--	--
3	--	++	+++	+++	--	+++
4	--[1]	--	--	+	--	+
8	--	--	--	+	--	--
9	+++	+	--	++	--	--
South						
5	--	--	--	+	--	++
6	--	--	--	--	--	++
7	--	--	--	+	--	+++

1 = fresh grape juice odor

Soil pH

Table 2 suggests that generally the pH of soil in the treatment unit is slightly acidic, but not as strongly acidic as that found in the control area. Only the soil in the upper 2 feet of location #4 is similar to the control. This sample location was immediately adjacent to a check furrow that was receiving effluent at the time of sampling. The soil in the upper zones of #4 was moist and had a noticeable aroma of grape juice, suggesting that their was an influence of current process water. It was noted by other chemical properties in this sample that process water had recently been applied to this soil.

Generally, the data suggest that the soil may undergo pH fluctuations immediately following process water application, but that the pH buffering capacity of the soil tends to bring soil back to the slightly acidic range sometime after the application. This is suggested by the pH data for locations 1 and 2 that had received process water at least a week prior to soil sampling.

Table 2. Soil pH in the three soil depth intervals at each sample location

LOCATION #	0-1	1-2	2-5
Control	**4.8**	**5.2**	**4.4**
2	6.4	6.3	7.9
4	5.0	5.0	7.9
6	6.0	5.8	5.9
3	6.0	6.5	7.3
5	5.9	5.5	7.9
1	5.9	6.1	6.9
7	5.9	6.1	7.4
8	5.5	5.4	6.8
9	5.5	5.2	6.4

Total Soluble Salts

Table 3 summarizes data for total soluble salts (ECe). Almost all of the locations within the current treatment unit have soluble salt levels higher than the control, suggesting some routine application of process water may have increased the total soluble salts in the treatment zone.

Visual observations made during sample collection, notably in checks most recently receiving effluent, suggested that the average percolation depth was approximately 3.5 to 4.5 feet. This is reflected in the data from locations 1, 2 and 3 that had received process water prior to sampling. The soluble salt concentration is relatively uniform throughout the 5 foot profile, whereas the control and locations 5, 7, and 8 show a trend of increasing salinity with depth, that might be assumed where soil had only received the prior winter season rain. The higher salinity (=2.4) in the upper foot of soil at location 4 appears to coincide with recent process water applications that moved laterally from the check furrow.

Table 3. Soil ECe in the three soil depth intervals at each sample location

LOCATION #	0-1	1-2	2-5
	-------------- dS/m	------------	
Control	**0.15**	**0.30**	**0.26**
2	0.60	0.56	0.62
4	2.40	0.39	0.49
6	0.35	0.36	0.32
3	0.96	0.96	0.84
5	0.48	0.34	0.69
1	0.37	0.46	0.47
7	0.43	0.49	0.48
8	0.35	0.68	0.95
9	0.47	0.53	0.13

<u>Soluble Cations – Sodium and Potassium</u>

Soluble sodium and potassium levels are summarized in Table 4. These cations are typically more mobile than calcium and magnesium and are indicators of accumulation and movement of soluble salts due to process water application. Almost all locations have higher sodium and potassium levels than the control. While sodium-to-potassium ratios are approximately 1 in the control location, the data generally indicates higher loading of potassium. Predictably the highest levels were found in the top 2 feet interval at locations closest to the inlet where checks (#4) had most recently received process water (1,2, and 3) or were immediately adjacent.. These data suggest that process water has percolated to the 2 to 5 foot depth interval.

Location #9, that had also recently received process water and is the closet sample location to the control, is more similar to the control, suggesting lower historical and current loading due to it's distance from the inlet.

Sample location #1 is also quite proximate to the control location, but soil was much more sandy throughout the 5 foot profile in comparison to either the control or location #9. The soils in those two locations had increasing silt/clay in the 2 to 5 foot interval and slightly higher organic matter and CEC (Tables 6 and 7, respectively), compare to increases in coarse sand in location #1.

Table 4. Soil soluble sodium and potassium in the three soil depth intervals at each sample location

LOCATION #	0-1		1-2		2-5	
	Na	K	Na	K	Na	K
	---meq L^{-1}---					
Control	**0.90**	**0.65**	**1.1**	**1.5**	**0.87**	**0.99**
2	4.3	3.0	2.4	2.9	3.2	2.9
4	5.9	10.0	4.0	3.7	4.7	0.18
6	2.1	2.4	2.0	2.2	1.8	0.9
3	3.3	5.1	3.5	5.9	3.0	4.3
5	2.2	3.6	3.0	2.6	3.7	0.20
1	0.57	2.0	1.0	4.2	1.0	1.6
7	2.6	2.0	2.4	1.4	2.5	0.27
8	1.0	1.6	1.2	2.3	1.7	0.92
9	2.0	0.91	2.2	0.79	1.7	1.9

Soluble Cations – Calcium and Magnesium

Table 5 summarizes soluble calcium and magnesium. Calcium and magnesium is generally increased due to process water application, although the mobility of these ions appears to be lower. Higher levels found in the 2 to 5 foot depth intervals at locations 4, 5, 7, 8, and 9 may be due to higher clay content and constituents of the cemented layers found in the 2 to 5 foot depth interval. As found for sodium and calcium, the highest soluble levels are found at location #4 most proximate to the inlet.

Table 5. Soil soluble calcium and magnesium in the three soil depth intervals at each sample location

LOCATION #	0-1		1-2		2-5	
	Ca	Mg	Ca	Mg	Ca	Mg
	------------------------------- meq L^{-1} -----------------------					
Control	**0.76**	**0.20**	**1.1**	**0.29**	**1.2**	**0.30**
2	2.0	1.1	0.50	3.0	0.63	0.25
4	4.9	2.7	2.1	0.89	5.2	1.6
6	3.3	1.5	6.2	2.9	1.8	0.75
3	2.0	1.0	1.3	0.67	1.0	0.47
5	1.6	0.8	1.2	0.57	3.2	1.3
1	0.71	0.36	3.4	1.3	1.8	0.73
7	1.6	0.57	1.4	0.56	13.9	0.87
8	2.1	0.49	3.0	1.2	7.6	2.7
9	1.7	0.54	3.2	0.28	3.1	0.87

<u>Total Organic Carbon (TOC) and Total Nitrogen (TN)</u>

Table 6 summarizes organic matter and total nitrogen. There is a large variation in these properties across the checks attributed to recent applications of process water, soil texture variations, poor distribution uniformity around the distribution ditch and, perhaps past land leveling. The control location has relatively high TOC and TN, most likely due to past cropping for hay, lower tillage rates, and average moisture content (therefore mineralization rates) that will tend to preserve/protect organic matter in soil. [The elevated levels reported for the 2 to 5 foot depth interval may be erroneous, and the TOC and TN concentrations are most likely similar to location #1.]

Poor distribution uniformity of applied water is indicative of the TOC and TN levels found in locations 3,4,5, and 6 (proximity to inlet) and 7 and 8 (located on shorter check runs). As noted for soluble cations, organic matter levels in the 2 to 5 foot depth interval for locations 4,5,7,8, and 9 may, in part, be due to higher clay/silt texture in comparison to locations such as #1.

Table 6. Soil TOC and TN in the three soil depth intervals at each sample location

LOCATION #	0-1		1-2		2-5	
	TOC	TN	TOC	TN	TOC	TN
Control	**6600**	**700**	**4000**	**430**	**5200**[1]	**520**[1]
2	4000	500	1400	200	670	110
4	7400	980	1900	310	1600	120
6	7100	680	4400	460	1700	210
3	11,000	1300	6400	750	1800	280
5	8600	940	4800	520	900	120
1	2400	220	1800	200	560	96
7	7900	750	4900	500	2200	230
8	5900	590	3700	400	1500	170
9	4900	540	1700	180	1000	120

[1] Questionable analytical result, however sample discarded prior to re-test

Cation Exchange Capacity

Cation exchange capacity (CEC) is summarized in Table 7. Cation exchange capacity is influenced by soil clay content, the mineralogy/activity of the clay fraction, and organic matter content. There is also large variation in this property, due to inherent factors and past process water applications. Location 1 and 2, being the sandiest sample locations with lower organic matter have among the lowest CEC values. Whereas locations 5, 6, 7, and 8, where clay content increased significantly with depth, have on average higher CEC values. Locations 3,4,5, and 6, close to the inlet, have likely been influenced by the accumulation of organic matter over years of repeated process water applications.

Table 7. Soil CEC in the three soil depth intervals at each sample location

LOCATION #	0-1	1-2	2-5
	------------ cmol$^+$/kg ------------		
Control	**7.0**	**7.0**	**4.5**
2	4.9	3.0	2.6
4	10	8.1	13
6	13	14	10
3	10	10	8.0
5	11	7.1	7.5
1	4.7	4.9	2.9
7	11	11	7.8
8	10	8.5	6.5
9	5.4	2.9	3.0

<u>Exchangeable Cations – Sodium and Potassium</u>

Table 8 summarizes results for exchangeable cations, sodium and potassium. Exchangeable cations are defined as and assumed to be those positively charged ions held by electrostatic attraction on clay surfaces and clay-humus complexes (negative charges). Most sample locations suggest accumulation of these ions due to process water application; and natural variation in CEC contribute to this variations as well.

Exchangeable potassium levels appear to be increasing due to process water application and this is most evident due to accumulation in locations closest to the inlet. While potassium is quite water soluble, the apparent soil mediated "stripping" may not be the cause, rather simply that potassium still physically associated with particulate organic matter is deposited closer to the inlet source. Locations 1, 8, and 9 do not appear to receive this organic fraction due to their distance from the inlet.

The data for soluble and exchangeable sodium and potassium suggest that potassium accumulation is the most important source available for downward percolation of potassium below the 5 foot depth of soil.

Table 8. Soil exchangeable sodium and potassium in the three soil depth intervals at each location

LOCATION #	0-1		1-2		2-5	
	Na	K	Na	K	Na	K
	------------------------------mg kg^{-1} -----------------------					
Control	**76**	**260**	**88**	**360**	**100**	**300**
2	180	620	140	590	140	630
4	150	1200	160	130	180	120
6	120	670	130	580	130	420
3	150	1100	170	1600	160	1400
5	130	1100	120	670	150	120
1	120	520	110	580	110	290
7	110	590	130	490	97	120
8	55	450	51	460	100	220
9	99	180	110	130	96	210

Exchangeable Cations – Calcium and Magnesium

Table 8 summarizes results for exchangeable cations, calcium and magnesium. Most sample locations suggest accumulation of these ions from process water applications; however, variations in CEC contribute to this variation as well. Ion levels are increasing due to process water application in locations closest to the inlet as seen for potassium. Calcium levels in locations 6, 7, and 8 may be due to increase clay content and the accumulated constituents of the cemented layers observed in these locations, rather than transport of wastewater calcium to the 2 to 5 foot depth interval.

Table 9. Soil exchangeable calcium and magnesium in the three soil depth intervals at each location

LOCATION #	0-1		1-2		2-5	
	Ca	Mg	Ca	Mg	Ca	Mg
	mg kg^{-1}					
Control	**320**	**27**	**350**	**37**	**230**	**25**
2	410	110	240	61	330	61
4	580	150	500	110	310	300
6	850	180	1100	270	930	190
3	590	130	550	130	660	140
5	620	140	440	93	250	240
1	350	73	360	77	500	99
7	600	95	910	160	830	170
8	620	61	540	98	760	120
9	280	36	250	9	270	35

Anions - Chloride

Table 10 summarizes chloride levels. Generally the differences in locations receiving process water and the control are reflected in the distribution and magnitude of increase in chloride. Locations 2 and 3 (closer to inlet) had recently received process water and have higher chloride levels, as did location 9. Of course the lower levels found in location 1 reflect not only the distance from the inlet (and assumed lower total process water loading), but the coarser sand fraction. However the levels found here are still 2 to 3-fold higher than the control. The data for locations 2, 3, 4, and 5 appear to reflect the historical higher loading in these locations and also suggest that process water is moving to at least the 2 to 5 foot depth interval.

Table 10. Soil chloride in the three soil depth intervals at each sample location

LOCATION #	0-1	1-2	2-5
	------------ meq L^{-1} ------------		
Control	**0.13**	**0.28**	**0.14**
2	1.3	1.5	1.8
4	3.8	1.7	1.7
6	0.53	0.47	0.45
3	3.6	2.6	1.6
5	1.0	1.6	1.4
1	0.36	0.38	0.37
7	1.0	1.5	1.4
8	0.40	0.53	0.45
9	1.5	1.2	1.3

Anions - Nitrate

Nitrate levels are summarized in Table 11. Under the fluctuating redox conditions assumed to exist prior to and following process water application, nitrate accumulation should only occur under aerobic conditions prior to and some time following process water application. Nitrate in the control location shows a pattern that might be assumed for the time when sampling occurred. The loamy sandy soil that had been dry for at least 5 months has a low nitrogen mineralization potential. The increase in nitrate observed in the 2 to 5 foot depth interval may be due to the previous winter season precipitation moving nitrate formed in the topsoil downward. It may also be higher due to better moisture conditions that promoted greater mineralization during the summer dry period.

Many of the locations had similar or lower nitrate levels than the control, likely reflecting biochemical reduction following process water application. Note that locations 1, 2, 3, and 9 that had received process water recently, have relatively low nitrate levels. In comparison, location 4 has accumulated high levels of nitrate, likely due to the influence of recent process water application in adjacent checks, where moisture had been increased, aerobic conditions persisted due to still low current organic loading, therefore allowing mineralization of the accumulated TN and subsurface lateral movement of soluble N. These data indicate that nitrate maybe undergoing significant biochemical reduction in the upper soil profile

Table 11. Soil nitrate in the three soil depth intervals at each sample location

LOCATION #	0-1	1-2	2-5
	------------ ppm-N	-------------	
Control	**4.6**	**1.1**	**8.0**
2	7.3	4.4	1.1
4	92.0	32.0	9.5
6	1.6	1.3	1.1
3	2.1	0.8	0.4
5	4.1	9.3	2.9
1	4.3	0.90	2.5
7	2.9	5.4	2.8
8	2.4	2.2	1.5
9	0.36	0.21	0.15

Anions - Sulfate

Table 12 summarizes the data for sulfate-sulfur. In comparison to nitrate, less apparent reduction of sulfate appears to be occurring. Suggesting a less intense and shorter-term anaerobic cycle occur following process water applications in these soils. Conversely, this may also indicate that sulfate may be an important accompanying anion during downward transport of soluble cations. All locations are higher than the control and those locations closer to the inlet or recently receiving process water have higher concentrations. The higher level observed at location #8 may be associated with the underlying Stockton clay, as well as, sulfate being a primary constituent of the cemented materials found in the lower depth interval.

Table 12. Soil sulfate-sulfur in the three soil depth intervals at each sample location

LOCATION #	0-1	1-2	2-5
	------------ meq L^{-1}-S ------------		
Control	**0.49**	**1.7**	**0.67**
2	2.0	1.8	2.0
4	4.3	3.1	4.0
6	1.4	2.1	1.8
3	3.1	3.8	4.3
5	2.1	2.0	1.8
1	1.3	2.9	2.7
7	1.6	2.0	1.9
8	1.9	5.4	8.1
9	1.8	1.1	0.88

Anions – Bicarbonate

Table 13 summarizes the data for bicarbonate. Bicarbonate dynamics and sources in soils are varied, and in the case of soils receiving process water, bicarbonate accumulation can/will be influenced by degradation of recently applied organic matter. Bicarbonate contributes to soil alkalinity as suggested by the following:

$$[1] \quad pH = 7.8 + \log(HCO_3^-) - \log PCO_2$$

Equation 1 indicates increasing soil pH with increasing bicarbonate levels or decreasing partial pressure (sic. concentration) of carbon dioxide. Process water initially causes a depression in soil pH as evidenced in location 3 (Table 2), mineralization of applied organic matter then increases the partial pressure of carbon dioxide, ultimately leading to formation of bicarbonate with a concurrent rise in soil pH. The data provides some indication of this, as evidenced by small accumulation of bicarbonate in 0 to 1 foot depth interval at location 2. The highest levels found were in the 2 to 5 foot depth intervals of locations closest to the inlet (#2, 3, 4, 5, and 6) with historically higher organic matter loads and locations 3 and 9 that had noticeable anaerobic odors at the time of sample collection. Most of the soil in the 2 to 5 foot depth with measurable bicarbonate had a pH of > 7.4, with the exception of location 9 that had a pH of 6.4. Given the anaerobic odor of soil there, it is assumed that soil pH would likely rise later after aerobic conditions returned and organic matter mineralization rates decreased.

Table 13. Soil bicarbonate in the three soil depth intervals at each sample location

LOCATION #	0-1	1-2	2-5
	------------ meq L^{-1} ------------		
Control	**<1.0**	**<1.0**	**<1.0**
2	2.0	<1.0	2.0
4	<1.0	<1.0	3.0
6	<1.0	<1.0	<1.0
3	<1.0	1.1	1.0
5	<1.0	<1.0	3.5
1	<1.0	<1.0	<1.0
7	<1.0	<1.0	1.0
8	<1.0	<1.0	2.6
9	<1.0	<1.0	3.5

Iron and Manganese

These two cation species are useful indicators to indirectly determine the influence of process water loading on soil redox status. Temporary anaerobiosis caused by microbial respiration and decomposition of organic matter will stimulate the subsequent biochemical reduction of nitrate, sulfate, iron and manganese. In these samples, extractable iron varied significantly, but did not appear to be related to recent process water application, rather a correlation (R=0.86) was found with total organic carbon (TOC) (Table 6). Conversely, the increases in extractable manganese appear to be related to recent process water applications in or adjacent to locations 2, 3, 4, and 9.

Following saturation and the exhaustion of available oxygen, microbial reduction of oxidized chemical species favors: nitrate > manganese > iron > sulfate. As discussed previously there is evidence suggesting significant nitrate reduction and little sulfate reduction following process water application. Combined with this data and that for bicarbonate, it suggests that anaerobic cycling is relatively rapid given the current process water application schedule. Soil chemistry data suggest that the current process water organic loading rates do exceed the soil's ability to mineralize organic carbon.

Table 14. Extractable iron (Fe) and manganese (Mn) in the three soil depth intervals at each sample location.

LOCATION #	0-1		1-2		2-5	
	Fe	Mn	Fe	Mn	Fe	Mn
	---------- mg kg^{-1} ----------					
Control	**260**	**15**	**180**	**21**	**361**	**23**
2	130	19	66	31	50	30
4	220	40	140	51	52	12
6	200	21	140	16	86	6.8
3	280	32	220	69	98	54
5	270	12	230	14	51	6.7
1	112	5.0	7.5	1.3	43	2.7
7	290	31	160	17	60	17
8	230	19	140	9.8	54	3.8
9	240	18	130	45	72	42

4.2. Vineyard Treatment Units

The vineyard blocks located to the east of the Main Disposal Area have different soil properties, likely related to inherent and management-induced factors. Similar to the Main Disposal unit, only a few checks receive process water at any given time. As the following data are derived from a composite sample from each unit area, little can be said about spatial variation across the blocks other than to refer to selected visual observations made during sampling.

Generally, the soils in both of these units tend to have a higher silt and clay fraction in comparison to the main disposal unit. process water is applied infrequently to each block over the course of a year and the majority of crop water needs are met with supplemental irrigation with well water. Soil samples were collected in the middle of crop alleys, approximately equidistant from each vine row, wastewater furrow, and drip line.

<u>Vineyard Block #1</u>
At the time of sampling, the growing season was complete and it appeared that there had not been any recent wastewater or well water irrigations. Generally, the soil samples were dry. The soil samples tended to be finer textured than that found in the main disposal unit and these properties were observed as shown in Table 15 (also refer to Figure 1):

Table 15. Selected visual observations of soil sub-samples in Block #1

LOCATION #	0-1	1-2	2-5
1	sandy clay loam	loam	sandy clay loam mottles, bleaching
2	sandy loam	sandy loam	sandy clay loam gley, mottles
3	sandy loam	silty sandy loam	sandy loam few mottles
4	sandy clay loam	sandy clay loam mottles, bleaching	loamy sand/s. loam mottles, bleaching
5	loamy sand	sandy loam cemented	sandy loam cemented, bleaching
6	clay loam	silt loam cemented	sandy loam cemented, bleaching

There was little evidence of recent process water application (e.g. odor, fresh mottles). In locations 5 and 6 there was a cemented horizon at approximately the 48 inch depth as described for Stockton clay soil series. Numerous regions of light colored, bleached layers or lenses were observed suggesting the influence of a seasonally perched water bearing zone. Grape roots were found at all depths, except below the cemented horizons and in the drier top foot of soil.

Table 16 summarizes chemical properties of the composite soil sample from block #1.

Soil pH - Conditions were similar to the locations in the main disposal unit where recent process water applications had been made.

Soluble Salts – The top foot of soil indicates concentration of salts, similar to location #4 in the main disposal unit. Given the sample location between vine rows, it is likely that this high salinity is due to capillary and lateral water movement and subsequent evaporation of well and process water.

Soluble cations - Higher levels in the top foot are directly related to interpretation above. However, it should be noted that potassium makes up a substantial portion of the soluble cation pool. The ratio of calcium to potassium is higher than that typically found in agricultural soils. Potassium may be accumulating in the upper horizons due historical application of residual organic matter from the winery (disposal of lees, and screenings) and recent discharge of process water.

Total Organic Carbon, Total and Ammonium-Nitrogen - Organic matter levels are substantially higher than the average found in the main disposal unit. Routine incorporation of winter vegetation and fall prunings in the alleys are more significant than process water applications. Drip irrigation practices lead to drier conditions in the 0 to 1 foot depth of the sub-sample locations, thus organic matter may be conserved to a greater degree. The accumulation of ammonium-N in the top foot is likely due to nitrogen mineralization and little plant uptake from the dry soil.

Cation Exchange Capacity and Exchangeable Cations - The CEC is generally higher than that observed in the main disposal unit and is consistent with the higher TOC (0 to 1 foot) and higher clay fraction. Accumulation of potassium is again evident and the ratio of calcium to potassium again is lower than that typical of agricultural soils. It does not appear that potassium accumulation is or has yet occurred in the 2 to 5 foot depth interval, suggesting that potassium movement below this depth may be limited.

Anions - The distribution of chloride and sulfate do not suggest deep percolation of process water and, on average are generally lower than that found in the main disposal unit. Conversely nitrate levels are quite high, particularly as no nitrogenous fertilizers are applied to the crop. The accumulation of nitrate in the top foot is likely due to annual N mineralization from incorporated residues, native soil organic mater, and subsequent nitrification, and lack of crop N uptake from this zone due to tillage and low soil moisture. The accumulated ammonium-N levels suggest the mineralization/nitrification potential. It is also possible that a small portion of this is due to lateral and capillary movement of nitrate formed from mineralization of process water constituents or from well water. Bicarbonate levels were insignificant, thereby suggesting lower total organic loading from process water or more time since the last loading.

Iron and Manganese - Extractable iron and manganese appear to be correlate with TOC, but provide little insight into or suggestion of recent redox cycling.

Table 16. Selected chemical properties in the three soil depth intervals in Block 1

PARAMETER	0-1	1-2	2-5
pH	5.7	7.0	7.9
ECe (dS/m)	2.7	1.4	0.8
Sol-Ca (meq/L)	8.1	4.1	2.7
Sol-Mg	6.0	3.4	3.2
Sol-Na	2.7	2.0	3.5
Sol-K	9.4	4.2	0.5
TOC (mg/kg)	15,000	5300	1300
TN	2000	720	210
NH_4-N	19	3.4	< 1.0
CEC ($cmol^+/kg$)	24	16	12
X-Ca (mg/kg)	1640	1410	1220
X-Mg	550	520	610
X-Na	160	160	210
X-K	2300	1300	390
Chloride (meq/L)	0.93	0.53	0.70
Sulfate-S (meq/L)	5.6	3.3	3.5
Nitrate-N (mg/kg)	120	40	19
Bicarb. (meq/L)	<1.0	<1.0	<1.0
Iron (mg/kg)	120	51	21
Manganese (mg/kg)	54	19	6.8

Vineyard Block #2

At the time of sampling, the growing season was complete although, it appeared that there had been recent process water applications to the north side of the unit. Generally, the soil samples were slightly moist to very moist. The soil samples tended to be finer textured than that found in the main disposal unit, but less so than in Block # 1. These properties were observed as shown in Table 17 (also refer to Figure 1):

Table 17. Selected visual observations of soil sub-samples in Block #2

LOCATION #	0-1	1-2	2-5
1	sandy clay loam	clay loam/s.c. loam mottles	silty clay loam mottles, gley, moisture
2	sandy loam moist, mottles	sandy clay loam moisture, mottles	sandy clay loam gley, odor, mottles
3	sandy loam	sandy clay loam moisture, mottles	sandy clay loam moisture, mottles
4	sandy loam slight moisture	sandy clay loam moisture, mottles	silty clay loam moisture, gley, cemented
5	loamy sand	sandy loam moisture	sandy loam cemented
6	loamy sand	loamy sand slight moisture	sandy loam/loamy s. mottles

There was clear evidence of recent process water applications at sample location 2, where soil had a strong (0 to 2 foot depth) anaerobic odor, moisture was high, and 25-50% of the soil was gleyed from approximately the 36 to 56 inch depth interval. Below 50 inches, there was no odor and below 56 inches gley colors were not apparent. Strong fresh mottling and gley colors were found in a number of locations. There was significantly more moisture in all sub-samples in comparison to Vineyard #1. Strong cementing was only noted in the lower depths at location 6. Grape roots were found at all depths.

Table 18 summarizes chemical properties of the composite soil samples from Block #2.

Soil pH - Conditions were more similar to the locations in the main disposal unit where very recent process water applications had been made. A lower soil pH was found at the 2 to 5 foot depth.

Soluble Salts – The top foot of soil indicates concentration of salts, similar to Block #1 unit. Given the sample location between vine rows, it is likely that this high salinity is due to capillary and lateral water movement and subsequent evaporation of well and process water. Higher salinity found in the 1 to 2 foot depth suggesting some influence of more recent process water applications.

Soluble cations - Higher levels in the 0 to 2 foot depth are related also related to subsequent evaporation of well and process water as discussed above. The relationship of soluble cations and ECe is apparently inversed in the results for the 1 to 2 and 2 to 5 foot depth intervals. The results indicate the downward movement of soluble constituents of processwater is apparent. Similar to Block #1 potassium makes up a substantial portion of the soluble cation pool. The ratio of calcium to potassium is higher than typically found in agricultural soils. Potassium is likely accumulating in the upper horizons due to residual organic matter applied to the vineyards (lees and screened solids) and process water.

Total Organic Carbon, Total and Ammonium-Nitrogen - Organic matter levels are substantially higher than the average found in the main disposal unit and organic matter in the 1 to 2 foot depth are almost identical to that of the top foot. Routine incorporation of winter vegetation and fall prunings in the alleys are more significant than process water applications, and higher organic matter levels may be partially explained by recent process water loading and perhaps some artifact of past land leveling. Lower accumulation of ammonium-N in the top foot may be due to lower CEC, rather than lower nitrogen mineralization..

Cation Exchange Capacity and Exchangeable Cations - The CEC is generally higher than that observed in the main disposal unit and is consistent with the higher TOC (0 to 1 foot) and higher clay fraction. Accumulation of potassium is again evident and the ratio of calcium to potassium again is lower than that typical of agricultural soils. Potassium accumulation appears to be higher in the 2 to 5 foot depth interval, suggesting that potassium movement is occurring to this depth interval. The lighter, coarser texture of soil here, in comparison to that in Block #1, and less cemented material at depth may favor deeper percolation of irrigation water and process water.

Anions - The distribution of chloride and sulfate suggest more recent percolation of process water, but on average the levels are generally lower than that found in the main disposal unit. Nitrate levels are high in the near surface soils. The accumulation of nitrate in the top foot is likely due to annual N mineralization from incorporated residues, native soil organic matter, subsequent nitrification, and lack of crop N uptake from this zone due to tillage and low soil moisture. It is also possible that some of this is due to lateral and capillary movement of nitrate formed from mineralization of process water constituents. Higher levels in the 2 to 5 foot depth interval suggest that organic loading from process water is not high enough to stimulate significant biochemical reduction of nitrate. Bicarbonate levels indicate more recent process water loading similar to that of location 2 in the main disposal unit.

<u>Iron and Manganese</u> – As previously noted, extractable iron and manganese appear to be correlated with TOC, but provide little insight into or suggestion of recent and strong redox cycling. This may support the suggestion that recent organic loading may not be adequate to stimulate biochemical reduction of nitrate or manganese.

Table 18. Selected chemical properties in the three soil depth intervals in Block 2

PARAMETER	0-1	1-2	2-5
pH	6.4	4.5	10.6
ECe (dS/m)	2.7	2.2	1.5
Sol-Ca (meq/L)	6.4	4.5	10.6
Sol-Mg	4.5	3.3	7.8
Sol-Na	4.2	4.1	5.8
Sol-K	11.3	8.0	13.4
TOC (%)	12,000	11,000	3600
TN (%)	1600	1600	510
NH_4-N (mg/kg)	10	5.3	2.0
CEC (cmol$^+$/kg)	19	16	ND[1]
X-Ca (mg/kg)	1340	910	570
X-Mg	350	270	200
X-Na	140	200	140
X-K	2200	1640	990
Chloride (meq/L)	0.94	0.68	0.85
Sulfate-S (meq/L)	4.7	3.5	3.4
Nitrate-N (mg/kg)	130	85	33
Bicarb. (meq/L)	2.0	<1.0	2.0
Iron (mg/kg)	200	170	79
Manganese (mg/kg)	23	37	10

[1] ND = analytical equipment error

5. CONCLUSIONS

It is important to note that this study reflects one round of sampling. Although, the physical condition of the soils is not expected to vary significantly over time, soil chemistry can be quite variable, particularly in the near surface horizons, as a result of several factors, temperature, moisture, fertigation and process water application practices and residual organic matter (i.e. plant cuttings and application of mulch). The results of the soil testing presented in this study represent a range of soil conditions, including soils that have been rested for some time versus soils that had recently received process water and in general the results of the soil testing show how organic matter and soluble salts are processed in the upper five feet of the disposal areas. Based on the results of the baseline study, FCE has prepared the following conclusions:

1. There does not appear to be any significant physical restrictions to plant rooting depth and treatment volume in both the Main Disposal Unit and the vineyard blocks.
2. Higher concentration of organic matter and soluble salts in soils in close proximity to the main channel that distributes water to the checks in the Main Disposal area indicate that the current disposal method is providing poor wastewater distribution uniformity across the Main Disposal Unit.
3. Spatial variation of some properties in the Main Disposal Unit may also be influenced by inherent soil properties and past land leveling activities.
4. There is evidence of accumulation of elevated concentrations of potassium in all upper soil profiles in all units, which is expected given that the grape juice is enriched with potassium. These elevated levels are not affecting agricultural use of the soils.
5. There was evidence of temporal soil pH reductions immediately following process water application. However, over time, the application of process water, results in an increase concentration of bicarbonate, and appears to slightly increase the soil pH in treated soils, as compared to the “control” or non-treated soil location. Process water applications may be slightly increasing soil pH in 2 to 5 foot depth interval.
6. Overall soil pH buffering capacity appears to be maintaining favorable condition for organic matter mineralization and crop uptake.
7. Organic matter is accumulating in upper soil profiles due primarily to bi-annual incorporation of plant residues and to a lesser degree application of process water.
8. Nitrogen mineralization, nitrification, and reduced crop uptake lead to seasonal accumulation of nitrate in the upper foot of vineyard soils. However, nitrate levels are substantially reduced at depths suggesting that process water loading to vineyards may provide an adequate amount of organic mater to support biochemical reduction of nitrate.
9. Overall, under current operational conditions, process water percolation depths in the Main Disposal Unit may average 3.5 to 4.5 feet. Deeper percolation likely occurs in areas closest to the inlet.
10. Modifying the wastewater distribution system should be made to improve process water distribution uniformity in the main disposal unit

6. SOIL MONITORING PLAN

FCE recommends that soil sampling shall be performed biennially (every two years) in order to assess changes in chemical characteristics of the effective treatment profile in both LTUs in response to continued wastewater applications. FCE does not expect soil conditions to change rapidly and considers a biennial sampling frequency to be sufficient to assess potential impacts to soil and groundwater.

This sampling program should accomplish four objectives:

1. Maintain the integrity and effectiveness of the soil-crop system to retain, process and remove applied salts and organic constituents applied in process water;

2. Assure that process water constituents are being applied uniformly across the surface and within the effective soil treatment volume; and

3. Confirm that the soil's cation exchange capacity (CEC) is not exceeded;.

6.1 Sampling Protocol

Sampling should occur in the fall season prior to the start of the rainy season.

6.1.1. Main Disposal Area

For the Main Disposal Area, sample locations (minimum of four) should include:

1. An area in close proximity to the discharge point at the head of the unit;
2. An area at the head of the last southerly check;
3. An area in the mid-point of the LTU; and
4. An area at the bottom of the farthest north check.

At each location a total of two replicate samples will be collected from three depth intervals from the upper 5 feet of soil. Two duplicate samples shall be collected from the 0 to 2 foot, 2 to 4 foot, and 4 to 5 foot depth intervals. The sampling tool will be scraped and wiped clean prior to each sub-sample collected. The duplicate samples from each depth interval shall be placed into clean, labeled sample bags. All samples (8 total) shall be stored on ice, in the dark until delivery to a certified analytical laboratory.

6.1.2. Vineyard Units

For the Vineyard units (Blocks 1 and 2) a minimum of ten (10) sample locations shall be established to obtain composite and representative samples in each unit. These sample locations should be considered permanent, such that succeeding annual samples are collected from the same approximate location. Sample locations shall be within three feet of vines.

At each location a sub-samples samples should be collected from the upper 5 feet of soil at three depth intervals. Sub-samples samples shall be collected from the 0 to 2 foot, 2 to 4 foot, and 4 to 5 foot depth intervals at each location. The sampling tool will be scraped and wiped clean prior to each sub-sample collected. The ten sub-samples from each depth increment shall be combined and homogenized, then quartered, remixed, and sub-sampled into labeled sample bags. All samples (3) for each unit (or six (6) total samples from the vineyards shall be transported to a state certified laboratory for analysis. The samples shall be stored on ice, in the dark until delivery to the certified analytical laboratory.

6.1.3. Control Sample

In a location that does not receive process water applications a permanent sample location in vineyards shall be established to obtain three control samples. At the control location a composite and representative sample shall be collected. The sample location should be considered permanent, such that succeeding annual samples are collected from the same approximate location. Sample locations shall be within three feet of vines.

At this location sub-samples samples should be collected from the upper 5 feet of soil at three depth intervals. Replicate sub-samples shall be collected from the 0 to 2 foot, 2 to 4 foot, and 4 to 5 foot depth intervals at each location. The sampling tool will be scraped and wiped clean prior to each duplicate sub-sample. Duplicate sub-sample from each depth increment shall be combined, homogenized, and stored into labeled sample bags. All samples (3) for the control location shall be transported to a state certified laboratory for analysis. The samples shall be stored on ice, in the dark until delivery to the certified analytical laboratory.

Each of the location (Main Disposal Area) and composite samples (Vineyard Blocks) from the three depth increments (15 total annual samples) shall be analyzed for the following parameters:

Soluble Ions Determined in Distilled Water Extracts	Additional Parameters Determined
• Calcium • Magnesium • Sodium • Potassium • Carbonate • Bicarbonate • Chloride • Sulfate • Nitrate • Nitrite	• Exchangeable Cations Calcium Magnesium Sodium Potassium Ammonium • Cation Exchange Capacity (CEC) • Total Nitrogen (TKN) • Total Organic Carbon (TOC) • Iron • Manganese • pH • Soluble Salts (ECe) • Sodium Absorption Ratio (SAR)

6.2. Data Interpretation and Trend Analysis

The results of the chemical characterization shall be evaluated in comparison to the control samples and the baseline conditions established in the April 2004 report. Specific attention should be made to trends in soluble and exchangeable potassium, chloride, pH and exchangeable potassium to sodium ratios shall be examined and interpreted. Data from the 4 to 5 foot will provide assessment of the potential for deeper translocation of ions and thus, the effectiveness of the treatment system.