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April 27, 2009

Mr. David Cuneo
Senior Environmental Specialist
Sonoma County Water Agency
404 Aviation Blvd.
Santa Rosa, CA 95403

Subject: Northern Sonoma County Agricultural Reuse Project, Final Environmental Impact Report: Technical Review of Hydrology and Water Quality Issues

Dear Mr. Cuneo:

I am a registered geologist and hydrogeologist in the State of California, with 25 years experience conducting local and basin-scale investigations of groundwater and surface-water hydrology and water quality. My project experience has included work for Sonoma County agencies preparing environmental impact reports related to winery wastewater, forest conversion to vineyards, and aggregate mining along the middle reach of the Russian River. I recently completed a technical review of a report on Dry Creek Valley groundwater conditions (Johnson 2008) on behalf of the Clean Water Coalition of Northern Sonoma County (CWCNSC). A copy of the memorandum describing my findings and additional analysis is attached. CWCNSC also asked me to review the subject FEIR to determine whether the analysis of hydrology and water quality impacts was complete and adequate. This letter contains the results of that review.

I have found that several important impacts were overlooked and that the analysis of others was cursory or unsubstantiated. As it stands, the FEIR is not an adequate document to fully inform SCWA and permitting agencies of the potential impacts of the proposed project. I recommend that the FEIR not be certified until these deficiencies have been corrected. My concerns are listed below with supporting data and analysis that may be useful in revising the FEIR.

1. New Impact: Use of NSCARP water for frost protection is likely to contaminate surface water and groundwater.

The project description states that frost protection is an allowed use of recycled water (FEIR Vol. 1, p. 2-11). Sprinkling for frost protection occurs on clear nights in spring, when soil moisture is typically near field capacity from winter rains and crop ET demand is low. Under these conditions, surface runoff of applied water is likely and has been observed by rural residents. This runoff—including all of the salts, nitrate, dissolved organic carbon, metals and other pollutants contained in the water—flows without dilution to local creeks and the Russian River. If recycled water is used for frost protection, there will be discharges of recycled water runoff along most of the length of Dry Creek and the Russian River where they cross the proposed NSCARP service area. The potential magnitude of these discharges is not trivial. NSCARP contemplates delivery of recycled water to 21,000 acres of vineyard along the Russian River and Dry Creek. A typical sprinkling rate for frost protection is 0.12 inches per hour (Kaismatis and others 1982). If all of the service area were simultaneously sprinkled on a cold night, the total application rate would be 2,500 cfs. If only 30% of the applied water became runoff, it would amount to 760 cfs of discharge into surface waterways, which is greater than or equal to the mean monthly flow for April in the Russian River at Healdsburg in 29 of the 68 years of record. The impact on fish and downstream municipal supply impacts could obviously be large during frost protection events. The FEIR failed to disclose this potential impact.

Frost protection water that infiltrates instead of running off is an equally large problem. Again, because soil moisture in spring is commonly close to field capacity, additional infiltration tends to simply pass through the root zone via large pores in the soil and percolate to the water table. Thus, most of the frost protection water that does not run off flows fairly directly to the water table, along with the salts, nitrate, metals and organic carbon it contains. This contamination of groundwater creates potentially significant impacts on groundwater salinity (see comment 3), toxics (see comment 4) and surface water quality by way of indirect discharge (see comment 5).

2. Impact HWQ-4: Inadequate analysis of nitrogen impacts on viticulture and groundwater

The discussion under HWQ-4 (FEIR p.3.8-42) dismisses potential nitrate impacts on viticulture and groundwater in two sentences:

> “Nitrate levels in recycled water, applied in accordance with accepted irrigation practices, are below the nitrate requirements of crops. Therefore, nitrate in recycled water would be almost entirely taken up by vegetation with minimal migration beyond the root zone.”

This analysis is inadequate for three reasons. First, the annual nitrogen load from NSCARP water may exceed the annual requirements for wine grapes. At buildout, NSCARP contemplates delivering as much as 20,135 AF/yr of recycled water to 21,521 acres of vineyard and orchard (of which 99% is vineyard; FEIR Vol. 1 Table 2.2 and p. 2-19). This corresponds to an average annual application of 11.2 inches per year. The nitrogen content of the recycled water averages 10.7 mg/L (as N) (FEIR Vol. 1, Table 3.8-2), which leads to an annual load of 27.8 pounds per acre per year. While this is within the normal annual range for table grapes (22-44 pounds [Peacock 1998]), it exceeds what many north coast wine grape growers apply. The University of California/Napa Sanitation District study cited in the FEIR (p. 3.2-26) stated that 14-21 pounds of nitrogen per acre per season is:

> “not exceptionally high, but it may be enough to be of concern to some growers…. There are some vineyards that rarely (if ever) receive nitrogen additions. Potential mitigation measures for growers concerned about nitrogen

> in the NSD recycled water include selective use of cover crops and having an additional source of water available for irrigation."

The Lake County Winegrape Growers agree: "grapevines require very little nitrogen, and in some vineyards nitrogen is seldom, if ever, applied" (http://www.lakecountywinegrape.org/growers/suswine.php accessed 3/31/2009).

The second point of inadequacy in the analysis if nitrogen impacts is that it ignores the seasonality of nitrogen utilization by grape vines and the close attention paid by growers to vine nutrient status. Even if the annual total nitrogen content of recycled water is acceptable, use of recycled water for irrigation eliminates growers' ability to manage water and nitrogen applications separately. A brief literature survey quickly turned up scientific and commercial studies confirming the seasonality of nitrogen uptake by grape vines and the impact of incorrect fertilizer timing and quantities on the grape crop and subsequent winemaking (for example, Peacock and others 1998; Keller 2005). Nitrogen uptake increases steadily from bud break to veraison, then declines. Excessive nitrogen applications lead to luxuriant canopy growth which must be pruned back to prevent mildew on the berries. Inadequate nitrogen status can reduce the amount of yeast available nitrogen in the berries, which interferes with fermentation. Nitrogen applications outside the season of uptake have a higher tendency to contaminate groundwater. The inability to manage the timing of irrigation and fertilization separately poses a large and undesirable constraint for growers. This will lead to adverse impacts on winegrape production, or low acceptance of NSCARP water by winegrape growers.

The third weakness of the nitrogen impact analysis is the omission of data for existing nitrate concentrations in groundwater. For example, Johnson (2008) compiled available water quality data for 12 wells in the Dry Creek valley and found elevated nitrate concentrations in three of them. One of two wells that received additional testing had traces of simazine (an herbicide) and trichloromethane (a disinfection byproduct). These results demonstrate that nitrogen and other contaminants can and do percolate past the root zone. Nitrogen concentrations in NSCARP water exceed the drinking water standard (10 mg/L as N). Recycled water applied for frost protection would not experience substantial losses by plant uptake at that time of year, and dilution from other sources of recharge would be diminished by NSCARP (see comment 5, below). Therefore, nitrate concentrations in rural domestic wells would likely increase and could theoretically exceed the drinking water standard.

In light of this additional information, the two-sentence discussion of nitrogen impacts in the FEIR is clearly inadequate.

3. Impact HWQ-4 and Master Response 15: Inadequate analysis of salinity impacts on groundwater

The discussion of impact HWQ-4 in the FEIR (Vol. 1, p. 3.8-42) incorrectly characterizes the impact of irrigating with NSCARP water on groundwater salinity as "minor" and incorrectly implies that such increases are in compliance with State law because of a certain clause in the Water Code. The discussion provides no data or calculations to support the claim that salinity increases would be minor. Master Response 15 estimates that salt concentrations would "double", citing the cumulative impact analysis completed for Santa Rosa's Discharge Compliance Project FEIR (City of Santa Rosa, 2008). A doubling of groundwater salinity is not minor, and can violate water quality standards or jeopardize beneficial uses.

For example, the total dissolved solids (TDS) concentration of groundwater in Dry Creek Valley averages about 200 mg/L (Johnson 2008). Average annual applications on vineyards are approximately 3.3 inches for frost protection (of which an estimated 70% infiltrates) and 10 inches for summer irrigation. Deep percolation of rainfall and irrigation water beneath the root zone averages about 7 inches per year (Johnson 2008; Wagner & Bonsignore 1999). All of the solutes in the applied water are dissolved into the deep percolation. A simple mass balance calculation indicates that the TDS concentration in deep percolation under existing conditions must be approximately 352 mg/L.[1] NSCARP water has an average TDS concentration of 432 mg/L (FEIR Table 3.8-2). Assuming normal irrigation of 11.2 inches at NSCARP buildout plus infiltration of 70% of water applied for frost protection leads to an estimated TDS concentration of approximately 807 mg/L[2]. This concentration is slightly more than double the concentration under existing conditions.

More importantly, 807 mg/L of TDS violates the state drinking water standard of 500 mg/L. The assertion in the FEIR that "The California State Water Code states that minor changes in salinity associated with recycled water projects are acceptable." (FEIR p. 3.8-42) is extremely misleading. First, there is no such statement in the Water Code. The closest similar statement is different in important respects:

> 13523.5. A regional board may not deny issuance of water reclamation requirements to a project which violates only a salinity standard in the basin plan.

Although a Regional Board might have the authority to waive compliance with its own basin plan standards, it would not have the authority to authorize violation of drinking water standards.

Groundwater TDS would be lower than deep percolation TDS if there were dilution with other sources of recharge. However, dilution from one of the major sources of recharge—stream percolation—would substantially decrease under NSCARP (see comment 5 below). Therefore, a domestic well downgradient of vineyards irrigated with NSCARP water would be at risk of pumping groundwater that violates the drinking water standard for TDS.

Master Response No. 15 (FEIR Vol. 3, p. 3-15) relied upon two studies conducted for the City of Santa Rosa's Discharge Compliance Project FEIR. One of the studies contained a significant error and the other involved hydrogeologic conditions very different from those in the proposed NSCARP service area. The first study was the evaluation of cumulative impacts

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[1] [(3.3 in)(0.7)(200 mg/L)+(10 in)(200 mg/L)]/(7 in) = 352 mg/L

[2] [(3.3 in)(0.7)(432 mg/L)+(11.2 in)(432 mg/L)]/(7.25 in) = 807 mg/L. The deep percolation rate assumes 80% irrigation efficiency for irrigation in excess of 10 in/yr (e.g. 20% of 1.2 in = 0.25), which is added to the 7 in/yr of annual deep percolation assumed for 10 in/yr of irrigation.

of the DCP and other projects on the percent recycled water in groundwater at potable supply wells. The analysis included a critical error regarding salt loading of the groundwater system. The analysis assumed that only 11% of applied irrigation water would percolate to the water table, based on an assumed 89% irrigation efficiency (Merritt Smith Consulting 2008, p. 4). The analysis proceeded to calculate the percent recycled water reaching wells, as if the 11% of irrigation water that percolates to the water table contains only 11% of the salts and other pollutants. In fact, deep percolation would contain nearly all of the dissolved constituents in the recycled water, because annual deep percolation is sufficient to flush them from the soil zone (see the University of California/Napa Sanitation District study cited in the discussion of Impact AG-4; FEIR Vol. 1, p. 3.2-27). Thus, although the analysis might have correctly estimated the percentage of recycled water molecules reaching the wells, that percentage grossly underestimates the percentage of recycled water salts that reach the wells.

The second study cited from the DCP EIR monitored groundwater quality near cropland on the Santa Rosa Plain irrigated with recycled water from Santa Rosa's wastewater treatment plant (Winzler & Kelly 2007). The report stated that wells in and downgradient of the application areas "do not appear to exhibit cumulative impacts related to irrigation with reclaimed water and biosolids application." However, this conclusion is not well supported by the data, which were replete with confounding effects. At three of the four study sites, there were noticeable water quality trends in the upgradient wells. Six of the 13 monitoring wells had cracked or damaged seals, and 5 of the 13 wells were thought to be potentially affected by inundation of the wellhead, cattle grazing around the well, adjacent farmyards and adjacent dairies. More importantly, soil and aquifer conditions in the study area were less conducive to contaminant transport than soils in the proposed NSCARP service area. Soils at the four test sites were mainly of the Blucher, Pajaro and Wright series, which have low-permeability layers of clay loam. Beneath the soil zone, the younger alluvium (typically 30-100 feet deep) is characterized as having "low permeability" (DWR Bulletin 118 http://www.groundwater.water.ca.gov/bulletin118/basin_desc/basins_s.cfm#gwb49htm accessed 4-20-2009). In light of these weaknesses and differences, the Santa Rosa study is not a reliable basis for concluding that groundwater contaimination is unlikely in the proposed NSCARP service area.

In summary, this comment lists five significant flaws in the analysis for Impact HWQ-4 and Master Response 15. The FEIR should not be certified until the flaws have been corrected and salinity impacts on groundwater have been characterized more realistically.

4. Impact PUB-7 and Master Response No. 9: Inadequate analysis of risks to aquatic and human health from groundwater contamination

The discussions of potential groundwater contamination from irrigation with recycled water (FEIR Vol. 1 pages 3.12-25 to 3.12-26 and Vol. 3 p. 3-11) rely on compliance with generic regulations regarding treatment level and setbacks from wells to conclude that the impacts would be less than significant as long as irrigation applications are not excessive. This analysis is inadequate because it ignores local conditions and studies that indicate a significant risk of contamination. It also ignores regulatory directives that call for additional analysis and restrictions if aquifer vulnerability is high.

The recycled water policy adopted by the State Water Resources Control Board two months ago exemplifies this tiered approach to regulation. Landscape irrigation projects using recycled water may proceed under a general statewide permit unless "unusual conditions" are present (section 7.b.(1)). The example of unusual conditions provided in the policy document is exactly the condition present throughout most of the NSCARP service area: "irrigation over high transmissivity soils over a shallow high quality aquifer".

A second example of regulatory adjustment to reflect high aquifer vulnerability is the Westside Recycled Water Project in western San Francisco (see http://sfwater.org/msc_main.cfm/MC_ID/13/MSC_ID/377). Recycled water used for landscape irrigation in Golden Gate Park and nearby areas will be treated with reverse osmosis in addition to the disinfected tertiary level of treatment normally required for such projects. This additional level of treatment probably reflects the high risk of aquifer contamination due to the presence of dune sand soils and the absence of clay confining layers above the water table.

Groundwater in the proposed NSCARP service area (Alexander Valley, Dry Creek Valley and the Middle Reach of the Russian River) is similarly vulnerable to contamination. The surficial soils (predominantly loams and sandy loams) are more likely to adsorb pollutants than the Sirdrak Sand soils in western San Francisco. However, the soils are not thick and are underlain by exceedingly permeable sands and gravels. Removal of many pollutants in the subsurface is by adsorption onto the surfaces of mineral particles, particularly silts and clays. The lack of such fine-grained sediments is evidenced by the fact that alluvial sands and gravels along the Russian River are very desirable for aggregate mining. At the Syar Industries gravel quarry pits along the Middle Reach, for example, the Yolo Loam "overburden" is typically 10 feet deep and as little as 3 feet deep (ESA 2007). Along Dry Creek, Yolo Loam and sandier soils comprise 80% of the valley floor. In the Alexander Valley, riverwash, sandy alluvial land and Cortina Very Gravelly Sandy Loam are widespread in addition to Yolo Loam varieties. The lack of fines in shallow alluvial materials is further confirmed in the California Department of Water Resources Bulletin 118 description of the basin, which notes that wells only 25-50 feet deep near Healdsburg can yield 200-500 gpm (http://www.groundwater.water.ca.gov/bulletin118/ basin_desc/basins_s.cfm#gwb49htm accessed 4-20-2009). I obtained a drillers log for a well along Dry Creek near Pena Creek that conforms with this pattern. The alluvium is only 44 feet deep and consists of 7 feet of loam over clean sands and gravels. Although the well has only 21 feet of screen, it reportedly produces 1,300 gpm.

Local data also demonstrate that attenuation of pollutants in the subsurface is unusually low. Field and laboratory tests of subsurface transport of pollutants in recycled water were completed for the City of Santa Rosa's Discharge Compliance Project (Kennedy/Jenks Consultants 2007a and 2007b). The laboratory test involved percolation of recycled water through columns of soils collected from the Russian River floodplain. The field study examined groundwater quality in monitoring wells downgradient of the "Basalt Pond", which receives effluent from the City of Healdsburg's municipal wastewater treatment plant. In both studies, transport of copper and nickel and total organic carbon (TOC) was much greater than expected. For example, 38% of the nickel was still present at a monitoring well 5,300 feet from the Basalt Pond. Attenuation of the metals by adsorption was not considered sufficient to meet the California Toxics Rule, which sets numerical standards for those and other pollutants. The tests also found an "unexpectedly low" average TOC attenuation of only 26%.

Additional tests gave support to the hypothesis that the metals failed to adsorb to sediments because they chelated with organic compounds also present in the recycled water. These interactive effects were not considered in prior modeling studies that had indicated low subsurface mobility. The only hypothesis offered for low TOC attenuation was that the concentrations were lower than in typical wastewater to begin with. The fact that the results of the experiments were unexpected is equivalent to an "unusual circumstance" from a regulatory standpoint. The fact that the transport distances were higher than expected undermines the conclusion in the FEIR that small (50 foot) setbacks from water supply wells or surface water bodies are sufficient to protect human and aquatic health.

Thus, groundwater in the NSCARP service area is sufficiently vulnerable to contamination that adherence to standard regulations and setbacks is an inadequate basis for concluding that aquatic and human health will not be impacted.

5. **New Impact: NSCARP will substantially alter local groundwater balances such that all surface waterways in the service area will convert from consistently losing to consistently gaining streams. This will increase contamination of groundwater and surface water by salts and pollutants in recycled water.**

The FEIR fails to describe the fundamental shift in groundwater balances that would result from replacing groundwater with recycled water as the primary source of irrigation supply. One response to comment mentions simply that the Santa Rosa DCP EIR "concluded that reduced groundwater pumping can result in discharge of groundwater to surface water sources" (comment T-5, FEIR Vol. 3, p. 4-32). This grossly understates the impact that NSCARP would have. The decrease in groundwater pumping would be large enough to reverse the current stream-aquifer relationships in summer and eliminate stream percolation as a source of groundwater recharge. Without this recharge, deep percolation beneath irrigated cropland—which would contain concentrated levels of salts and pollutants—would experience little dilution in the aquifers. Without dilution, groundwater at potable supply wells could exceed drinking water standards for salinity (see comment 3, above) and California Toxics Rule limits for copper and nickel (see comment 4, above). Furthermore, constant seepage from groundwater into streams—without the seasonal reversal that occurs under existing conditions—creates a new pathway for chronic contamination of surface waterways by pollutants contained in recycled water. Each link in this cascade of impacts is elaborated below.

A recent USGS study of groundwater conditions in the Alexander Valley used the difference in flow between two gages on the Russian River (Cloverdale and Healdsburg) to demonstrate that the river gains flow along the valley in winter and loses flow in summer (Metzger 2006). In a recent year of normal flow (2000) the cumulative dry season flow loss was 2,800 AF. Assuming 10 inches of summer irrigation on the 6,629 acres of vineyard in the Alexander Valley, current dry-season groundwater pumping is approximately 5,524 AF. Comparing the pumping and flow loss figures shows that concurrent seepage from the Russian River supplies about half of the dry-season groundwater pumping. If NSCARP water replaced all of the groundwater used for irrigation—which is the long-term assumption in the FEIR—the dry-season groundwater balance would shift from negative to positive, and groundwater would seep into the river instead of the other way around. An evaluation of groundwater-surface water interactions along the Russian River completed for the Santa Rosa Discharge Compliance Project EIR reviewed several additional studies that showed that pumping induces seepage from the river and causes losing conditions in summer (Kennedy/Jenks Consultants 2007c).

The same seepage reversal would occur in Dry Creek Valley. Johnson (2008) tabulated flow differences between gages near Warm Springs Dam and the Russian River and found that the average cumulative flow loss during June-October was over 3,000 AF. Groundwater pumping to irrigate the 5,909 acres of vineyard and 188 acres of orchard in Dry Creek Valley is approximately 5,100 AF (again assuming 10 inches of applied water). Thus, as in the Alexander Valley, about half of the dry-season groundwater pumping is supplied by concurrent seepage from Dry Creek. Replacing groundwater with NSCARP water would shift the groundwater balance from negative to positive and would shift the creek from losing to gaining.

Reversing the direction of seepage along Dry Creek and the Russian River has significant water quality implications. First, salts, metals, dissolved organic carbon and other pollutants in recycled water are evaporatively concentrated in the soil following irrigation. The concentrated solutes then percolate to the water table. Under existing conditions, recharge from deep percolation is diluted by induced recharge from the river during the dry season, but with NSCARP this dilution would no longer occur. Other sources of recharge for dilution—such as groundwater inflow from hillsides along the creek and river valleys—are relatively small. This leads to a condition in which solute concentrations in groundwater will gradually approach the concentrations in deep percolation, and under NSCARP those concentrations would exceed drinking water standards and the California Toxics Rule.

Reversing the seepage direction along Dry Creek and the Russian River would also create a new pathway for contaminants to enter those waterways. The waterways intersect the groundwater system at the water table. The shortest and fastest subsurface flow paths for recycled water that has reached the water table is to flow laterally to the creek or river. Deeper flow paths offer much greater resistance to flow because they are longer and because hydraulic conductivity along deep flow paths is much lower due to greater compaction of the alluvium and anisotropy caused by grain orientation and layering of the alluvial deposits. Therefore, recharge from deep percolation beneath cropland under NSCARP would not mix uniformly throughout the groundwater system before discharging to creeks and rivers. Rather, most of it would flow laterally at shallow depth to the discharge point, with little dilution by deeper groundwater.

The short, fast flow paths from the water table beneath vineyards to nearby creeks and rivers provide a conduit for pollutants in recycled water to enter surface waterways during the summer low-flow season. Field studies have demonstrated that some pollutants are only partially removed during flow through aquifers. The field investigation of subsurface transport of wastewater contaminants downgradient of the “Basalt Pond” (which receives discharges from the City of Healdsburgs’ wastewater treatment plant) found surprisingly low attenuation of copper and nickel at wells as much as 5,300 feet downgradient. Much of the proposed NSCARP irrigation service area is within 5,300 feet of Dry Creek or the Russian River (Kennedy/Jenks Consultants 2007b), so percolated pollutants from applied irrigation water could reach those waterways.

In addition to elevated concentrations of copper and nickel, the field study found that groundwater derived from infiltrated recycled water was consistently low in dissolved oxygen. This would pose an additional threat to aquatic life when the groundwater discharges into Dry Creek or the Russian River.

To summarize this impact, NSCARP would fundamentally change the dry-season groundwater balance, which in combination with other project effects would create a pathway for concentrated pollutants derived from NSCARP irrigation water to enter surface waterways, with potentially significant impacts on water quality and aquatic life.

Each of the five comments presented above represents a major omission or flaw in the analysis presented in the FEIR. Until those errors have been corrected, the FEIR is not adequate as an informational document to guide decision makers responsible for approving or implementing the NSCARP. I recommend that the FEIR not be certified until the potential impacts described herein are fully evaluated and mitigated.

Thank you for considering these comments. Please do not hesitate to call me if you have any questions.

Sincerely,

Gus Yates

Gus Yates PG, CHg

Attachment: Technical memorandum dated March 9, 2009 reviewing Johnson (2008) report.

References Cited

ESA, Inc. June 2007. Syar phase VI use permit and ARM plan amendment. Draft subsequent environmental impact report. State Clearinghouse Number 2004102054. San Francisco, CA. Prepared for Sonoma County Permit and Resource Management Department, Santa Rosa, CA.

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______________________. 2007c. Santa Rosa IRWP – Discharge Compliance Project, regional groundwater-surface water interactions along the Russian River and the Laguna de Santa Rosa. Technical memorandum I-8. Prepared for City of Santa Rosa.

Merritt Smith Consulting. September 30, 2008. Discharge Compliance Project EIR, Exhibit A: evaluation of cumulative concentrations of recycled water in groundwater and surface water resulting from DCP discharge to the Russian River and cumulative projects. Technical memorandum prepared for Pat Collins, Winzler & Kelly.

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Winzler & Kelly Consulting Engineers. March 22, 2007. Report of soil and groundwater monitoring, City of Santa Rosa subregional reclamation system. Santa Rosa, CA. Prepared for City of Santa Rosa, CA.

MEMORANDUM

Gus Yates, PG, CHg, Consulting Hydrologist
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Date:	March 3, 2009
To:	Fred Corson, Clean Water Coalition of Northern Sonoma County
From:	Gus Yates, Consulting Hydrologist
Cc:	
Subject:	Northern Sonoma County Agricultural Reuse Project: Revised Versions of Nick Johnson's Water and Salt Balance Tables for Dry Creek Basin

As we discussed by telephone, I revised the water balance table (Table 16) and salt balance table (Table 17) in Nick Johnson's December 2008 report "Potential Water Supply Impacts to Dry Creek Valley from NSCARP and a Bypass Pipeline". The purpose of the revisions was to adhere more clearly to well-defined boundaries of the flow system. To that end, I developed a schematic diagram of the hydrologic system in the Dry Creek Valley, including the creek, soil zone and groundwater zone (Figure 1). My water balance is an average annual balance for the groundwater zone.

The revised water balance is shown in Table 1, followed by notes explaining the assumptions and data used to derive various items. I retained Nick's estimates wherever they were consistent with my boundaries and approach, which was the case for most of the flow items. The magnitude of the revised budget (13,400 ac-ft/yr of inflows and outflows) is comparable to the budget in Table 16 (12,300 ac-ft/yr).

In this system, changes in recharge and groundwater pumping are balanced by corresponding changes in seepage to and from Dry Creek. The principal effect of NSCARP on the flow system would be to substantially decrease groundwater pumping, which in turn would convert Dry Creek from a losing stream to a gaining stream in summer. The variations of the project (high or low irrigation rates and optional use of recycled water for frost protection) had the same general effect but with slightly different changes in selected flow items.

The revised water balance table does not include the effects of a bypass pipeline for water deliveries from Lake Sonoma because I do not think a pipeline would cause additional impacts on the water balance. This conclusion is based on the assumption that the pipeline would not be allowed to decrease flows below the levels recommended in the Biological Assessment for steelhead and salmon. The Assessment recommends summer flows of 25 cfs at the mouth of Dry Creek, downstream of the flow gains and losses along Dry Creek valley. Current flow losses are on the order of 11 cfs, and under NSCARP project conditions the creek would gain rather than lose flow. Thus, streamflow in the creek would continue to be able to receive or deliver the flow gains and losses indicated in Table 1 for existing and project conditions.

The revised salt budget table (Table 2) is structured slightly differently than Nick's Table 17, but it retains many of the same assumptions and data. Table 2 calculates the average annual salt inflows and outflows from the basin as mass fluxes (tons per year) rather than as concentrations. The itemization of inflows parallels the diagram and the water balance table. A separate table is shown for existing conditions and each of the four combinations of NSCARP conditions. At the end of each table, the annual increase in salt mass is divided into the estimated total volume of groundwater in the basin to obtain the annual increase in salinity that would result if the net salt load were mixed uniformly throughout the basin. This last assumption is unrealistic, but it provides a basis for comparing the impacts of each project variation and also indicates a general magnitude of the existing and project salinity impacts.

Finally, Table 3 shows the change in TDS concentration of deep percolation below the root zone in a hypothetical vineyard under existing conditions and each of the possible NSCARP project conditions. This analysis shows that the project could double the salinity of deep percolation, which is roughly the same conclusion reached in Nick's analysis.

Dry Creek Basin Groundwater Balance

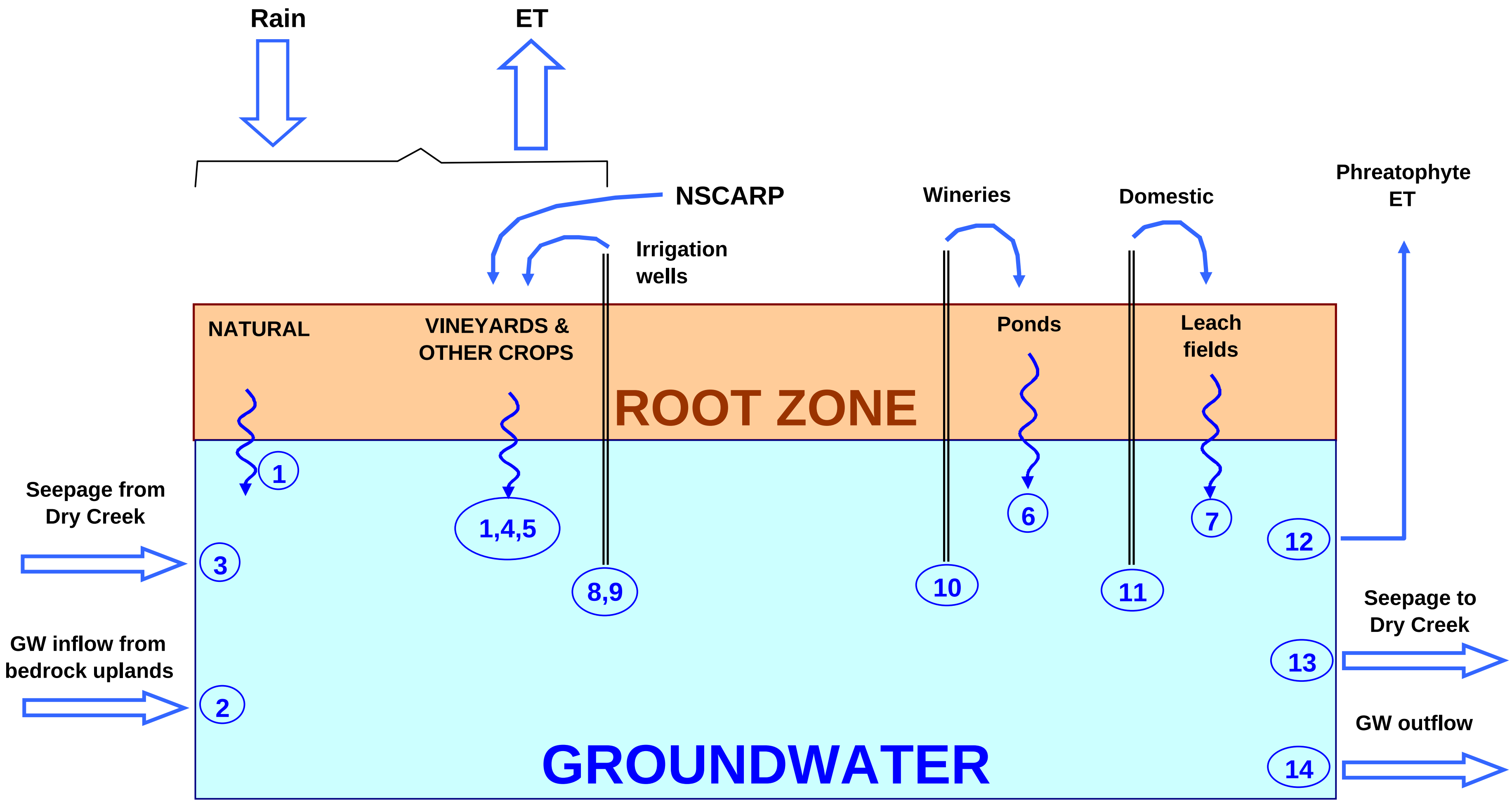

Table 1. Average Annual Water Balance for Dry Creek Groundwater Basin (Acre-Feet per Year)

Diagram Label	Budget Item	Existing	NSCARP, Summer Irrigation Only: Low Irrigation	NSCARP, Summer Irrigation Only: High Irrigation	NSCARP with Frost Protection: Low Irrigation	NSCARP with Frost Protection: High Irrigation
	Inflows					
1	Rainfall recharge valley floor	5,658	5,658	5,658	5,658	5,658
2	GW inflow from adjacent bedrock	2,217	2,217	2,217	2,217	2,217
	Percolation from Dry Creek					
3	Summer	4,000	0	0	0	0
3	Winter	0	0	0	0	0
	Irrigation deep percolation					
	Vineyards					
4	Frost protection	1,059	1,059	1,059	1,059	1,059
4	Summer irrigation	0	0	1,017	0	1,017
5	Other crops	160	160	160	160	160
	Other return flows (septic, etc.)					
6	Wineries	125	125	125	125	125
7	Domestic	214	214	214	214	214
	TOTAL	13,433	9,433	10,449	9,433	10,449
	Outflows					
	Groundwater pumping					
8	Vineyard frost protection	1,513	1,513	1,513	0	0
8	Vineyard irrigation	7,800	1,853	1,853	1,853	1,853
9	Other crops	800	800	800	800	800
10	Wineries	250	250	250	250	250
11	Domestic	450	450	450	450	450
12	Phreatophyte GW ET	364	364	364	364	364
	GW seepage into Dry Creek					
13	Summer	0	435	1,452	1,948	2,964
13	Winter	3,434	3,434	3,434	3,434	3,434
14	GW outflow	334	334	334	334	334
	TOTAL	13,433	9,433	10,449	9,433	10,449
	Annual storage change					
	Inflows minus outflows	0	0	0	0	0
	Change in water levels	0	0	0	0	0

Table 1, continued -- Notes on Groundwater Balance

Line No.	Data Sources and Assumptions
Global	Changes in GW pumping are primarily compensated for by changes in GW seepage to and from Dry Creek.
Global	The bypass pipeline would not cause any additional changes in the GW balance beyond those caused by NSCARP because Dry Creek summer flows would still be sufficient to absorb the changes in seepage gains and losses. Proposed summer flows in the Biological Assessment are 25 cfs at the mouth of Dry Creek (i.e. after all upstream seepage gains and losses). The magnitude of the seepage changes under NSCARP are a shift from a flow loss of about 11 cfs during a 6-month dry season to a flow gain of about 3 cfs.
1	Johnson, Table 16. 7 in/yr on 9,700 acres.
2	Johnson, Table 16. 2 in/yr on 13,300 acres of adjacent bedrock.
3	Johnson, Table 16. Existing condition summer percolation is difference between gaged flow in Dry Creek at Warm Springs Dam and at the Russian River. Creek assumed to gain flow from GW seepage in winter. Under NSCARP conditions, GW pumping for irrigation is decreased by 5,100 af/yr. It is assumed that this is first balanced by decreasing percolation **from** Dry Creek in summer (to zero), and the remaining imbalance becomes increased seepage **into** Dry Creek.
4	Vineyard irrigation assumed to be 100% efficient at up to 10 in/yr applied water (Johnson, Section 2.6). Any irrigation in excess of 10 in/yr is assumed to be inefficient and to percolate through the root zone to GW. 2 in/yr x 6100 ac of NSCARP vineyards = 1,107 af/yr.
5	400 ac of orchard and pasture receive 24 in/yr applied water at 80% efficiency (Johnson, Section 2.5.2)
6	Johnson, Section 2.6. Wineries use 250 af/yr, half of which percolates back to GW from wastewater storage ponds.
7	Johnson, Section 2.6. Domestic wells pump 450 af/yr of GW, 50% is used indoors and 75% of indoor use percolates to GW via leach fields. 20% of outdoor water use (irrigation) becomes deep percolation below the root zone.
8	Johnson, Section 2.5.2. 8,000 ac of vineyard use 10 in/yr for irrigation and 5 in/yr for frost protection under existing conditions. NSCARP assumes 6100 acres of vineyard would be irrigated at 7 in/yr (low estimate) or 12 in/yr (high estimate). It is assumed here that the remaining 1,900 ac of vineyards would continue receiving 7 in/yr of GW irrigation. Frost protection is assumed to be 5 in/yr supplied by GW on all vineyards. Thus, the decrease in vineyard irrigation pumping is 6,100 ac x 10 in/yr = 5,083 af/yr.
9	Johnson, Section 2.5.2. 400 acres of orchard and pasture receive an estimated 24 in/yr of irrigation.
10	Johnson, Section 2.6. Wineries pump an estimated 250 af/yr of GW for processing.
11	Johnson, Section 2.6. Rural domestic wells pump an estimated 450 af/yr

12 Johnson, Section 2.5.3. Phreatophyte ET of GW estimated to be 15 miles long x 100 ft wide x 24 in/yr

13 Dry Creek assumed to be losing water along its entire length in summer under existing conditions. The gain in winter derives from Johnson's 800 af/yr of "Groundwater discharge to stream baseflow and riparian ET" (which was calculated as the residual in his budget). In this table, phreatophyte ET and subsurface GW outflow are calculated separately (364 and 334 af/yr, respectively), leaving 800-364-334=102 af/yr. This is rounded upward to 176 af/yr to better balance the budget. Under NSCARP, the decrease in GW pumping for irrigation is first balanced by a decrease in seepage **from** Dry Creek, and the remaining imbalance becomes increased seepage **into** Dry Creek.

14 Subsurface outflow to the Russian River and Middle Reach groundwater basin calculated from Darcy's Law: 60 ft/d x 2 mi width x 50 ft depth x 0.00126 ft/ft gradient.

Table 2. Dry Creek Groundwater Basin Salt Balance

		Existing Conditions				
Diagram Label	Salt Budget Item	Acres	in/yr	AFY	WQ mg/L	Salt load ton/yr
	Salt inputs					
1	Rainfall percolation	9,700	7	5,658	0	0
2	GW inflow from bedrock			2,217	200	547
3	Percolation from Dry Creek			4,000	150	740
	Vineyard irrigation water					
4	NSCARP frost protection	0	0	0	432	0
4	NSCARP irrigation	0	0	0	432	0
4	GW frost protection	5,500	3.3	1,513	200	373
4	GW irrigation	8,000	11.7	7,800	200	1,925
5	Orchard & pasture irrigation	400	24	800	200	197
6	Winery wastewater			125	800	123
7	Domestic wastewater			214	800	211
	TOTAL					4,117
	Salt outputs					
	Well pumping					
	Vineyards					
8	Frost protection	5,500	3.3	1,513	200	373
8	Summer irrigation	8,000	11.7	7,800	200	1,925
9	Orchard & pasture			800	200	197
10	Wineries			250	200	62
11	Domestic			450	200	111
12	Phreatophytes			364	0	0
	GW seepage into Dry Creek					
13	Summer			0	200	0
13	Winter			3,434	200	847
14	GW outflow			334	200	83
	TOTAL					3,598
	Inputs minus outputs					519
Basinwide groundwater TDS trend						
	GW volume (Johnson, Table 2) (AF)					70,000
	Average rate of increase (mg/L/yr)					6

Table 2, continued

		NSCARP Low Irrigation, GW Frost Protection				
Diagram Label	Salt Budget Item	Acres	in/yr	AFY	WQ mg/L	Salt load ton/yr
	Salt inputs					
1	Rainfall percolation	9,700	7	5,658	0	0
2	GW inflow from bedrock			2,217	200	547
3	Percolation from Dry Creek			0	150	0
	Vineyard irrigation water					
4	NSCARP frost protection	0	0	0	432	0
4	NSCARP irrigation	6,100	8.7	4,423	432	2,357
4	GW frost protection	5,500	3.3	1,513	200	373
4	GW irrigation	1,900	11.7	1,853	200	457
5	Orchard & pasture irrigation	400	24	800	200	197
6	Winery wastewater			125	800	123
7	Domestic wastewater			214	800	211
	TOTAL					4,266
	Salt outputs					
	Well pumping					
	Vineyards					
8	Frost protection	5,500	3.3	1,513	200	373
8	Summer irrigation	1,900	11.7	1,853	200	457
9	Orchard & pasture			800	200	197
10	Wineries			250	200	62
11	Domestic			450	200	111
12	Phreatophytes			364	0	0
	GW seepage into Dry Creek					
13	Summer			435	200	107
13	Winter			3,434	200	847
14	GW outflow			334	200	83
	TOTAL					2,238
	Inputs minus outputs					2,028
Basinwide groundwater TDS trend						
	GW volume (Johnson, Table 2) (AF					70,000
	Average rate of increase (mg/L/yr)					23

Table 2, continued

		NSCARP High Irrigation, GW Frost Protection				
Diagram Label	Salt Budget Item	Acres	in/yr	AFY	WQ mg/L	Salt load ton/yr
	Salt inputs					
1	Rainfall percolation	9,700	7	5,658	0	0
2	GW inflow from bedrock			2,217	200	547
3	Percolation from Dry Creek			0	150	0
	Vineyard irrigation water					
4	NSCARP frost protection	0	0	0	432	0
4	NSCARP irrigation	6100	13.7	6,964	432	3,712
4	GW frost protection	5,500	3.3	1,513	200	373
4	GW irrigation	1900	11.7	1,853	200	457
5	Orchard & pasture irrigation	400	24	800	200	197
6	Winery wastewater			125	800	123
7	Domestic wastewater			214	800	211
	TOTAL					5,621
	Salt outputs					
	Well pumping					
	Vineyards					
8	Frost protection	5,500	3.3	1,513	200	373
8	Summer irrigation	1,900	11.7	1,853	200	457
9	Orchard & pasture			800	200	197
10	Wineries			250	200	62
11	Domestic			450	200	111
12	Phreatophytes			364	0	0
	GW seepage into Dry Creek					
13	Summer			1,452	200	358
13	Winter			3,434	200	847
14	GW outflow			334	200	83
	TOTAL					2,489
	Inputs minus outputs					3,132
Basinwide groundwater TDS trend						
	GW volume (Johnson, Table 2) (AF					70,000
	Average rate of increase (mg/L/yr)					36

Table 2, continued

		NSCARP Low Irrigation, NSCARP Frost Protection				
Diagram Label	Salt Budget Item	Acres	in/yr	AFY	WQ mg/L	Salt load ton/yr
	Salt inputs					
1	Rainfall percolation	9,700	7	5,658	0	0
2	GW inflow from bedrock			2,217	200	547
3	Percolation from Dry Creek			0	150	0
	Vineyard irrigation water					
4	NSCARP frost protection	5,500	3.3	1,513	432	806
4	NSCARP irrigation	6,100	8.7	4,423	432	2,357
4	GW frost protection	0	0	0	200	0
4	GW irrigation	1,900	11.7	1,853	200	457
5	Orchard & pasture irrigation	400	24	800	200	197
6	Winery wastewater			125	800	123
7	Domestic wastewater			214	800	211
	TOTAL					4,699
	Salt outputs					
	Well pumping					
	Vineyards					
8	Frost protection	0	0.0	0	200	0
8	Summer irrigation	1,900	11.7	1,853	200	457
9	Orchard & pasture			800	200	197
10	Wineries			250	200	62
11	Domestic			450	200	111
12	Phreatophytes			364	0	0
	GW seepage into Dry Creek					
13	Summer			1,948	200	481
13	Winter			3,434	200	847
14	GW outflow			334	200	83
	TOTAL					2,238
	Inputs minus outputs					2,461
Basinwide groundwater TDS trend						
	GW volume (Johnson, Table 2) (AF					70,000
	Average rate of increase (mg/L/yr)					28

Table 3. Change in Recharge TDS Below a Converted Vineyard

Existing

	Frost	Irrig	Combined
TDS applied water (mg/L)	200	200	
Inches applied water	2.31	10	12.31
Inches deep percolation			9.31
TDS deep percolation			264

NSCARP Low Irrigation, GW Frost Protection

	Frost	Irrig	Combined
TDS applied water (mg/L)	200	500	
Inches applied water	2.31	8.7	11.01
Inches deep percolation			9.31
TDS deep percolation			517

NSCARP High Irrigation, GW Frost Protection

	Frost	Irrig	Combined
TDS applied water (mg/L)	200	500	
Inches applied water	2.31	13.7	16.01
Inches deep percolation			11.31
TDS deep percolation			647

NSCARP Low Irrigation, NSCARP Frost Protection

	Frost	Irrig	Combined
TDS applied water (mg/L)	500	500	
Inches applied water	2.31	8.7	11.01
Inches deep percolation			9.31
TDS deep percolation			591

NSCARP High Irrigation, NSCARP Frost Protection

	Frost	Irrig	Combined
TDS applied water (mg/L)	500	500	
Inches applied water	2.31	13.7	16.01
Inches deep percolation			11.31
TDS deep percolation			708