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3 January 2010

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Jeffrey S. Young (Chair) and Members of the
Central Coast Regional Water Quality Control Board
895 Aerovista Place, Suite 101
San Luis Obispo, California 93401

Dear Mr. Young and Colleagues,

I am writing to comment on the Draft Conditional Waiver of Waste Disharge Requirements for Discharges from Irrigated Lands, Order No. R3-2011-006 ("Ag. Waiver") and the associated Monitoring and Reporting Program (MRP). I conduct research, teach, and provide technical assistance to regional groups, cities, and agencies concerned with water resources through my position as a Professor of Earth and Planetary Sciences at the University of California, Santa Cruz, where I have worked since 1995. I have some experience in studies of water supply (quantity and quality) associated with surface water – groundwater interactions and groundwater resources, but I'm not an expert in matters of irrigation management. The views presented in this letter are mine alone and are not intended to represent an official position by the University of California.

I appreciate the care and effort that have been required for preparation of the Draft Ag. Waiver, MRP, Staff Report, and associated documents by the Central Coast Regional Water Quality Control Board ("Regional Board") and staff. Clearly it is challenging to balance agricultural, municipal, industrial and environmental water resource needs, particularly during a time of increasing demand, economic uncertainty, climate variability, and skepticism about the role of government in managing natural resources. That said, I fear that the Draft Ag. Waiver and associated documents may present some unintended problems for the Regional Board going forward, and for constituencies subject to the Board's regulation, particularly with regard to the availability and quality of groundwater resources. I summarize my concerns in the rest of this letter, with an emphasis on conditions in the Pajaro Valley, but many of these concerns will apply more broadly to the Central Coast Hydrologic Region.

One fundamental goal of the proposed regulations is *to restore hydrologic and ecosystem function* to water systems associated with irrigated agriculture, so as to improve the quality and sustainability of these resources for coming generations. The hydrologic cycle is impacted by agricultural and other human activities, and some of these impacts have degraded the quality of both surface water and groundwater resources. One likely impact of extensive urbanization and agricultural development is to limit the extent of groundwater recharge, the percolation of surface water through the vadose zone and across the water table. For this reason, the improvement of recharge function should be considered an important part of restoring regional hydrologic conditions. Reductions in recharge can occur because of shorter retention times for surface runoff and lowering of the infiltration capacity of shallow soils. A combination of increased pumpage and reduced recharge can lead subsequently lead to groundwater overdraft, as has occurred in the Pajaro Valley Groundwater Basin. Overdraft can lead, in turn, to a lowering of water levels, reduced water quality, loss of baseflow to streams, degradation of critical aquatic habitat, ground subsidence, and seawater intrusion. The full extent by which groundwater recharge has been reduced by development in the Pajaro Valley (and in other groundwater–dependent basins that have undergone extensive development) is difficult to quantify, in part because the recharge process itself is cryptic. Nevertheless, it is clear that an important part of bringing the Pajaro Valley Groundwater Basin back into hydrologic balance will involve *restoring some of the groundwater recharge function that has been lost as a result of decades of urbanization and agricultural development*. Reducing pumpage alone likely will not be sufficient to secure reliable, long-term supplies for the Central Coast Hydrologic Region – improving recharge conditions will be required as well. In addition, enhanced surface water infiltration and groundwater recharge can help to achieve essential water quality goals, as described below.

Managed aquifer recharge (MAR) has been applied successfully in the Pajaro Valley Groundwater Basin through the Harkins Slough project and associated management practices and infrastructure developed by the Pajaro Valley Water Management Agency (PVWMA), serving to improve both water supply and water quality in the basin. There are likely to be opportunities for enhancing recharge in other parts of the Pajaro Valley, particularly when linked to low impact development and stormwater capture. Colleagues and I are currently working on a GIS-based analysis of surface and subsurface conditions that might be conducive to MAR on a distributed basis throughout the Pajaro Valley, in collaboration with local growers, landowners, the Santa Cruz County Resource Conservation District, the PVWMA, and other stakeholders. The next step in this effort will be conducting a series of local pilot studies to provide "groundtruth" to GIS-based analyses, and to assess improvements to water supply and quality that can be achieved through distributed MAR. MAR-based improvements to water quality in the Pajaro Valley may come from two distinct mechanisms.

First, water applied to percolation basins from stormwater capture during and immediately after the wet season will have a high quality relative to that in underlying aquifers in many locations. Getting some of this water into the ground is important for improving and maintaining water quality in critical aquifers. Second, considerable improvement in water quality can be achieved during percolation of surface water because of beneficial microbial and filtering processes that occur during passage of water through the vadose zone. Recent studies of the Harkins Slough MAR percolation system have demonstrated a removal of ~50% of nitrate from surface water (~500 to 600 kg NO_3-N removed from ~600–800 acre-feet of infiltration), an efficiency commensurate with that achieved from vegetative buffer strip applications. Research shows that most of this removal is attributable to denitrification, which represents complete removal of nitrate from the aquatic system. The extent to which similar water quality benefits can be achieved during MAR at other sites around the Pajaro Valley remains to be determined, but colleagues and I are planning for a series of pilot studies that will help to assess the potential for water quality improvements through MAR. It is important to achieve as much denitrification as possible during infiltration and recharge because relatively little occurs once the water enters underlying aquifers (due to a lack of available carbon, the introduction of excess air, and other factors). Current and planned studies should provide information that is useful for evaluating what kinds of MAR approaches are most beneficial. As part of finalizing the draft Ag. Waiver, I urge that opportunities for enhancing groundwater recharge, and improving both water supply and water quality, not be stifled. Please consider designing the Ag. Waiver so as to encourage the development of field-scale pilot studies that can provide information needed to assess the efficacy of MAR to augment water supply and improve water quality. Pilot and operational systems will need to rely on adaptive management strategies, applied flexibly based on local field conditions, to achieve maximum benefit. Studies will need to be completed site by site because hydrologic, soil, and other conditions are highly variable in space and time.

The development of distributed MAR projects around the Pajaro Valley, and in similar basins within the Central Coast Hydrologic Region, has the potential to improve both water supply and water quality conditions more broadly. Benefits could extend to surface water systems such as streams and wetlands, flows in which can be enhanced by raising the local water table and/or introducing secondary supply (for example, water discharged from recycling and other treatment systems). The latter can help to achieve simultaneous benefit to surface water and groundwater systems by increasing surface flows late in the water year, and taking advantage of recharge that occurs naturally from losing streams. Enhancing and maintaining groundwater recharge through streams is also encouraged through reductions in sediment delivery to streams: fine-grained sediments that collect on streambeds during low flow conditions serve to reduce infiltration and "disconnect" surface water conveyances from underlying aquifers. In addition, the movement of surface water into the streambed and back out again ("hyporheic flow"), which is common in many streams, helps to speed nutrient cycling and regulate stream temperature, both of which can benefit aquatic habitat. Capturing a small amount of excess winter runoff for recharge will reduce sediment and nutrient loading of streams. Maintaining elevated flows in streams during the second half of the water year, when flows tend to be low (and dry gaps can develop), contributes to improvement to both surface water and groundwater conditions by enhancing surface water – groundwater interactions. Flexibility in management of stream flows will be helpful in finding appropriate supplies of water that can be introduced to streams to benefit basin hydrologic conditions for the long term. Available water may not meet drinking water standards at all times, but there can be a significant net benefit to introducing available water if the quality is *sufficiently good* so as to improve conditions relative to what would occur in its absence.

My final concern has to do with draft sampling, analysis, and reporting requirements as described in the Draft MRP. I have overseen and participated in several water sampling, measurement, and analysis projects, involving specially trained and supervised personnel, and a surprisingly high fraction of the samples and data collected through these projects is of poor quality. As a rule of thumb, I have found that generally 10-20% of data and samples collected are "bad" or otherwise inconsistent with the majority of data and samples, despite the best efforts to drive down the number of errors in practice. In some cases, it is possible to resolve inconsistencies based on poor instrument calibration, incorrect field practices, or other factors, but it is often not possible to determine exactly why a particular sample or data point is invalid. This is the nature of working with complex natural–human water systems. My reading of the Draft MRP suggests that an enormous sampling and data collection effort will be required to assess many aspects of irrigation management and associated water quality. The more samples and data are collected, the more bad values likely will be introduced in the composite data set (particularly if there are hundreds or thousands of separate individuals responsible for collection of samples and data). It is not clear who will decide which data or samples are good or bad. It is often necessary to assess results by cross-plotting multiple constituents or ratios between conservative and non-conservative solutes to determine, for example, whether an apparent improvement to water quality might result from source control versus dilution. In addition, although the draft MRP includes requirements for development of a Quality Assurance Project Plan, and specific requirements for laboratory analytical methods, other aspects of sample collection and monitoring are likely to be highly variable in quality and their representative nature. For example, measuring the discharge of small streams, ditches, drains, and similar conveyances is difficult and imprecise, and errors of 50-100% at flows ≤1 cfs are common. Numerous choices will be made in how field samples are collected, e.g., how deep a water bottle is placed when it is filled, whether wells in adjacent fields are on or off when sampling from another well, and these decisions are likely to influence the chemistry of recovered samples. And collection of samples and data is only the beginning – considerable analyses, hydrologic assessment, modeling, and other work will be required to interpret data sets from individual sites and aggregates of sites. Managing these analytical requirements will comprise a significant burden to Regional Board staff, landowners, growers, and others, and results will likely be subject to multiple interpretations.

This last concern relates to the issue of developing MAR projects, as discussed earlier in this letter. The success of pilot studies of MAR sites will depend, in part, on results of field monitoring, sample analysis, and modeling. For these assessments, the sampling frequencies likely will be more extensive than the basic level of monitoring outlined in the MRP, at least for brief periods. But at other times, sampling requirements may be more modest. The extent of the sampling program associated with pilot studies of MAR should be developed based on local conditions, including ambient water quality at the time when projects are developed. Adaptive management is essential for achieving the greatest water quality benefits. If water quality standards and sampling requirements are overly prescriptive for development of these systems, both water supply and water quality will suffer in the long term. Managed aquifer recharge can contribute to widespread water supply and quality improvements in the Central Coast Hydrologic Region, but some flexibility will be required to implement viable MAR pilot studies and implementation projects.

I remain optimistic that improved water resource conditions can be developed throughout the Central Coast Hydrologic Region while preserving agricultural, economic, social, and environmental benefits. Focusing on the goal of *restoring hydrologic and ecosystem function* is essential for developing rigorous and practical requirements and monitoring programs. I wish you and your colleagues success in your efforts.

Sincerely,

Andrew T. Fisher