An Integrated Approach For Water Quality: The PAM Connection— West Stanislaus HUA, CA

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USDA conservation and education agencies in partnership with a resource conservation district have successfully met water quality objectives the past five years through a comprehensive, integrated, locally managed watershed project in Stanislaus County, California (90 mi south of Sacramento in the San Joaquin Valley). The West Stanislaus Hydrologic Unit Area (HUA) project is one of 36 HUA's nationwide established in 1991 by USDA's "Water Quality Initiative."

Irrigation-induced erosion has been studied in the West Stanislaus Watershed area for over 15 years and these studies have contributed greatly to developing statewide predictive tools. Many Best Management Practices (BMPs) have been evaluated during this period. The innovative evaluation and use of PAM by HUA agencies is a more recent practice that has proven to have potential for reducing significant amounts of sediment and pesticide residues from entering the impaired San Joaquin River.

The West Stanislaus Resource Conservation District (RCD) serves as the local, grass-roots sponsoring agency. RCD's are special districts formed for the purpose of addressing local resource conservation needs under Division 9 of the California Public Resources Code. There are 116 RCDs statewide that establish local conservation priorities and seek technical and financial assistance from a wide variety of local, state and federal agencies (conservation districts nationwide have established enduring relationships with USDA agencies through Memoranda of Understandings). RCD Directors are elected or appointed and volunteer their time to improve the resources in their respective communities.

The primary USDA agencies "working together" on the HUA are the Natural Resources Conservation Service — NRCS (formerly the Soil Conservation Service), the Farm Service Agency — FSA (formerly the Agricultural Stabilization and Conservation Service) and the University of California Cooperative Extension. Since the HUA began in 1991, over 25 additional local, state and federal agencies are participating or cooperating in varying degrees to implement their objectives in a coordinated manner.

HUA agencies conducted a comprehensive information and education program through newsletters, magazine articles, journals, tours, videos, brochures, fact-sheets, meetings, seminars, steering committees, formal and informal presentations throughout the western states, and one-on-one discussions with growers. The February 1996 issue of National

Geographic Magazine contained an article on nonpoint source pollution with a segment on the West Stanislaus HUA.

A comprehensive "West Stanislaus Sediment Reduction Plan" (February 1992) was published by the NRCS Water Resources Planning Staff and funded by the California Central Valley Regional Water Quality Control Board at the request of the RCD. This plan established the base-line in the watershed and acknowledged that over 1 million tons of sediment could potentially be lost by irrigation-induced erosion annually in the HUA. It had been previously documented that DDT (organochlorine) pesticide residues legally applied in the HUA over two decades ago still persist in these soils and were negatively impacting the San Joaquin River.

The plan was developed by an multi-disciplinary team of engineers, biologists, soil scientists, agronomists, water quality specialists, farm advisors, soil conservationists, geologists, economists and sociologists. The plan listed 17 conservation practices that, when used in combination with managerial practices, would significantly reduce the volume of sediment leaving irrigated fields in the HUA. The plan "emphasizes that the best solution is a local solution." Within the plan, an implementation program is established. This implementation program is consistent with the 1991 California Inland Surface Water Plan which utilizes 3 levels of implementation: (1) voluntary implementation of BMPs, (2) regulatory-based encouragement of BMP implementation, and (3) regulatory implementation, such as waste discharge requirements or discharge prohibitions.

The RCD concluded from previous pilot-projects and studies that a sediment reduction goal of 80-85% was economically feasible and achievable by growers in the HUA with adequate technical and financial assistance. The RCD established a 300 mg/l goal (opaque in color) for all HUA cost-shared projects (down from an average drain with 1500 mg/l — chocolate brown in color).

In 1991, the HUA began promoting and implementing BMPs using an integrated approach of (1) information and education, (2) technical assistance, and (3) cost-sharing of BMP installation. An NRCS Sociologist stated "participation in the project is estimated to be high: 71% of the population, affecting 81,181 acres. Five years later, the result of these efforts have been documented in comprehensive "resource management plans."

Highlights from the "West Stanislaus Hydrologic Unit Area 1995 Progress Report" follow:

Approximately 24% (30,568 ac) of the total area in the HUA have adopted structural and managerial BMPs documented in Total Resource Management Plans and Long Term Agreements (LTAs). Cumulative savings as a direct result of HUA assistance:

▼ 960 lbs. of DDT isomers from offsite impacts.

▼ 525,945 tons of sediment from offsite impacts.

▼ 30,560 ac/ft of irrigation water.

▼ 13,495 ac of Irrigation Water Management Practices.

▼ 19% average absolute improved irrigation efficiency.

▼ Controlled drainage practices have been implemented on 9,717 ac.

Cost-sharing under Agricultural Conservation Program (ACP primarily through LTAs) and Water Quality Incentives Program (WQIP) were utilized to encourage adoption of BMPs. An additional 42% (54,180 ac) of the total area in the HUA had previously utilized structural BMPs from prior technical and financial assistance, and/or non cost-shared implementation of BMPs. Therefore, approximately 66% of the HUA has been adequately treated. Some of the remaining 34% (43,860 ac) have minimal BMPs installed and need significant treatment to meet the HUA objective of 300mg/L. All irrigated lands need managerial BMPs on an annual basis.

HUA leaders have estimated that over 90% of the farmers are aware of the HUA goals and most are implementing some BMPs. New FSA cost-shared practices, such as Integrated Crop Management (SP-53) have been promoted in the HUA to reduce the use of pesticides and nutrients along with Shallow Water Areas for Wildlife (WL-2).

Significant wetland enhancements have been implemented since the HUA began including restoration of wetlands on prior converted cropland (PC). Numerous sediment basins provide temporary habitat for wildlife in the HUA. UCCE has tracked the location of all sediment basins (installed with or without cost-share) and this map could easily be converted to a Geographical Information System (GIS) format.

In 1992, the first ever "National Irrigation-Induced Erosion and Water Quality Conference" was conducted in Boise, Idaho. NRCS and UCCE collaborated on a technical paper and poster presentation to share the California perspective. This was a significant event that has led to the National Survey on Irrigation-Induced Erosion as part of USDA's National Resource Inventory.

At that conference, HUA leaders learned of significant research being conducted by the Agricultural Research Service (USDA-ARS) in Kimberly, Idaho, on soil conditioners; specifically water soluble anionic polyacrylamide (PAM). Professor John Letey from the University of California, Riverside had also been conducting laboratory research on PAM and collaborated with UCCE in late 1992 to conduct field trials in the HUA to evaluate reductions in soil loss, pesticide residues (DDT) in tail-water runoff and improvements in irrigation infiltration rates.

How does PAM Work? USDA-ARS, Kimberly, Idaho states "*Water-applied PAM increases soil cohesion and strengthens aggregates it contacts in the furrow by binding exposed soil particles together more securely. This greatly reduces detachment and transport of sediments in irrigation runoff. Soil erodibility at the soil/water interface is reduced by improved inter-aggregate bonding and by better maintenance of surface roughness. PAM also acts as a settling agent. It flocculates (clumps together) the fine particles dispersed by and carried in the flow, causing them to settle to the furrow bottom. Fewer dispersed fine particles remain in the infiltrating water to block pores and reduce infiltration rates. Pore structure is maintained, preventing the usual infiltration rate reduction. This*

decreases runoff rate and amount, which further reduces stream force, carrying capacity and transport volume."

Field trial results in the HUA indicate a 95-98% reduction in soil loss and a corresponding reduction in pesticide residues leaving the fields through furrow irrigation (see Table 1). Additionally, a 10–40% increase in infiltration was observed in treated furrows compared to non-treated furrows. PAM helps preserve some of the existing soil structure and porosity in the furrow by "coating" the surface of the furrow with a fine, fragile "web" of long polymer molecules. Because fine particles are held in place, they do not "slake" and clog soil pores. Thus infiltration rates remain high, resulting in a net increase of infiltration. Non-treated furrows in the HUA degrade to the point where up to 75% or more of the applied irrigation water may run off the end of the field. Significant loads of sediment and soil-sorbed pesticide residues are carried with the runoff into man-made drains and intermittent streams and, ultimately, to the San Joaquin River.

Further local studies determined that:

▼ Applications of PAM at rates as low as 1 ppm metered into the irrigation water can significantly reduce erosion (an average of over 90%).

▼ For conditions in the HUA, a continuous, low concentration application of PAM works best.

▼ PAM applications into the irrigation water also substantially increase water infiltration (an average of 10–40%).

▼ There was some carryover effects from one irrigation to the next, but the effects on drain water clarity was minimal.

▼ PAM maintains existing soil structural units (peds or clods) reducing crusting (silting over) by silts and very fine sands of existing pores.

Recent demonstrations have compared different formulations and methods of application of the PAM into the irrigation water. The original studies were conducted using a 2% slurry stock solution produced by mixing the granular PAM with water, then metering this solution into the irrigation water. Comparable results to those obtained by metering a stock solution have been realized using direct application of the PAM via a granular applicator, provided there is an opportunity for the PAM to dissolve into the irrigation water. This past season, UCCE compared a third method of application, a blockformulated to slowly dissolve (slow release), again with similar effects on infiltration and water clarity (see Figs. 1 and 2).

UCCE continues to conduct additional field trials in cooperation with growers and PAM manufacturers. All soils (fine and fine-loamy, Typic and Calcixerollic Xerochrepts: El Solyo, Vernalis and Zacharias series; fine, Typic Haploxererts: Capay series; and fine Mollic Haploxeralfs: Stomar series) in the HUA have responded favorably to PAM applications resulting in tailwater with very high clarity (<10 mg/l).

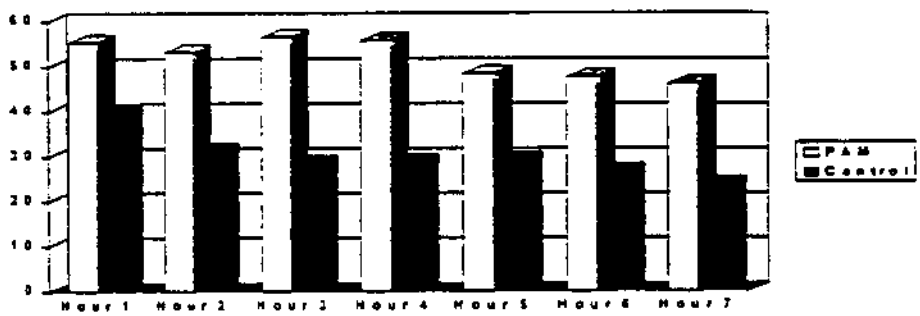
The HUA has been the California test site for purposes of evaluating PAM for NRCS Field Office Technical Guide standards and specifications. The California Central Valley Regional Water Quality Control Board requested NRCS's "assistance in evaluating the potential impacts of utilizing polymers as a best management practice on a widespread basis."

TABLE 1 1993 TSS Results

	PAM	Control	% Reduction
10 ppm	30	664	96
5 ppm	16	653	98
2.5 ppm	28	611	96

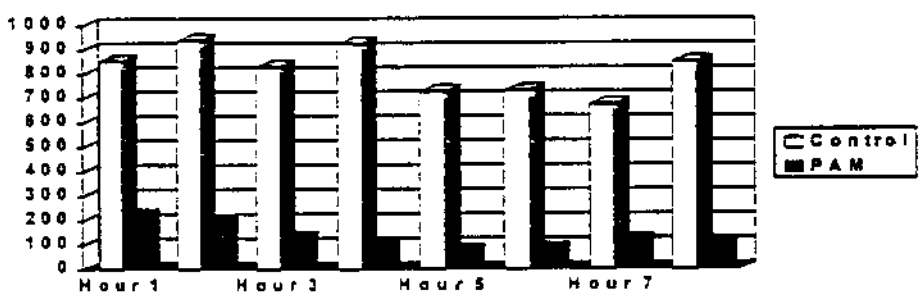
1993 TSS (total suspended solids) results. TSS measured in mg/L. This is the amount of sediment that stays on the field and out of drains, sediment basins, streams and the river.

Figure 1. 1995 Mean Infiltration Results



1995 infiltration results based on five trials using the Power Block. Percent (%) of water applied v. time.

Figure 2. 1995 Mean TSS Results



1995 TSS in mg/L (ppm) for five trials using the Power Block.

The HUA has coordinated two seminars that brought scientists from across the nation (and England) to discuss the widespread use of PAM in agriculture. Chemists, microbiologists, agronomists, soil scientists, toxicologists and other disciplines met June 8, 1995, at the NRCS State Office to share the latest science on PAM. A video tape is available of this historic meeting.

In a letter to the Environmental Protection Agency, Region 9, San Francisco, USDA-ARS scientists state, *"PAM use for erosion control is at the heart of the concept of agricultural sustainability. It provides a potent environmental benefit without negative impact on flora and fauna. It halts erosion (about half a ton per ounce of PAM used). It increases infiltration, thus enabling conservation of water (California's scarcest resource). It allows changes in furrow irrigation management that provide more uniform water application, reducing the potential for nitrate leaching. It removes substantial amounts of sediment, phosphorus and pesticides from return-flows, and greatly reduces return flow BOD. Because furrow reshaping and sediment pond or ditch cleaning are needed less frequently with PAM use, it also conserves fuel, lessens air pollution, and reduces equipment wear and labor."*

As a result of the experience gained in the HUA and scientific support from university researchers, government researchers and industry researchers, California NRCS approved the NRCS West National Technical Center's Interim Conservation Practice Standard 201, Irrigation Erosion Control (Polyacrylamide - PAM). This standard enables NRCS field offices to include this practice in their on-farm planning and has been approved for use in WQIP plans.

HUA leaders have envisioned a full scale demonstration farm, located on the NASA-AMES Crows Landing Facility in the HUA. The agricultural outlease property has been extensively studied and monitored by the NRCS, RCD and UCCE. This is the same site as the recently completed "Crows Landing 319 Demonstration Project" where the RCD evaluated BMPs in controlling the off-site movement of pesticides and sediment. Contractual incentives and controls are in place to assure HUA goals are achieved. Additional contractual agreements could be established to provide a "safety net" for expenses and/or losses over and above those which may be reasonable in any given crop year.

The goal of the full scale demonstration farm is to provide a commercially farmed study area to compare science-based applications of organic soil amendments (manures, green waste compost and perhaps biosolids) and soil conditioners (PAM) to maintain or improve aggregate stability and soil quality. A science-based approach could provide valuable answers to alternative approaches to solving irrigation-induced erosion. All the cooperating agencies contacted to date have been supportive of this idea. A meeting of interested agencies was conducted November 21, 1995, to share progress and future objectives. We acknowledge the need to maintain existing partnerships and develop new ones.

The HUA was the focus of a US General Accounting Office (GAO) report to the Committee on Agriculture, Nutrition, and Forestry, U.S. Senate titled "AGRICULTURE AND THE ENVIRONMENT: Information on and Characteristics of Selected Watershed Projects" (GAO/RCED-95-218). The GAO Project Manager wrote: *"As you will see, the West Stanislaus County watershed project plays a prominent role in this report. The project is cited several times in the body of the report and is the focus of Appendix II."*

The resulting GAO report to the US Senate states *"participants in all 9 (watershed projects evaluated) echoed two key lessons learned: the need for (1) flexibility in the kinds of financial and technical assistance provided by federal agencies and (2) local tailoring of approaches to watershed management. Because watershed projects differ in characteristics such as the type and source of pollutants, local agricultural practices, and the community's attitudes, participant's believed that a prescriptive, one-size-fits-all approach would be inappropriate (pp 1-2)."* The GAO report acknowledges "adding a polymer (PAM) to the irrigation water causes the sediment to settle out much faster, reducing erosion runoff from the fields."

The HUA has had a presence in the community with favorable local and regional newspaper articles. The RCD's mobile irrigation lab truck has signs that clearly display all HUA cooperating agencies. RCD Directors are recognized by other farmers in the community as leaders of a successful, grass-roots voluntary effort. NRCS Economists determined that partnerships developed bythe HUA project generated $1.8 million of direct economic benefits in the HUA.

PAM has clearly generated a lot of interest and is part of an integrated approach for water quality in the West Stanislaus Hydrologic Unit Area Project.

About the authors

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