GRANT NUMBER: 20050736

Progress Report Final Report

Reporting Period: Jan 1, 2007 to Dec 31, 2008

Submittal Date February, 22 2008

Agency Name: University of California Cooperative Extension, Monterey County

Project Title: Evaluation of Polyacrylamide (PAM) for Reducing Sediment and Nutrient Losses from Agricultural fields

Contractor Name: Michael Cahn

Project Director: Michael Cahn

Printed Name Signature

Table of Deliverables

(Place your Table of Deliverables here for both your midterm and final reports. It should be the same Table of Deliverables that was sent to Foundation along with your signed award letter. See sample below.)

Table 1. Deliverables Schedule

Tasks	Description of Deliverables	Due Date	% of work completed	Date Submitted
1.0	Develop and Implement Quality Assurance Project Plan	5/1/07	100%	September 2007
1.1	Write QAPP for conducting PAM practice effectiveness trials	3/1/07	100%	August 2007
1.2	Implement QAPP for project	5/1/07	100%	September 2007
2.0	Evaluate Using Polyacrylamide for Improving the Quality of Tail-Water	9/31/08	100%	January 2009
2.1	PAM Literature Review	3/1/07	100%	January 2007
2.2	Identify Grower Cooperators	3/1/07	100%	January 2007
2.3	Conduct Field-Demonstration Trials	9/1/08	100%	June 2008
2.4	Analyze and Summarize Trial Results	9/31/08	100%	Dec 2008
3.0	Conduct an Outreach program on Using Polyacrylamide	9/31/08	100%	January 2009
3.1	Irrigation Field Day	3/1/08	100%	June 2007
3.2	Grower Meeting Presentations	4/1/08	100%	January 2009
3.3	Newletter/Trade publication articles	5/31/08	100%	January 2009

List of Deliverables Submitted For Final Report *(by subtask number, please clearly mark the subtask number at the top left hand corner of each deliverable)*

- 1.1, 1.2
- 2.1,2.2,2.3,2.4
- 3.1,3.2,3.3

<u>Progress Report Narrative</u>

(Provide a brief introduction or summary of the report (e.g., "During the reporting period, project activities focused on completing design of the three sediment basins"…. <u>Or</u> "Activities were largely focused on organizing and hosting 4

tailgate meetings to discuss …" Or "Water Quality data was collected monthly at 6 sites, with data analysis indicating that…" etc.)

Introduction:

The objective of this project is to evaluate the effectiveness of polyacrylamide (PAM) to reduce sediment and nutrients in irrigation run-off from commercial vegetable fields located in the lower Salinas and Elkhorn watersheds. Trials were designed to both demonstrate to growers how to use PAM at a field-level scale, and collect data on the effectiveness of this practice.

Polyacrylamide is a long, linear-chained polymer used to stabilize soil and prevent erosion from agricultural fields. Various forms of PAM exist, but the type used for erosion control, is an anionic, large molecule (12-15 megagrams per mole) that is water soluble. PAM is commercially available in dry granular, emulsified liquid, and dry tablet forms, and costs between $2 to 4 per pound.

Numerous studies have shown that PAM reduces run-off and improves water quality by stabilizing the aggregate structure of soil, by improving infiltration, and by flocculating out suspended sediments from irrigation tail-water. Most of the research and demonstrations of PAM for agricultural uses were conducted in Idaho and Washington states where soils are highly erodable and where approximately 1 million acres of land are currently treated with PAM. Growers in the San Joaquin Valley as well as in the Bakersfield areas of California are now using PAM to reduce soil erosion during the irrigation season. Preliminary work in the Salinas area demonstrated that PAM injected into sprinkler water at a 5 ppm concentration was sufficient to remove 95% of the sediment and 75% of the phosphorus from the tail water. Non agricultural uses of PAM include waste and potable water treatment, processing and washing of fruits and vegetables, clarification of juices, cosmetics, and paper manufacturing.

Summary of Activities

Task 1 – Develop and Implement Quality Assurance Plan (Cumulative 100% complete)

(Describe by sub-task activities, problems, successes, milestones… If a deliverable is complete, please state that, and add a copy of the deliverable (listed above). If a deliverable is not complete, please state that, and describe progress towards completing the deliverable).

The Quality Assurance Project Plan (QAPP) was completed and submitted to the regional board staff in August 2007, approved by CCRWCB staff, and implemented in September 2007. The QAPP is included as attachment 2.

Task 2 - Evaluate Using Polyacrylamide for Improving the Quality of Tail-water (Cumulative 100% complete)

(Describe at sub-task level activities, problems, successes, milestones… same as above)

2.1 PAM literature review

A literature review on use of PAM for control of agricultural tail water was written by Michael Cahn and is submitted with this report in attachment 1. Additionally, Donald Weston of UC Berkeley submitted a literature review to the central coast regional water quality control board on the toxicity of PAM to aquatic organisms. Michael Cahn, who is participating on a project funded by the state water quality control board, is collaborating with Donald Weston on toxicity testing of PAM after application to soil.

2.2 Identification of grower cooperators

The cooperation of growers for this project was announced at the Monterey County Water Resources Agency, Agricultural Water Advisory Committee (AWAC) meeting in October, 2006 and February 2007. At least 3 potential cooperators were identified from this meeting and 2 other cooperators were identified from personal calls. Three cooperators participated in the 3 trials conducted in the fall of 2007 and spring of 2008.

2.3 Conduct field-demonstration trials

Field trials began in September 2007. Two trials were conducted in romaine lettuce fields located in the lower Salinas watershed and one trial was conducted in strawberries located in the Elkhorn slough watershed. Large plots between 0.7 and 1 acre were established at the vegetable field trial sites. The strawberry field trial compared irrigation run-off from adjacent blocks of about 2.5 acres in area. Two additional trials were conducted in romaine between April and May of 2008.

Procedures

<u>Vegetable irrigation trials</u>
Treatments assigned to the plots were: 1. untreated control, 2. Terawet PAM25 5 ppm active ingredient concentration in the irrigation water, 3. Ciba Soilfix PAM at a 5 ppm active ingredient concentration in the irrigaition water. Both PAM products are liquids. PAM25 is a 25% anionic polyacrylamide product that includes inert ingredients of water and humectant substances. Soilfix is a 50% anionic polyacrylamide product that has mineral oil as an inert ingredient. Treatments were randomly assigned to the plots following a latin square design. Replication was over time, such that each plot was irrigated with all three treatments during 3 separate irrigation events. Because the untreated control treatment had PAM applied during previous irrigations it was designated as a “moving control treatment”, a 4^{th} treatment, where PAM was not applied in previous irrigations and designated “fixed location control”, was included in the at sites 2, 3, and 4.

<u>Strawberry irrigation trial</u>
Treatments assigned to blocks were: 1. untreated control and 2. Ciba Soilfix PAM at a 5 ppm active ingredient concentration in the irrigation water. Treatments were repeated in the same block during 4 separate irrigation events. The irrigations were conducted after transplanting when plants are typically established with frequent irrigations using overhead sprinklers. Plastic mulch was not present on the beds.

<u>Treatment applications</u>
Chemical injection pumps were used to meter the PAM products into the main distribution line of the overhead sprinklers during the duration of each irrigation event. Flow meters were installed on the main line to measure the applied water on each plot or block.

<u>Run-off measurement and sampling</u>
Flumes positioned at the end of the plots or blocks (for strawberry trial), were used to measure run-off amounts and collect composite samples during the irrigation events. The flumes were equipped with a stilling well and float device record that the height of water entering and a peristaltic pump was activated at 5 minute intervals to sample the run-off into a collection container, in an ice chest. A datalogger (Campbell Scientific CR1000) is used to record the water height and activate the sample pump. The amount of water collected (20-200 ml per sample) is proportioned to the flow rate to produce an accurate composite sample of the run-off water. Water samples were analyzed for pH, EC, and temperature immediately after irrigation events and then frozen and sent to the DANR lab for analyses.

2.4 Analyze and Summarize Trial Results

Statisical analyses were conducted for data from the 4 vegetable irrigation trials for this report. Results were analyzed for individual trials and across trial sites using the general linear means procedure available from Statistical Analysis Software (SAS, 2005). F-tests and least significant differences were calculated to evaluate significance of treatment differences. Data were also expressed as a percentage of the fixed control treatment at vegetable trial sites 2-4. Relative data were also analyzed using a general linear means procedure. A summary of results for individual trials and for combined trials is presented in Tables 4-5, and Figure 1.

Strawberry trial

Data are not presented for this report. Observations of run-off showed that Soilfix polyacrylamide was effective in reducing suspended sediments and turbidity in furrows between beds compared to an untreated control block. However, run-off treated with PAM had significant suspended sediments after flowing through a tail water ditch that was located on a ~10% slope. We presume the velocity of the run-off flowing in the tail water ditch re-suspended sediments. At the collection point located at the lowest end of the blocks, no difference in suspended sediments, turbidity, and nutrients was measured in run-off from the control and PAM treated blocks (data not presented).

Vegetable trials

Both PAM products significantly reduced sediment, turbidity and total phosphorus concentrations in irrigation tail water (Tables 4-6). Treatments effects were significantly different at sites 2-4 but not at site 1. Because replication of treatments was minimal (3), only large differences would be expected to be statically significant in an individual trial. Treatment effects were statistically significant when the data from all 4 sites was pooled. Average reduction in suspended sediments in the irrigation run-off was 91% for Soilfix and 74% for PAM25 in comparison to a moving untreated control. Average reduction in turbidity in the irrigation run-off was 95% for Soilfix and 91% for PAM25 compared to a moving untreated control treatment. The average reduction in total suspended sediments relative to the fixed located control treatment for trials 2-4 was 96% for Soilfix PAM and 84% for PAM25 (Table 6). The average reduction in total turbidity relative to the fixed located control treatment for trials 2-4 was 92% for Soilfix PAM and 90% for PAM25. Average reduction in total P in the irrigation run-off was 67% for Soilfix and 43% for PAM25 compared to the moving control treatment (Table 4). The average reduction in total P relative to the fixed located control treatment for trials 2-4 was 77% for Soilfix PAM and 60% for PAM25 (Table 6). Soilfix PAM also significantly reduced soluble P in run-off compared to the moving and fixed control treatments (Table 4 and 6). Soilfix significantly reduced total P, soluble P, and total N more than PAM25, but suspended sediments and turbidity were not significantly different between the 2 PAM formulations.

The PAM treatments caused small or no reduction in the concentration of Nitrate-N, Total N, and K at most sites. Unlike results of past trials, high level of nitrate in the run-off limited the ability of PAM to reduce total N levels. The high levels of nitrogen at site 2 were caused by the grower injecting N fertilizer into the irrigation water during the 2nd and 3rd irrigation events and because the irrigation water had a high level of nitrate (Table 3B). The irrigation water at site 4 also had a high concentration of nitrate (Table 3B).

The PAM treatments had no significant effect on the volume of irrigation run-off, which suggests that these products are not increasing the infiltration rates of the soil (Table 5). Irrigation run-off varied significantly between field sites (4.6% of applied water at site 1 and 51% of applied water at site 4), and may be attributed to the stage of the crop when the trials were conducted and soil type. The trial at site 1 was conducted during the germination of the crop, when the soil was not saturated. The trial at site 2 was conducted after the crop had received multiple irrigations, and therefore the soil would likely have been more saturated than at site 1. The PAM treatments significantly reduced sediment and phosphorus loads relative to the moving untreated control (Table 5).

Comparison of the moving control treatment with the fixed-located control treatment at trials 2-4 demonstrated that previous applications of PAM continued to reduced suspended sediment, turbidity, and total P concentrations in the run-off when PAM was not applied (Table 6). The residual effect of PAM on total suspended sediments in the run-off increased with the number of previous applications of PAM (Figure 1).

Task 3 - Conduct an Outreach program on Using Polyacrylamide (Cumulative 100% complete)
(Describe at sub-task level activities, problems, successes, milestones… same as above)

3.1 Irrigation field day

The effectiveness of PAM to control sediment was demonstrated at the Pyrethroid management workshop held at the USDA-ARS Spence Research Farm, Salinas, CA on June 22, 2007. Participants learned the basics of using PAM, including the use of injection equipment.

3.2 Outreach meeting presentations

The use of PAM for control of sediments and nutrients in agricultural run-off was presented at the following 5 grower and agency clientele meetings:

Managing irrigation run-off. California Irrigation Institute. January 23, 2007. Sacramento CA

Evaluation of management practices for controlling sediment. Pyrethroid Management Workshop., June 11, 2007, Watsonville, CA

Managing irrigation and storm run-off for improved water quality. Sustainable AgExpo, November 1, 2007, Paso Robles CA.

Evaluation of polymers for controlling sprinkler run-off from vegetable fields on the central coast, National Water Conference, February 6, 2008.

Evaluation of polymers for controlling sprinkler run-off from vegetable fields on the central coast, Central Coast Regional Water Quality Control Board, January 5, 2009

3.3 Newsletter/Trade publication articles

Results of field trials conducted in this project are being summarized in a newsletter (Monterey Co. Crop Notes) and trade journal article. We are also developing a guide on using polyacrylamide for sprinkler systems.

Table 1. Soil chemical and physical characteristics at strawberry field trial site.

depth	pH	EC	SAR	TKN	Olsen P	Cation Exchange Capacity	Organic Matter	Sand	Silt	Clay
		dS/m		%	ppm	meq/100 g	%			
0 - 1 ft	7.2	0.51	1	0.057	119	9.5	0.90	72	20	9
1- 2 ft	7.2	0.67	1	0.052	116	9.4	0.88	73	18	10
1 -3 ft	7.2	1.39	2	0.037	63	8.7	0.55	72	19	10

Table 2. Soil chemical and physical characteristics at field trial sites 1, 2, and 4.

depth	pH	EC	SAR	TKN	Olsen P	Cation Exchange Capacity	Organic Matter	Sand	Silt	Clay
		dS/m		%	ppm	meq/100 g	%			
						site 1[x]				
0 - 1 ft	7.1	1.46	2	0.072	75	14.5	0.93	56	28	16
1- 2 ft	7.2	1.46	2	0.053	61	14.9	0.73	57	26	17
1 -3 ft	7.2	1.22	2	0.043	27	19.1	0.46	51	26	23
						site 2				
0 - 1 ft	7.4	0.74	1	0.054	144	10.0	0.84	66	21	13
1- 2 ft	7.4	1.04	2	0.042	97	9.1	0.67	68	20	12
1 -3 ft	7.3	1.70	2	0.029	60	7.7	0.38	69	19	12
						site 4				
0 - 1 ft	7.2	1.16	1	0.041	72	26.8	0.78	81	11	8
1- 2 ft	7.2	1.11	2	0.031	50	10.5	0.71	80	13	7
1 -3 ft	7.1	1.29	2	0.026	27	5.4	0.61	82	11	7

x site 1 and 3 have similar soil types.

Table 3A. Chemical analysis of irrigation water used for trials at sites 1-4.

Site	pH	EC	TDS	SAR	Cl	B (Soluble)	HCO3	CO3
		dS/m	ppm		ppm			
1	7.5	0.7	430	2.1	1.9	<0.1	2.6	<0.1
2	8.0	1.0	580	2.3	4.0	<0.1	2.2	<0.1
3	8.4	0.6	350	2.7	1.8	<0.1	1.9	0.4
4	8.2	1.0	702	1.4	3.3	<0.1	1.0	1.3

Table 3B. Chemical analysis of irrigation water used for trials at sites 1-4.

Site	TKN	NH4-N	NO3-N	P (Total)	PO4-P	K	SO4-S	TSS	Turbidity
	ppm								NTU
1	0.2	<0.05	6.9	<0.1	0.06	2.5	25.1	<4	1
2	0.2	<0.05	14.8	<0.1	0.07	3.0	12.1	9	2
3	0.4	0.05	5.3	<0.1	0.07	2.6	23.4	50	26
4	0.8	0.78	51.1	<0.1	<0.05	2.1	24.4	26	13

Table 4. Effects of PAM treatments on chemical and nutrient composition of irrigation run-off from vegetable fields.

Treatment Description	pH	EC	Total Dissolved Solids	Total P	Soluble P	Total Kjeldahl N	NO_3-N	NH_4-N	Soluble K
		dS/m	ppm						
	site 1								
Untreated Moving Control[x]	7.4	0.72	470	1.07	0.20	1.5	7.2	0.11	4.1
PAM25	7.2	0.75	470	0.43	0.17	1.7	6.6	0.48	4.1
Soilfix	7.4	0.71	450	0.37	0.14	1.0	7.1	0.05	3.6
$LSD_{0.05}$	1.1	0.031	35	1.35	0.05	4.0	3.0	0.32	0.7
F-test treatment p-value	NS[y]	0.06	NS	NS	0.08	NS	NS	0.0504	NS
F-test control vs PAM contrast p-value	NS	NS	NS	NS	0.05	NS	NS	NS	NS
F-test PAM25 vs Soilfix contrast p-value	NS	0.03	NS	NS	NS	NS	NS	0.0299	NS
	site 2								
Untreated Moving Control	7.7	1.88	1160	1.77	0.52	58.4	53.3	31.47	4.5
PAM25	7.9	1.41	767	0.97	0.47	35.2	26.4	13.43	5.1
Soilfix	8.0	1.60	870	0.53	0.39	41.6	74.9	39.00	4.4
$LSD_{0.05}$	0.9	1.57	1541	0.31	0.361	51.3	93.9	33.2	2.0
F-test treatment p-value	NS	NS	NS	0.007	NS	NS	NS	NS	NS
F-test control vs PAM contrast p-value	NS	NS	NS	0.004	NS	NS	NS	NS	NS
F-test PAM25 vs Soilfix contrast p-value	NS	NS	NS	0.027	NS	NS	NS	0.08	NS
	site 3								
Untreated Moving Control	8.8	0.63	373	1.17	0.49	1.4	5.6	0.09	3.5
PAM25	9.1	0.62	393	0.90	0.60	1.6	5.9	0.45	4.1
Soilfix	9.1	0.56	363	0.50	0.42	0.9	4.7	0.06	4.6
$LSD_{0.05}$	1.2	0.16	70	0.62	0.21	0.8	1.6	0.67	5.8
F-test treatment p-value	NS	NS	NS	0.08	NS	0.10	NS	NS	NS
F-test control vs PAM contrast p-value	NS	NS	NS	0.06	NS	NS	NS	NS	NS
F-test PAM25 vs Soilfix contrast p-value	NS	NS	NS	NS	0.07	0.05	0.08	NS	NS
	site 4								
Untreated Moving Control	8.4	1.07	877	2.03	0.31	1.7	49.8	0.07	3.5
PAM25	8.5	1.08	843	1.13	0.26	2.2	50.2	1.15	3.8
Soilfix	8.5	1.04	733	0.60	0.15	0.8	48.3	0.12	3.3
$LSD_{0.05}$	0.2	0.07	154	1.15	0.19	0.2	3.1	1.43	0.6
F-test treatment p-value	NS	0.10	NS	0.06	NS	NS	NS	NS	NS
F-test control vs PAM contrast p-value	NS	NS	NS	NS	NS	NS	NS	NS	NS
F-test PAM25 vs Soilfix contrast p-value	NS	NS	0.09	NS	NS	0.07	NS	0.09	0.07
	all sites pooled								
Untreated Moving Control	8.1	1.08	720	1.51	0.38	15.7	29.0	7.94	3.9
PAM25	8.2	0.96	618	0.86	0.37	10.2	22.3	3.88	4.3
Soilfix	8.3	0.98	604	0.50	0.28	11.1	33.8	9.82	4.0
$LSD_{0.05}$	0.3	0.21	208	0.26	0.06	6.9	12.6	4.46	0.8
F-test treatment p-value	NS	NS	NS	<.0001	0.008	NS	NS	0.04	NS
F-test treatment*site p-value	NS	NS	NS	NS	NS	NS	NS	0.01	NS
F-test control vs PAM contrast p-value	NS	NS	NS	<.0001	0.05	0.08	NS	NS	NS
F-test PAM25 vs Soilfix contrast p-value	NS	NS	NS	0.012	0.006	NS	0.07	0.02	0.079

[x] PAM was applied during previous irrigations
[y] not statistically significant

Table 5. Effect of PAM treatment on suspended sediments and nutrient concentration in irrigation run-off from vegetable fields.

Treatment Description	Total Suspended Solids	Turbidity	Run-off		Sediment load	Total P load	Total N load
	mg/L	NTU	gal/acre/irrigation	% of applied water	-------- lb/acre/irrigation --------		
	---------- site 1 ----------						
Untreated Moving Control[x]	412	594	1022	4.3	2.5	0.007	0.012
PAM25	50	29	930	3.8	0.4	0.003	0.012
Soilfix	24	21	1410	5.6	0.3	0.004	0.012
$LSD_{0.05}$	782	1161	1726	6.7	6.1	0.016	0.033
F-test treatment p-value	NS[y]	NS	NS	NS	NS	NS	NS
F-test control vs PAM contrast p-value	NS	NS	NS	NS	NS	NS	NS
F-test PAM25 vs Soilfix contrast p-value	NS	NS	NS	NS	NS	NS	NS
	---------- site 2 ----------						
Untreated Moving Control	616	294	7748	16.5	39.6	0.116	4.09
PAM25	130	26	6814	15.1	6.6	0.050	1.72
Soilfix	51	12	6610	13.8	3.6	0.030	3.04
$LSD_{0.05}$	236	100	3208	8.3	10.2	0.058	3.91
F-test treatment p-value	0.016	0.011	NS	NS	0.007	0.043	NS
F-test control vs PAM contrast p-value	0.008	0.005	NS	NS	0.004	0.023	NS
F-test PAM25 vs Soilfix contrast p-value	NS	NS	NS	NS	NS	NS	NS
	---------- site 3 ----------						
Untreated Moving Control	455	212	2859	12.1	10.8	0.027	0.033
PAM25	158	46	2109	9.5	2.6	0.015	0.028
Soilfix	53	17	2438	10.9	1.2	0.011	0.020
$LSD_{0.05}$	169	133	4231	17.3	8.7	0.033	0.031
F-test treatment p-value	0.02	0.04	NS	NS	0.07	NS	NS
F-test control vs PAM contrast p-value	0.01	0.02	NS	NS	0.04	NS	NS
F-test PAM25 vs Soilfix contrast p-value	NS	NS	NS	NS	NS	NS	NS
	---------- site 4 ----------						
Untreated Moving Control	738	427	8228	53.0	59.9	0.156	0.137
PAM25	209	37	5992	43.9	10.5	0.057	0.107
Soilfix	39	31	7992	55.3	2.3	0.044	0.055
$LSD_{0.05}$	--	994	3977	18.9	--	0.207	0.2136
F-test treatment p-value	NS	NS	NS	NS	NS	NS	NS
F-test control vs PAM contrast p-value	NS	0.04	NS	NS	0.004	0.023	NS
F-test PAM25 vs Soilfix contrast p-value	NS	NS	NS	NS	NS	NS	NS
	----------all sites pooled ----------						
Untreated Moving Control	555	382	4964	21.5	28.2	0.076	1.069
PAM25	137	34	3961	18.1	5.0	0.031	0.467
Soilfix	42	20	4613	21.4	1.8	0.022	0.782
$LSD_{0.05}$	263	206	919	3.7	3.8	0.029	0.525
F-test treatment p-value	0.0002	0.0058	0.09	NS	0.007	0.006	0.081
F-test treatment*site p-value	NS	NS	NS	NS	NS	NS	0.06
F-test control vs PAM contrast p-value	0.0001	0.002	0.09	NS	0.005	0.002	0.05
F-test PAM25 vs Soilfix contrast p-value	NS	NS	NS	0.0742	NS	NS	NS

[x] PAM was applied during previous irrigations

[y] not statistically significant

Table 6. Effects of PAM and moving control treatments on suspended sediments and nutrient concentration in run-off expressed as a percentage of the fixed location control treatment.

Treatment Description	Total P	Soluble P	Total Kjeldahl N	NO_3-N	Total Suspended Solids	Turbidity	Run-off
	% of fixed location control[x]						
	site 2						
Untreated Moving Control[y]	52	82	102	75	44	45	55
PAM25	28	71	55	61	9	4	90
Soilfix	16	61	60	102	3	2	119
$LSD_{0.05}$	10	58	151	163	26	28	43
F-test treatment p-value	0.007	NS[z]	NS	NS	0.03	0.03	NS
F-test control vs PAM contrast p-value	0.004	NS	NS	NS	0.02	0.02	NS
F-test PAM25 vs Soilfix contrast p-value	0.03	NS	NS	NS	NS	NS	NS
	site 3						
Untreated Moving Control	66	106	69	84	57	70	45
PAM25	52	126	77	88	21	15	34
Soilfix	27	92	41	70	6	6	33
$LSD_{0.05}$	34	41	38	26	23	32	66
F-test treatment p-value	0.07	NS	0.10	NS	0.02	0.02	NS
F-test control vs PAM contrast p-value	0.06	NS	NS	NS	0.01	0.01	NS
F-test PAM25 vs Soilfix contrast p-value	0.09	0.07	0.06	0.10	0.10	NS	NS
	site 4						
Untreated Moving Control	75	115	88	90	68	115	114
PAM25	39	98	110	90	18	11	92
Soilfix	26	54	47	87	3	16	117
$LSD_{0.05}$	43	91	97	7	--	161	40
F-test treatment p-value	0.07	NS	NS	NS	NS	NS	NS
F-test control vs PAM contrast p-value	0.04	NS	NS	NS	NS	0.09	NS
F-test PAM25 vs Soilfix contrast p-value	NS	NS	0.11	NS	NS	NS	NS
	all sites pooled						
Untreated Moving Control	64	101	86	83	57	77	85
PAM25	40	99	81	80	16	10	71
Soilfix	23	69	50	86	4	8	76
$LSD_{0.05}$	10	22	35	31	15	32	17
F-test treatment p-value	0.0002	0.02	0.08	NS	0.001	0.003	NS
F-test treatment*site p-value	NS	NS	NS	NS	NS	NS	NS
F-test control vs PAM contrast p-value	0.0001	0.07	NS	NS	0.0004	0.001	NS
F-test PAM25 vs Soilfix contrast p-value	0.007	0.02	0.07	NS	NS	NS	NS

[y] no PAM was applied during previous irrigations

[x] PAM applied during previous irrigations

[z] not statistically significant

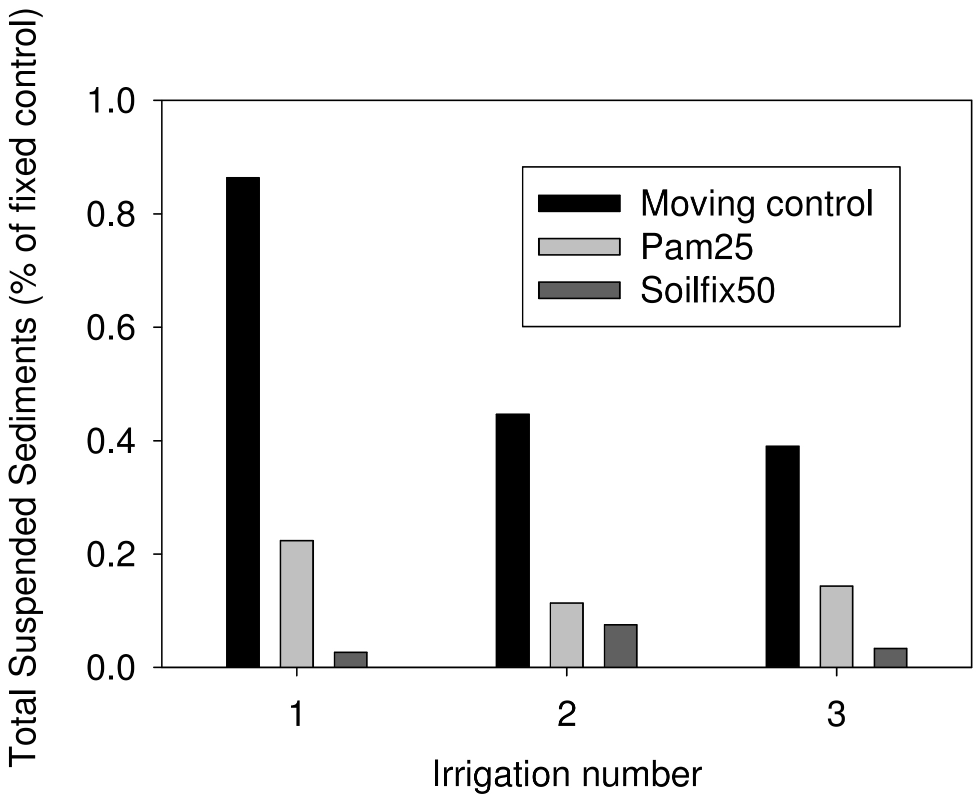

Figure 1. Effect of PAM and moving control treatment on total suspended sediments with increasing number of irrigations expressed as a percentage of the fixed location control treatment. PAM was previously applied in the moving control treatment before irrigations 2 and 3.

Evaluation of Polyacrylamide (PAM) for Reducing Sediment and Nutrient Losses from Agricultural fields: Literature Review

The vegetable industry on the central coast of California intensively uses water and fertilizer to produce 70% of the lettuce in the United States. Soils cultivated for vegetable production in this region are usually high in P (Johnstone et. al. 2005) and N, and consequently concentrations of nutrients in irrigation tail water are high enough to impair surface water quality. Because the cool-season vegetable industry is located in watersheds draining into the Monterey Bay National Marine Sanctuary, producers are under regulatory pressure to implement practices that reduce the load of nutrients and sediment that migrate from agricultural fields into surface water bodies. Sediment, P, and NO3 are listed on the EPA 303 list for the Salinas and Pajaro rivers which drain in to the Monterey Bay.

Catchment ponds are used on some ranches to retain and reuse tail water, but most growers discharge run-off into tributaries to the Salinas and Pajaro Rivers. Though conversion to drip irrigation has reduced run-off in the region; 65% of the agricultural land is presently irrigated with overhead sprinklers, and in most cases where drip is used, sprinklers are used for stand establishment. As much as 30% of water applied by overhead sprinklers during stand establishment may run-off the tail end of fields that are slope or located on soils susceptible to crusting.

The use of high molecular weight (12-15 Mg mole) anionic PAMs for reducing erosion and run-off from furrows has been documented in several regions of the United States, including the silt loam soils loess soils of the Northwest (Lentz and Sojka, 1994; Lentz et al. 1992; Trout et al. 1995), fine textured clay soils of the San Joaquin Valley of California (McElhney and Osterli, 1996). PAM added at low concentrations (10 mg L-1) to advancing furrow water at rates of 1 to 2 kg ha-1, has been documented to increase infiltration and reduce runoff by maintaining aggregate stability, thereby reducing soil erosion by as much as 99% (Lentz et al. 1992; Lentz and Sojka, 1994; Trout et al., 1995). However, reductions in infiltration have been measured on sandy loam soils of the southern San Joaquin Valley of California, which could increase run-off (Trout and Ajwa, 2001; Ajwa and Trout, 2006). On these soil textures, PAM may reduce infiltration by increasing the relative viscosity of the irrigation water.

In addition to furrow systems, PAM used with sprinklers, has been shown to control erosion and improve infiltration and water quality. Rates of PAM were often higher than used for furrow systems and reductions in erosion and run-off were often less than reported for furrow systems. Levy et al. (1991) were able to reduce run-off under center pivot and self-propelled sprinklers to 50 - 70% of the control by spraying a 0.25% PAM solution at a rate of 20 kg ha^{-1} on the soil surface before irrigating. They noted that the concentration of sediments in the run-off was not significantly different between the PAM and untreated plots. Smith et al. (1990) reported higher infiltration rates and as much as 95% less soil loss compared to an untreated control when PAM sprayed onto the soil surface at a rate of 20 kg ha-1 before irrigating with a rain simulator.

As an alternative to preteating the soil with PAM at high rates, a number of studies have demonstrated that applying low rates of PAM through the sprinkler water provided significant control of erosion (Aase et al. 1998; Bjorneberg and Aase 2000; Levy et al. 1992; Santos et al. 2003). In a simulation of overhead sprinklers, PAM added to irrigation water at 10 and 20 mg L-1 (6 and 12 kg ha-1 per irrigation) increased FIR and reduced sediment loss by as much as 70% during 3 consecutive irrigations (Levy et al. 1992). Aase et al. (1998) reported reducing run-off by 48% and soil loss by 66% during 3 consecutive sprinkler simulations by applying 4 kg PAM ha-1 in the first irrigation. Bjorneberg and Aase (2000) found better control of erosion by applying PAM with each irrigation at a 7.5 mg L concentration (1 kg ha) rather than applying 3 kg ha-1 PAM only in the first application. Bjorneberg et al.(2003) found comparable control of erosion by applying 3.1 kg ha-1 PAM in the initial irrigation with overhead sprinklers and by splitting the same rate among 4 irrigations.

As well as reducing erosion and runoff, PAM can improve the quality of irrigation tail water by flocculating and settling suspended solids (Aly and Lety 1988; Ajwa and Trout 2005, Laird 1997). Mason et al. (2005) reported PAM applied at 2 mg L-1 concentrations was effective in reducing turbidity and particulate P in agricultural drainage water from the Imperial Valley of California. Entry and Sojka (2003) reported that adding 10 mg L of anionic PAM to the advancing water in furrows significantly reduced total P, dissolved P, and total N in the tail water. Lentz et al. (2001) found that, PAM added to advancing furrow water at a 10 mg L concentration, reduced losses of total P by 92% and molybdate reactive P by 87%.

Conclusions

Because of the need to identify and implement BMPs that dramatically protect water quality on the Central Coast of California, the effectiveness of PAM to reduce run-off, sediment, and nutrient loss from vegetable fields should be determined in on-farm trial

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Miscellaneous Items

- Please clearly label all deliverables by sub-task #.
- Send two hard copies of your written progress report, both with original signatures, to the Regional Board. Please send electronic copies to both the Regional Board and the Community Foundation (Jeff Bryant)
- Send two hard copies of your invoice, both with original signatures, to the Regional Board. Please send electronic copies to both the Regional Board and the Community Foundation (Jeff Bryant)
- Use the Invoice format, also provided. Do not send a written progress report without an invoice or vice versa.
- Number all pages including pictures, laboratory data, diagrams, etc.
- If you have something that is due, and you think it will not be complete, please contact me (Amanda) ahead of time. If I have not heard from you, and a deliverable is due, and it is not completed, the next payment will be docked for each deliverable not completed. All deliverables must be completed before the end of the contract

.Group A Elements: Project Management

1. Title and Approval Sheets

Quality Assurance Project Plan

For

PROJECT NAME:	PGE Non-Point Source Funds Grant for North Monterey County- Evaluation of Polyacrylamide (PAM) for Reducing Sediment and Nutrient Losses from Agricultural Fields, Northern Monterey Co.
Proposal Identification Number:	20050736
Date:	Aug. 20, 2007
NAME OF RESPONSIBLE ORGANIZATION :	University of California Cooperative Extension, Monterey County

APPROVAL SIGNATURES

GRANT ORGANIZATION:

Title:	Name:	Signature:	Date*:
Project Manager Irrigation Farm Advisor	Michael Cahn		
QA Officer Irrigation Farm Advisor	Michael Cahn		
UC DANR Laboratory Manager	Dirk Holstege		

REGIONAL BOARD:

Title:	Name:	Signature:	Date*:
Contract Manager	Amanda Bern		
QA Officer	Karen Worcester		

** This is a contractual document. The signature dates indicate the earliest date when the project can start.*

2. Table of Contents

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3. Distribution List

Title:	Name (Affiliation):	Tel. No.:	QAPP No*:
Project Manager Irrigation and Water Resources Advisor	Michael Cahn	831-759-7377	1
Regional Board Contract Manager	Amanda Bern (CCWQCB)	805-594-6197	Original
Regional Board QA Officer	Karen Worcester (CCWQCB)	805-549-3333	1
UC DANR Laboratory Manager	Dirk Holstege	530-752-0147	1

4. Project/Task Organization

4.1 Involved parties and roles.

The mission of the University of California Cooperative Extension (UCCE), Monterey County is to provide research based information to growers and allied agricultural industry personnel to improve crop production and efficiency using environmentally sound practices that safeguard the quality of life and natural resources for all County residents. UCCE personnel will conduct research on and demonstrate practices for using polyacrylamide (PAM) to reduce runoff and improve the quality of runoff water. The researchers will assess the effectiveness of PAM by establishing research/demonstration trials in commercial vegetable fields. The effect of these practices will be evaluated through careful monitoring of runoff and evaluation of the quality of the runoff waters. Michael Cahn is the project manager and will be responsible for the overall project.

Michael Cahn will coordinate with vegetable growers to establish the trials in commercial fields. Grower cooperators for the trials will be selected upon evaluating sites with suitable conditions such as the uniformity, appropriateness of the slope and soil types.

Water samples will be sent to the University of California Department of Natural Resources (DANR) Analytical Laboratory for specific soil characteristics. DANR Analytical Laboratory is a premier facility operated by the University to support field work by UC Cooperative Extension researchers and farm advisors.

Table 1. (Element 4) Personnel responsibilities.

Name	***Organizational Affiliation***	***Title***	***Contact Information*** ***(Telephone number, fax number, email address.)***
Michael Cahn	*UCCE*	*Irrigation and Water Resources Advisor*	*Phone 831-759-7377* *Fax: 758-3018* *mdcahn@ucdavis.edu*
Dirk Holstege	*UC DANR Analytical Laboratory*	*Laboratory Manager*	*Phone 530-752-0147* *Fax: 530-752-9892* *danranlab@ucdavis.edu*

4.2 Quality Assurance Officer role

Michael Cahn is UCCE's Quality Assurance Officer. Michael's role is to establish the quality assurance and quality control procedures found in this QAPP as part of the sampling, field analysis, and analysis procedures. Michael will work with all participants on this project, including the staff research associates under his supervision, and communicate all quality assurance and quality control issues contained in this QAPP.

Michael Cahn will review and assess all procedures during the life of the contract against QAPP requirements. Michael Cahn will report all findings to Karen Worcester, including all requests for corrective action. Michael Cahn may stop all actions if there are significant deviations from required practices or if there is evidence of a systematic failure.

QA/QC reports will be submitted with billing invoices to the Contract Manager, Amanda Bern. All data that follow QAPP criteria will be approved by QA officer and records. Data that do not meet QAPP criteria will be flagged as appropriate in Section 22. All QA/QC records will be kept by the UCCE, Monterey County for three years.

4.3 Persons responsible for QAPP update and maintenance.

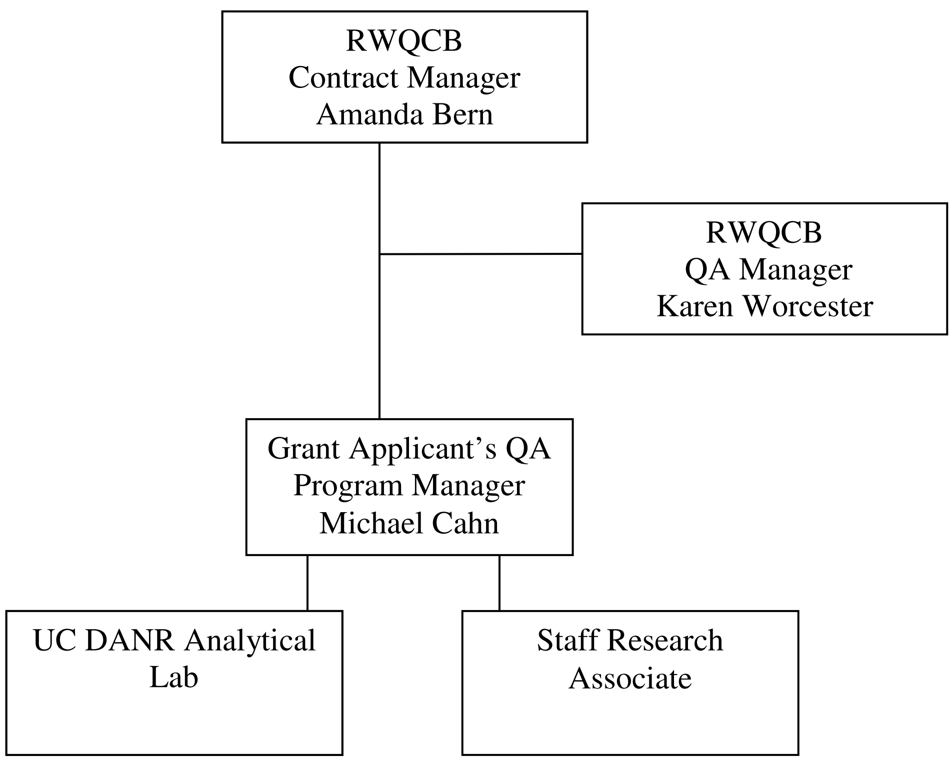
Changes and updates to this QAPP may be made after a review of the evidence for change by UCCE's Project Manager and Quality Assurance Officer, and with the concurrence of both the State Board's Contract Manager and Quality Assurance Officer. UCCE's Quality Assurance

Officer will be responsible for making the changes, submitting drafts for review, preparing a final copy, and submitting the final for signature.

4.4 Organizational chart and responsibilities

Figure 1 represents project organization. The QAPP was developed in a coordinated effort between the subcontractors and their respective laboratory staff. The QA officer, Michael Cahn is independent of the data collection effort and will serve as the QA officer for this project. Michael Cahn will supervise the staff research associate (to be determined) on the QA protocols. Michael Cahn will also serve as the liaison for samples submitted for analysis to the UC DANR laboratory.

Figure 1. Organizational chart.



5. Problem Definition/Background

5.1 Problem statement.

Nonpoint source (NPS) discharge of nutrients and sediment is a water quality problem along the Central Coast of California. Agriculture is one of the primary sources for nutrient and sediment loading of surface waters that drain into receiving waters including the Monterey Bay National Marine Sanctuary. Agriculture on the Central Coast of California is intensive due to the high value of the commodities produced and the number of crops grown per season.

Furrow and sprinkler systems are used to irrigate approximately 90% of the vegetables grown on the central coast. Significant amounts of runoff can occur from vegetable fields irrigated with both of these irrigation systems. Although surface drip irrigation is used in almost 30% of the vegetable acreage in Monterey County, almost all of these vegetable crops are established with overhead sprinklers from planting until sidedressing (approximately the first 3 weeks of the crop). The use of surface-placed drip tape significantly reduces irrigation run-off; however, the use of surface drip is most common for lettuce, and less common for cole crops such as broccoli and cauliflower, which are often irrigated with sprinklers during the entire crop cycle. Currently, a majority of the acres under vegetable production use overhead sprinklers for at least 50% of the crop cycle. Additionally, furrow irrigation is used after crop establishment on fields located on medium textured soils with a uniform 1 to 2% slope. Under furrow irrigation, water that does not infiltrate into the soil as it advances across the field runs off the lower end of the field, and if not re-used, eventually drains into creeks and ditches that drain into the Salinas and Pajaro rivers.

Runoff from furrow and sprinkler systems transports sediment and nutrients from agricultural fields into surface water supplies. The impact of sprinkler water droplets and the force of flowing water degrade soil aggregates, detaching particles, which become suspended in irrigation runoff. Although a portion of the nitrogen and phosphorus carried in irrigation runoff is in a soluble form, much of the organic fraction is adsorbed to transported sediments. Strategies that could improve infiltration and stabilize soil aggregates could reduce runoff and the loss of sediment and nutrients from agricultural lands.

Treatment of soils with polyacrylamide (PAM), a large polymer chain molecule (10-15 Mg/mole), could potentially decrease sediments and nutrients lost from furrow and sprinkler irrigated vegetable fields by improving infiltration and stabilizing soil aggregates. Research in the northwest of the United States demonstrated that anionic PAM injected during the first few hours of a furrow irrigation at 10 ppm concentrations could stabilized soil sufficiently to reduce soil erosion by more than 90% and significantly reduce ortho- and total P concentrations in irrigation runoff (Lentz and Sojka 1996). Many other studies have also documented the erosion control benefits of PAM in furrow systems (Bahr et al. 1996, Lentz et al. 1992., Lentz and Sojka 1994, Sojka and Lentz 1993, Sojka et al. 1998, Trout and Lentz 1993, Trout et al. 1993, and Trout et al. 1995) Applying PAM with sprinkler systems has had similar erosion control benefits by stabilizing aggregate structure, and preventing soil pore plugging and the development of a crust layer (Ben-Hur 1994, Bjorneberg and Aase 2000, Levy et al. 1991, Levy et al. 1992).

The low rate of polyacrylamide (~1 lb/acre/irrigation) needed to reduce runoff and improve water quality minimizes the costs ($15-35/acre/crop) for growers and should facilitate adoption of this technology if it is shown to have significant benefits in the Central Coast region. Reported erosion control benefits of PAM have been somewhat conflicting in California. McElkiney and Osterli (1996) showed that PAM, applied to a fine textured soil in the San Joaquin Valley, can have as much as a 95% reduction in soil erosion and 10-40% increase in infiltration rate. In contrast, Ajwa and Trout (2006) showed that PAM did not increase infiltration on a coarse-loamy soil in the same region. Water quality may also interact with the chemistry of PAM (Shainberg et al. 1990, Wallace and Wallace 1996). Much of the San Joaquin Valley is irrigated with good quality water, while on the central coast, most growers irrigate with ground water that typically has an EC > 1 dS/m and an SAR > 3. Because PAM has not been extensively researched in the central coast, this project would focus on quantifying the effects of PAM on infiltration, soil erosion, and sediment and nutrient concentrations in irrigation tail water, for the soil types, water qualities, and cropping systems typical for this region.

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5.2 Decisions or outcomes.

Field trials will provide an opportunity to test strategies for using polyacrylamide for cool season vegetable production. By working closely with growers and getting their feedback on the various techniques for using PAM it is hoped that workable strategies that have a high potential of widespread adoption can be developed and demonstrated to vegetable growers in the lower Salinas Valley. Specific measurements of the quantity and quality of runoff waters will provide quantitative evidence of the effectiveness of these proposed practices.

5.3 Water quality or regulatory criteria

There are no established water criteria for nitrogen, phosphorus, total dissolved solids, total suspended solids, and turbidity for the watersheds where the research will be undertaken. Nevertheless, the water quality objectives for the Central Coast regional water quality control board basin plan can be applied to these water bodies. For example, the Regional Board's Basin Plan specifies a water quality objective of Nitrate-N concentrations in surface waters of 10 mg N L^{-1}*, which is the same as the drinking water standard. Therefore, this limit will be used as part of the criteria to determine the success of this project. Likewise, the turbidity objective for inland surface waters is less than 20% increase in background levels for turbidities between 0 and 50 JTU and less than an increase of 10 JTU for levels ranging from 50 – 100 JTU, and finally less than a 10% increase above background levels for water bodies with a background turbidty level greater than 100 JTU.*

6. Project/Task Description

6.1 Work statement and produced products.

This project will compare water quality and nutrient loads from vegetable fields under sprinklers with and without polyacrylamide in the irrigation water. Sites will be identified that represent sloping land, typical of runoff prone conditions, in which to establish the research/demonstration plots. The trials will be established at planting, and plots will be equipped with water sampling devices that can also measure the quantity of water leaving the test plots and sample run-off. During runoff-generating irrigations, UCCE personnel will monitor the equipment and collect water samples for subsequent analysis by the DANR Lab at UC Davis.

Project report will be submitted to the Regional Board contract manager, Amanda Bern. This report will include the project effectiveness evaluation by determining sediment and nutrient load reductions to surface waters. The results of these finding will be made available to growers through a variety of extension outreach methods: field days, articles in the Crop Notes Newsletter, posting on the UCCE, Monterey County website, one on one consultations and presentations at the annual Irrigation and Nutrient Management Conference held each February by the UCCE, Monterey County.

6.2. Constituents to be monitored and measurement techniques.

- *Run-off Volume: Water flow will be monitored in each plot during irrigation run-off events.*
- *Run-off Water Quality: Water samples collected at 5 minute intervals during irrigation events will be composited and analyzed for total-N, nitrate-N, Total-P, ortho-P, pH, electrical conductivity, suspended sediments, and turbididty.*

To further evaluate the project, background information on cultural practices of will be collected:

1. Soil type (texture), plot length and width, slope
2. Soil nutrient level
3. Quality of irrigation water
4. Cropping history

6.3 Project schedule

Table 2 summarizes project schedule. The timeline reflects anticipated dates to accomplish project tasks. Any adjustments of these dates will need approval of the contract manager, Amanda Bern.

Table 2. Project schedule timeline.

Activity	***Date (MM/DD/YY)***		***Deliverable***	***Deliverable Due Date***
	Anticipated Date of Initiation	***Anticipated Date of Completion***		
QAPP	*03/1/07*	*09/01/07*	*Modified QAPP*	*09/01/07*
Identify grower cooperators (2007-2008)	*03/15/07*	*05/31/08*	*Growers and experimental sites identified*	*05/31/08*
Irrigation Trials (2007-2008)	*09/01/07*	*08/31/08*	*Water samples submitted to DANR Lab*	*08/31/08*
PAM Literature Review	*03/01/07*	*10/31/07*	*Review submitted to Water Board*	*10/31/08*
Educational Outreach	*3/1/08*	*5/31/08*	*Workshops and educational articles*	*5/31/08*
Final Report	*09/01/08*	*09/31/08*	*Final Report*	*09/31/08*

6.4 Geographical setting

The Central Coast region of California is characterized by a Mediterranean climate with mild winters. Rainfall varies on an interannual, north-south gradient and in relation to landforms and topography. Summer temperatures are generally cooler near the coast, where there is often more fog, and increase inland. Sloping vegetable ground is located along the edges of the Salinas Valley. See Figure 2 for the regional extent of the program and evaluation.

Figure 2 – Map of the regional extent of the program and effectiveness evaluation.

6.5 Constraints

This project will utilize replicated experimental design which will allow for statistical analysis utilizing analysis of variance (ANOVA). However, the issue of variability (e.g. slope, soil type and soil fertility) can complicate the results of the monitoring.

There are a number of constraints on this project that reflect the nature of doing on-farm research. These are highly managed systems with practical considerations by the growers; therefore, UCCE has limited control or influence on these management practices. Furthermore, to elicit cooperation from growers, field installations must be limited in size and avoid interfering with farm management. In practical terms, run-off sampling equipment must be non-invasive and field visits must be limited. In the development of the QAPP, the normal water quality sampling procedures have been modified given these constraints.

Sites selected are representative of the erodable crop lands for vegetable production within the geographical area covered by the PGE grant program. Grower-cooperators have agreed to the monitoring with the understanding that site locations will not be disclosed (Table 3). In order to meet grower cooperator concerns, growers and their ranch locations remain anonymous. However, the data collected can be applied to a range of soil types and slopes and therefore these data should be applicable throughout the region.

***Table 3. Grower-crops selected for evaluation*.**

Site No.	***Cropping Sytem***	***Soil type***	***Location***	***Monitoring***
1	*Lettuce*	*Sandy Loam*	*TBD*	*09/1/07 – 10/15/07*
2	*TBD*	*Loamy Sand*	*TBD*	*TBD*
3	*TBD*			

7. Quality Objectives and Criteria for Measurement Data

EPA/SWRCB have established criteria to maintain data quality to ensure the usefulness of the data from a number of perspectives. It is, therefore, important to evaluate the relevance of these criteria to this project in a systematic way.

Water quality data are legally defensible: Water quality data in surface water or groundwater or discharges must meet high scientific standards to establish and enforce state and federal regulations. The evaluation of this project, however, is based on cooperation from private landowners, who remain anonymous; therefore the use of these data can not be used to directly enforce actions on grower cooperators.

Water quality data can assess anthropogenic influences: In the context of water chemistry variability, contamination mechanisms, and groundwater/surface water processes, site comparability allows resource management agencies to evaluate natural and anthropogenic influences and develop proper regulatory polices. Therefore, data reporting limits must be standardized to evaluate background versus elevated concentrations. This project focuses on highly managed agro-ecosystems where nutrient concentrations will be well above EPA/SWAMP reporting limit criteria. In contrast to water samples collected from state waters, nutrient concentrations in irrigation runoff and soil extractions are relatively high (e.g. as high as 2 mg N/g. of dry soil) and justifiable in this context. Nevertheless, the analytical methods developed in this QAPP strive to meet EPA/SWAMP criteria to the extent possible.

Data collected across sites and at various times must be comparable: Water quality varies in surface water, groundwater, and discharges in temporal and spatial scales. To ensure that this variability is understood, standardized methods that include external standards, analytical checks (e.g. blanks, spikes, and cross-laboratory check), equipment inspection and maintenance, and proper procedures (e.g. training) must be included. Nevertheless, the source of variability in soil and irrigation runoff is unique to specific farm management decisions in the context of physical and biological processes. Runoff volume and water quality variability maybe vary an order of magnitude in a single season. Run-off and soil nutrient concentrations can vary two or three orders of magnitude. Capturing this variability is beyond the scope of this project. Instead, project evaluation will characterize water volume and quality. For example, it is more important to have multiple measures of run-off with a precision of 80 L than fewer values with a precision of 0.5 L, which is meaningless in agriculturally managed fields. Therefore, we have designed our sampling procedures and analytical methods appropriate to this variability. These procedures and methods include the highest integrity possible, while providing meaningful values for model calibration.

Applied water *Water applied to the field during irrigation events will be measured with a propeller flow meter installed on the main irrigation pipe. The flow meter was calibrated by the manufacturer and has an accuracy of ±2% of a reading and ±0.25% repeatability.*

Irrigation Runoff

Samples of run-off may be collected by 2 different methods, depending on the size of the plots used in the trials. For small plots that have less than 10 gallons per minute of run-off, a sump pump activated with a float switch is used to pump water collected at the lower end of the plot through a residential flow meter which records the gallons of runoff and diverts a portion of the water into a sample bucket. For large plots that have more than 10 gallons per minute of run-off, flumes equipped with a stilling well and float device record that the height of water passing through the weir and a peristaltic pump is activated at 5 minute intervals to sample the run-off into a collection container. A datalogger (Campbell Scientific CR1000) is used to record the water height and activate the sample pump. The amount of water collected (20-200 ml per sample) is proportioned to the flow rate to produce an accurate composite sample of the run-off water, with a repeatability of ±5%.

Runoff Volume

Run-off from irrigation events will be measured at the end of the field plots by methods designed for small and large plots. For large plots, a trapezoidal flume equipped with a float device measures the height of water, which is proportional to the flow rate. Flow rates can be accurately measured between 1 to 300 gallons per minute. Water height in the flume will be measured at 5 second intervals and averaged every 5 minutes using a datalogger. The water height data will be converted to flow rate using the manufacturer's calibration equation. The total volume of run-off can be calculated by integrating the flow rates during the entire irrigation event. According to the manufacturer the accuracy of these flumes is less than ±2% variation and the accuracy of the float device is less than ±2% variation.

For small plots, a sump pump activated with a float switch is used to pump water collected at the lower end of the plot through a residential flow meter which records the gallons of runoff with an accuracy of ±5% variation

Runoff Water Quality—Conductivity/pH

Water samples will be analyzed for conductivity and pH in the field at each sample collection event (Table 4).

Table 4. Electrical Conductivity and pH DQOs. There are no SWAMP requirements for precision or completeness for these parameters; however, the suggested values will be used.

Parameter	Method	Resolution	Accuracy	SWAMP Suggested Precision	SWAMP Suggested Completeness
Electrical conductivity	Forestry Suppliers waterproof electrical conductivity meter	1 uS	±2 uS	±1 uS	90%

pH	Oakton pH Testr10 (Range: 1.0-15.0)	0.5 units	±1 unit[1]	±0.5 units	90%

<u>Runoff Water Quality—TS, TSS, TDS</u>

Field duplicate sample/s will be taken at 5% of the samples to define the accuracy of the samples of the runoff. Laboratory accuracy and precision cannot be determined for each sample run due to the destruction of the sample during analysis (no possible replicate or spike). However, in order to assess the accuracy and precision field splits in addition to field duplicates can be used test the analytical variability. Splits for TSS will be done at the UC DANR laboratory with a sample splitter on 5% of the samples.

<u>Runoff Water Quality—Nutrients</u>

During sample collection, field duplicates will be taken to define the accuracy of the samples of the runoff. Duplicates from the field collection plastic container will be collected at 5% of samples with at least one per sample location. Water samples will be cooled within 2 hours of completing each irrigation event to 4 ºC.

In the laboratory, standard solutions, reagent or method blanks, bottle blanks, replicates, and spikes will be run with the samples to assess the accuracy and precision of the laboratory method and techniques (See Section 13 for methods, accuracy and detection limits). Dissolved nutrients will be analyzed using DANR 847 and DANR 865. All analysis is done according UC DANR SOP specifications for each individual analysis. Each sample run is documented and results are made available by UC DANR.

The accuracy of methods is checked against standard solutions of known concentrations with every sample analysis run. These standards are obtained from ASTM and include a low range, middle range, and high range concentrations. Accuracy will be assessed by the percent error between the known concentration of the standard, and the reading or measured value from the spectrophotometer. The acceptable % error (% Error = (measured value-standard value)/standard value) for each method is presented in Section 13.

Method blanks are performed with RO (water purified by reverse osmosis) water in place of the sample. All blank runs are reported by UC DANR with output results. A blank consists of RO water in a re-used, cleaned, and acid washed sample bottle. To ensure no contamination from the sample bottle, method blanks must contain no quantifiable nutrients, i.e. the blank should be less than the method detection limit (Table 4). Method blanks will be run with each analysis.

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[1] Note: pH is highly sensitive to colloids in the water column, thus field-based measurements in turbid waters are inaccurate. We will not access this field accuracy but use pH units as a .coarse indication of H^+ availability.

One sample (preferably one of the duplicates) is chosen as the QC sample. This sample will be used for both replication and spiking. Using the same sample for all QC will ensure clarity and continuity in data management and reporting.

A replicate on a least one sample per set, or 5% of samples will ensure precision. This is done by running the QC sample in the beginning of the sample run, and running another sample from the same bottle again at the end of the sample run. Calculating the % difference (% Difference = (replicate 1 - replicate 2) / average of replicates) between the replicates will assess precision.

*Sample spikes or Standard Reference Materials (SRM) will ensure the accuracy of laboratory results. At least one sample spike or SRM will be conducted per sample run. The percent recovery (% Recovery = (measured spike value / expected spike value) * 100) from this spike will be used to assess the accuracy of the method and technique, where the expected spike value is the average of the sample value and standard concentration.*

Table 5 illustrates nutrient analysis methods employed by UC DANR, the SWAMP DQO requirements for precision and spike recovery and the completeness goals that will be utilized in this project.

Table 5. Nutrient DQOs for UC DANR Laboratory.

Parameter	Method	Method Detection Limit	Accuracy of the Method	SWAMP Precision Requirement	SWAMP Recovery Requirement	SWAMP Suggested Completeness	Acceptable % Error for Standards
Total Ammonia-Nitrogen (NH_3-N)	DANR 847	0.05 mg/Kg	7%	Laboratory replicate within ±25%	Matrix Spike 80% - 120%	90%	10%
Orthophosphate (PO_4^{3-})	DANR 865	0.05 mg/Kg	5%	Laboratory replicate within ±25%	Matrix Spike 80% - 120%	90%	10%
Nitrate+ Nitrite-Nitrogen (NO_3^--N)	DANR 847	0.05 mg/Kg	7%	Laboratory replicate within ±25%	Matrix Spike 80% - 120%	90%	10%
Total Kjeldahl Nitrogen (TKN-N)	DANR 850	0.1 mg Kg^{-1}	8%	Laboratory replicate within ±25%	N/A	90%	10%
Total Phosphorous	DANR 890	0.1 mg Kg^{-1}	8%	Laboratory replicate within ±25%	N/A	90%	10%

Samples will be analyzed for solids using DANR 870 (Table 6). Field duplicate sample/s will be taken to define the accuracy of the samples at representing runoff sediment concentrations. Laboratory accuracy and precision cannot be determined for each sample run due to the destruction of the sample during analysis (no possible replicate or spike). Detection limits and reproducibility is listed in Section 13.

Table 6. Total Solids, Total Suspended Solids, and Total Dissolved Solids DQOs. There are no SWAMP requirements for accuracy, precision, or completeness for these analyses; however, the suggested values will be used.

Analysis	Method	Method Detection Limit	SWAMP Suggested Accuracy	SWAMP Suggested Precision	SWAMP Suggested Completeness
Total Solids, Total Suspended Solids, and Total Dissolved Solids	DANR 870	10 mg/Kg	80% - 120%	Laboratory replicate within ±25%	90%

<u>*Soil Properties Testing*</u>

At each field and each ranch soil samples at the beginning and the conclusion (or when appropriate) to determine the following parameters: Soil Texture Size (DANR 470), Soil Organic Matter Content (DANR 410), and Soil Total N/C (DANR 320). Several soil samples from each unit will be collected and homogenized (if appropriate) to obtain a representative sample. Soil is highly variable and the number of homogenized sub samples (no less than six) will be determined by UCCE. All DQOs have been listed in Section 13 under the appropriate method. Laboratory accuracy and precision cannot be determined for each sample run due to the destruction of the sample during analysis (no possible replicate or spike), however, well homogenized soil samples will be used to assess laboratory analysis at a rate of 5% of the samples.

8. Special Training Needs/Certification

8.1 Specialized training or certifications.

The UCCE researcher associated with this project has had specialized academic and professional training in appropriate categories. These are too numerous to summarize, but his curriculum vitae is included in Appendix A. The CV represent expertise in a wide range of disciplines and have been assembled for this project because of their expertise in the following areas:

Soil science and fertility management

Spatial and temporal variability

Irrigation evaluation and management

Water quality and monitoring

Analytical methods

8.2 Training and certification documentation.

Training will be documented using the Training Record Sheet, Appendix B.

8.3 Training personnel.

UCCE Farm Advisor, Michael Cahn, will oversee staff training for field procedures that include runoff volume and water quality. He is responsible for safety in the field and his staff will not undertake field activity without prior training. Some field tasks that may require training include:

- Field notes and observations
- Measuring runoff
- Runoff pH and electrical conductivity
- Nutrient sampling
- Total Solids, Total Suspended Solids, and Total Dissolved Solids sampling
- Labeling and sample preservation

9. Documents And Records

The UCCE Farm Advisor will be responsible for maintaining all field collected records that are pertinent to the establishment of the field trials. Hardcopy data sheets will be stored for the length of the project. Data are stored and backed up regularly on PC computers. Runoff records will be stored and maintained by Michael Cahn, UCCE. These records will be stored in hard copy and electronic versions and will be backed up regularly on PC computers.

Copies of the QAPP will be distributed to all parties involved with the project, as described in Section 1. Any future versions will also be distributed to this group. All versions of the QAPP that are distributed will be maintained by Michael Cahn at the UCCE office in Salinas.

All grant required monitoring deliverables will be provided to the project manager, who will then pass them on to the State Board Contract Manager, Amanda Bern. Copies of all documents, records and all original field books will be maintained by respective contractors.

Group B: Data Generation and Acquisition
10. Sampling Process Design

The objective of this project is to evaluate the effect of low concentrations of polyacrylamide (PAM) on the quality of irrigation run-off induced by overhead sprinklers in vegetable systems. The project will evaluate the amount of nutrient and sediment loss under standard irrigation practices and when low concentrations of PAM (< 10 ppm) are added to the irrigation water.

Vegetable fields that have uniform slope and soil type will be selected in the project study area. This project will generate sound scientific information on the effectiveness of PAM to reduce sediment and nutrient loss carried in run-off from agricultural fields. Practices that can provide measurable reductions in nutrient and sediment runoff will be discussed with growers and workable strategies will be evaluated in replicated and non-replicated field trials. The trials will include a control (standard treatment). Plots size will be determined by what is workable for the growers operation without disrupting commercial production. However, the plots will be large enough to provide a field scale evaluation. During irrigation events we will collect composite samples of run-off. Run-off samples will analyzed for total suspended sediments, turbidity, ortho-phosphate, total phosphorus, total nitrogen, nitrate-nitrogen, total dissolved solids, electrical conductivity and pH at the University of California, DANR laboratory.

This project provides will provide information on the effectiveness of a management practice that may significantly reduce sediment and nutrient levels in run-off from vegetable fields. This practice focuses on keeping the sediments and nutrient on the fields, but can be used in conjunction with other conservation practices, such as vegetated water-ways and grass filter strips.

The data generated from this project will be useful to evaluate the effectiveness of using PAM at a watershed-scale level. Data will be collected from the Chualar Loam and Arnold Loamy Sand soil type which represent the major soil types of the Elkhorn Slough and Chualar Creek watersheds.

11. Sampling Methods

Applied water: *Water applied to the field during irrigation events will be measured with a propeller flow meter installed on the main irrigation pipe. The flow meter was calibrated by the manufacturer (McCrometer, Inc.) and has an accuracy of ±2% of a reading and ±0.25% repeatability.*

Runoff: Samples of irrigation run-off can be collected by 2 different methods depending on the size of the plots used in the trials. For small plots that have less than 10 gallons per minute of run-off, a sump pump activated with a float switch is used to pump water collected at the lower end of the plot through a residential flow meter which records the gallons of runoff and diverts a portion of the water into a sample bucket. For large plots that have more than 10 gallons per minute of run-off, flumes equipped with a stilling well and float device record that the height of water passing through the weir and peristaltic pump is activated at 5 minute intervals to sample the run-off into a collection container.

Runoff Volume: For large plots, run-off from irrigation events will be measured at the tail of the field using a trapezoidal H-flume (Plasti-fab Inc) equipped with a stilling well and float device that is connected to a variable resister (±2% accuracy and ±0.25% repeatability) to measure the height of water Flow rates can be accurately measured between 1 to 300 gallons per minute. Water height in the flume will be measured at 5 second intervals and averaged every 5 minutes using a datalogger. The water height data will be converted to flow rate using the manufacturer's calibration equation. The total volume of run-off can be calculated by integrating the flow rates during entire irrigation event.

For small plots with flow of less than 10 gallons per minute, a sump pump activated with a float switch is used to pump water collected at the lower end of the plot through a residential flow meter (Precision meters Inc.) which records the gallons of runoff with an accuracy of ±2% variation.

Runoff Water Quality: Runoff samples must be representative, therefore, we have programmed a datalogger to take flow-proportional samples into clean, plastic buckets that have been rinsed three times prior to use. To prevent degradation of samples they should be collected within 12 hours of completing an irrigation event and cooled to 4^{o}C. and held in the dark; holding time for some nutrients (nitrate, ortho-phosphate) is 48 hours). After mixing the water in the bucket, sub-samples of water will be removed and put in a cooler at 4^{o}C. Field buckets will be replaced with clean buckets after each use. Field measurements of EC and pH will be conducted by UCCE staff. Samples will be taken and analyzed for TSS, TDS, total Kjeldahl nitrogen, nitrate-N, ortho-phosphate, and total phosphorus at the UC DANR laboratory.

Soil Sampling: Generally, representative soil samples will be collected from each field trial by sampling the top foot of soil from randomized sub-sample locations. The actual number of sub-samples will vary dependent on field size and configuration, but in any field no fewer than 10 and no more than 25 sub-samples will be collected. These sub-samples will be mixed thoroughly in a clean container, and then sub-sampled for the analytical sample. Soil samples will be placed in labeled plastic bags, placed temporarily on ice in a dark cooler, prior to timely submission to

DANR laboratory. All of the core sections will be inspected for textural change and recorded. No preservation procedures are necessary.

12. Sample Handling and Custody

Water runoff samples will be collected with an automatic pump and put into a clean, plastic container. The automated system has been designed to composite flow proportional samples. The volume of water will be recorded after each irrigation event. The water will be mixed and a sub-sample will be taken for nutrient analysis. Sub-samples will be put into clean plastic bottles and put in a cooler at $4^{o}C$ (Table 8). These samples will be transported to UC Cooperative Extension Office in Salinas. Ammonium, nitrate, and ortho-phosphate samples will be filtered and frozen and sent frozen to UC DANR for water quality analysis. Water samples that include sediments will be analyzed for TKN and Total P. Samples will be frozen and sent to UC DANR for analysis in a Styrofoam cooler with ice.. Water samples for TSS and TDS will be sent directly to DANR in a Styrofoam cooler with ice. Other samples for soil property parameters will be double bagged in plastic to maintain field moisture conditions. Temperatures must be between above freezing and below warm temperatures that can alter mineralogical properties.

All sample collections, transportation, and transference will be tracked with a Chain of Custody (COC) form, when samples are transferred to the UC DANR laboratory. Forms will be supplied by outside laboratories. UC DANR supplies work order request forms, and with the shipping record will be used as the chain of custody record.

Samples may be disposed of when analyses are completed and all analytical quality assurance/quality control procedures are reviewed and accepted. Generally, these are to be stored until the end of the project.

Table 7 -- Sample handling and custody.

Parameter	*Matrix*	*Container*	*Volume*	*Field Preservation*	*Laboratory Process and Holding Time*
pH	*Water*	*Plastic container*	*variable*	*None*	*none*
Nitrate + Nitrite	*Water*	*Polyethylene bottle*	*150 ml*	*4°C*	*48 hours 4°C; filtered, 30 days frozen*[2]
Ammonium	*Water*	*Polyethylene bottle*	*500 ml*	*4°C*	*48 hours 4°C; filtered, 30 days frozen*
Soluble Phosphorous	*Water*	*Polyethylene bottle*	*150 ml*	*4°C*	*48 hours 4°C; filtered, 30 days frozen*
Total Solids, Total Suspended Solids, Total Dissolved Solids	*Water*	*Polyethylene bottle*	*1000 ml*	*4°C*	*7 days, 4°C*
TKN	*Water*	*Polyethylene bottle*	*1000 ml*	*4°C*	*48 hours 4°C; 30 days frozen*[3]
Total P	*Water*	*Polyethylene bottle*	*300 ml*	*4°C*	*48 hours 4°C; 30 days frozen*
Soil Nitrate + Ammonium	*KCl Extract*	*Polyethylene Tube*	*~25 ml*	*4°C*	*24 hours 4°C; filtered, frozen 30 days*
Soil Nitrate	*$CaCl_2$ extractant*	*Plastic Baggies*	*~500 g*	*4°C*	*48 hours 4°C; extraction, filter, and frozen 30 days*
Soil Water Retention	*Soil*	*Intact cores*	*~1 kg*	*1-35°C, double bagged*	*Dried, pulverized, 6 months, room temperature*
Particle Size	*Soil*	*Plastic baggies*	*~ 1 kg*	*1-35°C, double bagged*	*No criteria, none*

[2]Clesceri, L. S., A. E. Greenberg and A. E. Eaton. 1998. Method *4500*-P. B. *5.* Standard Methods for the Examination of Water and Wastewater, 20th Edition. The method holding time has been extended to 30 days, which can have minor affects on the accuracy of the measures. Since these are on-farm BMP comparisons and are not surface water samples; the criteria have been relaxed in order to sample farm runoff effectively.
[3]Clesceri, L. S., A. E. Greenberg and A. E. Eaton. 1998. Method *4500*-N_{org}. A. 2. Standard Methods for the Examination of Water and Wastewater, 20th Edition. The method holding time has been extended to 30 days, which can have minor affects on the accuracy of the measures. Since these are on-farm BMP comparisons and are not surface water samples; the criteria have been relaxed in order to sample farm runoff effectively.

Parameter	***Matrix***	***Container***	***Volume***	***Field Preservation***	***Laboratory Process and Holding Time***
Total Nitrogen and Carbon	*Soil*	*Plastic baggies*	*100 g*	*1-35°C, double bagged*	*Dried, pulverized, 6 months, room temperature*
Exchangeable Potassium, Calcium, Magnesium, and Sodium	*Soil*	*Plastic baggies*	*100 g*	*1-35°C, double bagged*	*Dried, pulverized, 6 months, room temperature*
Cation Exchange Capacity	*Soil*	*Plastic baggies*	*100 g*	*1-35°C, double bagged*	*Dried, pulverized, 6 months, room temperature*
Soil Organic Matter	*Soil*	*Plastic baggies*	*100 g*	*1-35°C, double bagged*	*Dried, pulverized, 6 months, room temperature*

13. Analytical Methods

Analysis of Soil

Representative soil samples will be analyzed by a certified laboratory for complete agronomic nutrient analysis. Cation exchange capacity and exchangeable cation fractions will be determined (DANR 430); plant available soil N will be determined by KCl extractions (DANR 312) and Phosphorous by the Olsen method (DANR 340). Other soil parameters will include total N and C (DANR 320) (or Organic Matter (DANR 410)—TBD), Particle size (if necessary) (DANR 460), Moisture retention (DANR 460).

Runoff Water Quality

pH and electrical conductivity will be measured using portable probes (Hanna pH and EC probe with a resolution of ± 0.1 pH units and ± 0.01 dS/m for electrical conductivity). It is most applicable to waters with a pH ranging from 4.0 to 9.0. Electrical conductivity represents a semi-quantified amount of soluble salts in the water (ECe). The higher the concentration of salt in a solution, the higher will be the electrical conductance (the reciprocal of resistance).

For inorganic nutrient analysis water samples collected from runoff will be filtered with GF/F filters and frozen and sent to UC DANR frozen to be analyzed for nitrate/nitrite and ammonium (DANR 847) and soluble phosphorous (DANR 865). Unfiltered and homogenized samples will be analyzed for total Kjeldahl nitrogen (DANR 850), total phosphorous (DANR 890), Total Solids, Total Suspended Solids, and Total Dissolved Solids (DANR 870).

UC DANR Analytical Laboratory

Samples sent to the UC DANR Analytical Laboratory will be analyzed using the following methods. These are standard procedures developed in the laboratory as specified at http://groups.ucanr.org/danranlab/Methods_of_Analyses545.

Soil Sample Analysis

Soil Nitrate and Extractable Ammonium: NO_3-N, NH_4-N (**DANR 312**)
Equilibrium extraction of soil for nitrate and ammonium with potassium chloride and subsequent determination by flow-injection analyzer.

Summary: This method involves the quantitative extraction of nitrate (NO3-N) from soils using an equilibrium extraction with 2.0 N KCl solution. Nitrate is determined by reduction to nitrite via a copperized cadmium column. The nitrite is then determined by diazotizing with sulfanilamide followed by coupling with N-(1-naphthyl)ethlyenediaminie dihydrochloride. The absorbance of the product is measured at 520 nm. This method is also semi-quantitative for ammonium (NH4-N) in soils. Ammonia is heated with salicylate and hypochlorite in an alkaline phosphate buffer. The presence of EDTA prevents precipitation of calcium and magnesium and sodium nitroprusside is added to enhance sensitivity. The absorbance of the reaction product is measured at 660 nm and is directly proportional to the original ammonia concentration. Extracts can be stored for up to three weeks at low temperature (<4°C). For long term storage, toluene or thymol may be added to the sample to prevent microbial growth. The method has detection limit of approximately 0.1 mg/kg (on a soil basis) and is generally reproducible within 7%.

Hofer, S. 2003. Determination of Ammonia (Salicylate) in 2M KCl soil extracts by Flow Injection Analysis. QuikChem Method 12-107-06-2-A. Lachat Instruments, Loveland, CO.o:p>

Knepel, K. 2003. Determination of Nitrate in 2M KCl soil extracts by Flow Injection Analysis. QuikChem Method 12-107-04-1-B. Lachat Instruments, Loveland, CO.

Extractable Phosphorous: Olsen-P (**DANR 340**)
Extractable phosphate based on alkaline extraction by 0.5 Normal NaHC03. Plant available phosphate for soils with pH greater than 6.5 by ascorbic acid reduction of phosphomolybdate complex and measurement by flow injection analysis.

Summary: This method estimates the relative bioavailability of inorganic ortho-phosphate (PO4-P) in soils with neutral to alkaline pH. It is not appropriate for soils which are mild to strongly acidic (pH <6.5). The method is based on the extraction of phosphate from the soil by 0.5 N sodium bicarbonate solution adjusted to pH 8.5. In the process of extraction, hydroxide and bicarbonate competitively desorb phosphate from soil particles and secondary absorption is minimized because of high pH. The orthophosphate ion reacts with ammonium molybdate and antimony potassium tartrate under acidic conditions to form a complex. This complex is reduced with abscorbic acid to form a blue complex which absorbs light at 880 nm. The absorbance is proportional to the concentration of orthophosphate in the sample. The method has shown to be well correlated to crop response to phosphorus fertilization on neutral to alkaline soils. The method has a detection limit of 1.0 mg/kg (soil basis) and is generally reproducible within 8%.
Olsen, S. R. and L. E. Sommers. 1982. Phosphorus. p. 403-430. *In:* A. L. Page, et al. (ed.) Methods of soil analysis: Part 2. Chemical and microbiological properties. ASA Monograph Number 9.

Prokopy, W. R. 1995. Phosphorus in 0.5 M sodium bicarbonate soil extracts. QuikChem Method 12-115-01-1-B. Lachat Instruments, Milwaukee, WI.

Total Soil Nitrogen and Carbon: N, C (**DANR 320**)
Combustion gas analyzer method for total nitrogen and total carbon.

Summary: This analytical method quantitatively determines the total amount of nitrogen and carbon in all forms in soil, botanical, and miscellaneous materials using a dynamic flash combustion system coupled with a gas chromatographic (GC) separation system and a thermal conductivity detection (TCD) system. The analytical method is based on the complete and instantaneous oxidation of the sample by "flash combustion" which converts all organic and inorganic substances into combustion gases (N2, NOx, CO2, and H20). The method has a detection limit of 0.01% for carbon and 0.04% for nitrogen and is generally reproducible within 5% (relative).

Method 972.43. Official Methods of Analysis of AOAC International, 16th Edition (1997), AOAC International, Arlington, VA.

Organic Matter: Walkey-Black OM, Org C (**DANR 410**)

Organic Matter by potassium dichromate reduction of organic carbon and subsequent spectrophotometric measurement (modified Walkley-Black).

Summary: This method quantifies the amount of oxidizable organic matter in which OM is oxidized with a known amount of Cr2O72- in the presence of sulfuric acid. The remaining Cr3+ chromate is determined spectrophotometrically at 600nm wavelength. The calculation of organic matter is based on organic matter containing 58% carbon. The method has a detection limit of approximately 0.01% and is generally reproducible within 8%.

Nelson, D. W. and L. E. Sommers. 1982. Total carbon, organic carbon and organic matter. p. 539-579. In: A. L. Page et al. (ed.) Methods of soil analysis: Part 2. Chemical and microbiological properties. ASA Monograph Number 9.

Particle Size: Sand/Silt/Clay (**DANR 460**)
Particle Size Analysis of sand, silt and clay in soil suspension by hydrometer.
Summary: This method quantitatively determines the physical proportions of three sizes of primary soil particles as determined by their settling rates in an aqueous solution using a hydrometer. The hydrometer method of estimating particle size analysis (sand, silt and clay content) is based on the dispersion of soil aggregates using a sodium hexametaphosphate solution and subsequent measurement based on changes in suspension density. The use of the ASTM 152 H-Type hydrometer is based on a standard temperature of 20°C and a particle density of 2.65 g cm^{-3}. Corrections for temperature and for solution viscosity are made by taking a hydrometer reading of a blank solution. The method has a detection limit of 2% sand, silt and clay (dry soil basis) and is generally reproducible within 8% (relative).

Sheldrick, B. H. and Wang, C. 1993. Particle-size Distribution. pp. 499-511. In: Carter, M. R. (ed), Soil Sampling and Methods of Analysis, Canadian Society of Soil Science, Lewis Publishers, Ann Arbor, MI.

Exchangeable Potassium, Calcium, Magnesium, and Sodium: X-K, X-CA, X-Mg, X-Na (**DANR 360**)
Equilibrium extraction of soil for plant available exchangeable potassium, sodium, calcium and magnesium using 1 Normal ammonium acetate (pH 7.0) and subsequent determination by atomic absorption/emission spectrometry.

Summary: This method is semi-quantitative and determines the amount of soil exchangeable K, Ca, Mg, and Na residing on the soil colloid exchange sites by displacement with ammonium acetate solution buffered to pH 7.0. Generally, these cations are associated with the exchange capacity of the soil. The method does not correct for calcium and magnesium extracted as free carbonates or gypsum. The method has a detection limit approximately of 1 mg/kg or 0.01 meq/100g and is generally reproducible within 7%.

Thomas, G. W. 1982. Exchangeable cations. p 159-165. In: A.L. Page et al. (ed.) Methods of soil analysis: Part 2. Chemical and microbiological properties. ASA Monograph Number 9.

Cation Exchange Capacity: CEC (**DANR 430**)

Cation Exchange Capacity by barium acetate saturation and calcium replacement.

Summary: The method determines the cation exchange capacity (CEC) of soil. The soil is quantitatively displaced of all exchangeable cations with Ba, followed by four deionized rinses to remove excess Ba. A known quantity of calcium is then exchanged for Ba and excess solution calcium is measured. CEC is determined by the difference in the quantity of the Ca added and the amount found in the resulting solution. The method has a detection limit of approximately 2.0 meq/100 g (soil basis) and is generally reproducible within 8%.

Janitzky, P. 1986. Cation exchange capacity. p. 21-23. In: M. J. Singer and P. Janitzky (ed.) Field and laboratory procedures used in a soil chromosequence study. U.S. Geological Survey Bulletin 1648.

Moisture Retention: Moisture Retention (**DANR 460**)
Moisture retention determination using the pressure plate system.
Summary: The method determines the soil moisture content under constant preset pressure potential (ranging from - 100 and - 1500 kPa). Soil is brought to near saturation and then is allowed to equilibrate under a set atmospheric pressure potential. The method is used to determine the available water capacity of soils and/or moisture release curve. The method detection limit is 0.1% and is reproducible within 10% (relative).

Klute, A. 1986. Water retention: laboratory methods. p. 635-662. *In:* A. Klute (ed.) Methods of soil analysis: Part 1. Physical and mineralogical methods. ASA Monograph Number 9.

Water Sample Analysis

Dissolved Nitrate and Ammonium: NO_3-N, NH_4-N, NO_2-N (**DANR 847**)
Determination by flow injection analyzer.

Summary: This method involves the quantitative analysis of ammonium (NH4-N), nitrate (NO3-N) and nitrite (NO2-N) in water. Nitrate is determined by reduction to nitrite via a copperized cadmium column. This nitrite is then determined by diazotizing with sulfanilamide followed by coupling with N-(1-naphthyl)ethlyenediaminie dihydrochloride. The absorbance of the product is measured at 520 nm. Nitrite is determined in the same manner with the cadmium column off-line. Ammonium is heated with salicylate and hypochlorite in an alkaline phosphate buffer. The presence of EDTA prevents precipitation of calcium and magnesium and sodium nitroprusside is added to enhance sensitivity. The absorbance of the reaction product is measured at 630 nm and is directly proportional to the original ammonium concentration. The method has a detection limit of approximately 0.05 mg L-1 for each constituent and is generally reproducible within 7%.

Note that the nitrate values reported include any nitrite in the sample. Nitrite is typically an insignificant fraction of the nitrate.

Wendt, K. 1999. Determination of Nitrate/Nitrite by Flow Injection Analysis (Low Flow Method). QuikChem Method 10-107-04-1-A. Lachat Instruments, Milwaukee, WI.
Switala, K. 1999. Determination of Ammonia by Flow Injection analysis. QuikChem Method 10-107-06-1-A. Lachat Instruments, Milwaukee, WI

Soluble Phosphorous: Soluble Reactive Phosphorous (**DANR 865**)
Quantitative determination by ascorbic acid reduction of phosphomolybdate complex and quantitative measurement by flow injection analysis.

Summary: This method quantitatively determines the amount of soluble phosphorus (P) in water. Phosphorus concentration in water is determined spectrophotometrically by reacting with ammonium molybdate and antimony potassium tartrate under acidic conditions to form a complex. This complex is reduced with abscorbic acid to form a blue complex which absorbs light at 880 nm. The absorbance is proportional to the concentration of phosphorus in the sample. Samples are analyzed using an automated Flow Injection Analyzer (Lachat). The method has a detection limit of 0.05 mg L^{-1} and is generally reproducible within 5%.
Flow Injection Analysis for Orthophosphate. Standard Methods for the Examination of Water and Wastewater, 20th Edition, 1998. 4-149 to 4-150.

Total Kjeldahl Nitrogen: TKN (**DANR 850)**
Total Kjeldahl Nitrogen in H2O. Total reduced nitrogen by the wet oxidation of H2O using standard Kjeldahl procedure with sulfuric acid and digestion catalyst.

Summary: The Total Kjeldahl Nitrogen (TKN) method is based on the wet oxidation of nitrogen using sulfuric acid and digestion catalyst. The procedure converts organic nitrogen to the ammonium form and subsequent determination of ammonium. The procedure does not quantitatively digest nitrogen from heterocyclic forms (bound in a carbon ring), from oxidized forms such as nitrate and nitrite. The method has a detection limit of approximately 0.1mg L-1 N and is generally reproducible within 8%.

Carlson, R. M. 1978. Automated separation and conductimetric determination of ammonia and dissolved carbon dioxide. Anal. Chem. 50:1528-1531

Total Phosphorus: Water Totals: P (**DANR 890**)

Summary: This method quantitatively determines the concentration of P utilizing a nitric acid/hydrogen peroxide microwave digestion and determination by atomic absorption spectrometry (AAS) and Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES). The methodology utilizes a pressure digestion/dissolution of the sample and is incomplete relative to the total oxidation of organic carbon. P is analyzed by ICP-AES with vacuum spectrometer. The method has detection limits ranging from 0.1 mg Kg-1 to 0.01%. The method is generally reproducible within 8%.

Sah, R. N. and R. O. Miller. 1992. Spontaneous reaction for acid dissolution of biological tissues in closed vessels. Anal. Chem. 64:230-233.

Meyer, G. A. and P. N. Keliher. 1992. An overview of analysis by inductively coupled plasma-atomic emission spectrometry. p. 473-505. In: A. Montaser and D.W. Golightly (ed.) Inductively coupled plasmas in analytical atomic spectrometry. VCH Publishers Inc. New York, NY.

Total Solids, Total Suspended Solids, and Total Dissolved Solids: TS, TSS, TDS (**DANR 870**)
Quantification of solids by oven drying and gravimetric analysis.

Summary: This method quantifies solids in water or wastewater samples using gravimetric analysis following oven drying. Solids refer to matter suspended or dissolved in the water or wastewater and may affect water or effluent quality in adverse ways. Waters with high dissolved solids generally are of inferior palatability and may induce unfavorable physiological reactions in transient consumers. Solids analyses are important in the control of biological and physical wastewater treatment processes and for assessing compliance with regulatory agency limitations. The method has a detection limit of approximately 4mg L^{-1} for TSS and 10mg L^{-1} for TDS and TS. The results are generally reproducible within 7%.

Clesceri, L. S., A. E. Greenberg and A. E. Eaton. 1998. Method 2540 B. (Total Solids), Method 2540 C. (Total Dissolved Solids) and Method 2540 D. (Total Suspended Solids). Standard Methods for the Examination of Water and Wastewater, 20th Edition.

14. Quality Control

The UC DANR Analytical Laboratory has well developed QC/QA procedures to guarantee the generation of precise and accurate analytical data. The quality assurance includes planned and systematic actions to provide confidence in each analytical result. The QA/QC Program has two components: Quality Assurance (QA) - the system used to verify that the entire analytical process is operating within acceptable limits and Quality Control (QC) - the mechanisms established to measure non-conforming method performance.

QA Procedures

- STANDARD OPERATING PROCEDURES (SOPS) - Each laboratory method is clearly described in standard operating procedures. These methods are periodically reviewed for updates.
- TRAINING - Tests are performed by trained staff members. Each staff member must meet performance criteria before performing a test.
- RELIABLE AND WELL-MAINTAINED EQUIPMENT - Each instrument is operated by trained staff members. Maintenance logbooks are kept for each instrument. The instruments are calibrated according to manufacturer guidelines and in accordance to the relevant SOPs. Balances, pipettes and other measuring devices are calibrated frequently.
- TRACEABILITY - Analytical standards used are traceable to certified reference materials. Internal reference materials are checked as far as is technically and economically practicable.
- ANNUAL REVIEW OF QC RESULTS – The results of proficiency testing and QC results are annually evaluated for trends. A system of control charts is used to determine if the system is in a state of statistical control and examine the relative variability of repetitive data. Control charts are also used with reference materials and spiked samples to assess the accuracy of measurements.

QC Procedures

- BLANKS – A reagent blank is analyzed with every set of samples that are extracted or digested. This reagent blank includes any and all reagents that are used in the analytical process and is carried through the entire process, including extraction and filtering or digestion.
- DUPLICATES – At least ten percent of samples are analyzed in duplicate. The first, last and every tenth sample are run in duplicate. Duplicate values typically should fall within 8% of each other for all samples unless sample homogeneity is a problem. This information is included in the report.
- STANDARD REFERENCE MATERIALS – At least one standard reference material is analyzed with each set of samples. The values for the standard reference materials are

included in the final report. Samples run with a standard reference material that falls outside the acceptable range are reanalyzed, including digestion or extraction if necessary.

- SPIKE SAMPLES – Sample fortifications or spikes are used to verify accuracy of tests requiring extensive sample manipulation (such as acid digestion) or for non-standard sample types.
- SAMPLE EXCHANGE AND CERTIFICATION PROGRAMS - The ANR Analytical Laboratory participates in a number of sample exchange and certification programs. The Laboratory participates in the International Plant Exchange for plant material and the North American Proficiency Testing Program for soils, water and plant material and manure. The Laboratory is certified by the National Forage Testing Association for the analysis of moisture, crude protein and acid detergent fiber in feed.

QC Procedures

- BLANKS – The main analytical instrument is internally calibrated to read over the range of 0 to 225 ppm nitrate. A reagent blank is checked with each large analytical run. The reagent blank contains the extractant dissolved in steam distilled water.
- DUPLICATE – Duplicate extractions will be performed on each soil sample. Duplicate samples are expected to fall within 10 percent of each other, regardless of sample homogeneity.
- STANDARD REFERENCES – A series of standard references are analyzed with each sample run. If sample runs appear to be outside of the acceptable range, samples are re-extracted and analyzed.
- SPIKE SAMPLES – A spiked sample will be used to determine the accuracy and recovery efficency of extraction and analytical procedure will be added to each run.
- SAMPLE SPLITS - Quality control will be achieved by submitting spot sample extracts to UC DANR Analytical Laboratory. The remaining supernatant will be filtered into a storage bottle, then frozen until sample submission. The resulting data will be compared to the above method by correlation analysis Spot checks will be done at a 5% rate.

QC/QA Field Procedures

- BLANKS – Distilled/dionized water will be used for a blank sample in the field by pumping the water through the sample pump and into the collection bucket at a rate of 10% of the samples
- SAMPLE SPLITS – Samples in the collection buckets will be split into duplicates and treated as separate samples to evaluate the effect of transport and holding time on the degradation of the sample. Sample splits will be conducted on 10% of the samples

15. Instrument/Equipment Testing, Inspection, and Maintenance

Field and laboratory equipment are inspected prior to their use. Any equipment that is not working will be fixed or replaced as soon as possible.

UCCE staff inspects and maintains all field equipment with each site visit. On-farm monitoring equipment is vulnerable to vandalism or damage due to farming practices. Therefore, as part of the regular routine of taking readings and getting water samples, equipment will be checked for damage or operational failures. UCCE staff will repair or replace equipment as conditions warrant.

Laboratory equipment will be maintained and inspected by individual laboratory facilities according to their operating procedures. The UC DANR laboratory has a complete and well-developed testing, inspection, and maintenance procedure. These procedures have been developed for each SOP and are summarized in section 14.

16. Instrument/Equipment Calibration and Frequency

Instrument calibration occurs regularly but is dependent on sampling and laboratory methodology.

Field measurements

All irrigation meters and runoff pumps are calibrated by the manufacturer. Runoff sampling pumps will be field calibrated at the beginning of each installation and checked periodically afterwards. pH and electrical conductivity probes will be calibrated weekly using low, medium, and high standard solutions that bracket sample concentrations. Records of the calibration of the EC and pH probe will be kept. Calibrations will be more frequent than weekly iff readings drift more than 20% between successive calilbrations.

Laboratory Analysis

UC DANR Analytical Laboratory has a well developed maintenance and calibration protocol that is consistent and well developed for each SOP as described in Sections 13-15. All equipment is regularly inspected by the laboratory manager. Equipment that is not functioning properly is immediately taken off-line and repaired or replaced. External standards are used for all calibrations, which are used for each run.

17. Inspection/Acceptance of supplies and Consumables

UCCE staff regularly inspect supplies and consumables. If equipment fails to meet manufacturer guidelines (e.g. disposal date is past due), then supplies are not used and discarded.

There are diverse project supplies and consumables used by UC DANR laboratory. In accordance, with each of their SOPs, the laboratory manager maintains supply and reagent inventory. These supplies and consumables are regularly inspected for chemical and physical integrity and those that do not meet these standards are discarded.

18. Non-Direct Measurements (Existing Data)

Farm Site Selection

Michael Cahn will select the vegetable field sites. He will evaluate the sites based upon appropriate and uniform slopes, as well as soil types. He will obtain background information on previous farming practices at the sites that may influence nutrient levels and soil condition.

Weather Data

Input weather data will be obtained from CIMIS (California Irrigation Management Information System), Department of Water Resources (DWR). CIMIS is an integrated network of over 125 automated active weather stations located throughout California. Registered users can obtain hourly, daily, and monthly data for a variety of data types. Daily and monthly data include evapotranspiration, precipitation, solar radiation, air temperature, soil temperature, vapor pressure/relative humidity, dew point, and wind speed. Air temperature and relative humidity include minimum, maximum, and average values. Hourly values include all of those mentioned and wind directions. Data is available for the complete history of each station. Data received by the CIMIS computer are quality tested and flagged if they fall outside a set standard. Missing data are also flagged. Quality control is based on metric units.

Quality tested data are stored in a relational database for on-demand access by CIMIS users. The quality control flags identify specific data problems. While their immediate use is to inform users of data credibility as related to the set of standards, the flags are also used to monitor sensor performance on a daily basis and to observe long-term trends in data quality, and therefore, test the performance of specific stations. DWR personnel examine the quality control program printout daily to detect potential malfunction of station sensors and schedule repair trips.

Data means and standard deviations for each station, theoretical limits, and some of the procedures described by Meek and Hatfield (1994) were used to test data quality. For stations that have less than five years of historical data, regional statistics are used. The new quality control criteria took effect on January 1, 2001. Each station is composed of the following sensors and their associated manufactured specifications:

Total solar radiation (pyranometer): LiCor LI200S. Sensitivity: ±5% error under natural sunlight conditions. Typically 80 micro Ampere per 1000 watts per square meter. Linearity: Maximum deviation of 1% up to 3000 watts per square meter. Response time: 10 micro seconds. Correction: Cosine corrected up to 80 degrees angle of incidence. Azimuth: ±1% error over 360 degrees at 45 degrees elevation.

Soil temperature (thermistor): Fenwal/ modified by Campbell Scientific Inc. 107b

Accuracy: Worst case ±0.4 degrees C over -33 to 48 degrees C, ±0.5 degrees C at -40 degrees C.

Air temperature/relative humidity. Fenwall Thermistor/HUMICAP H-sensor HMP35C

Range 0 to 100% RH, -35 to +50 degrees C. Accuracy: ±2% RH (0-90% RH), ±5% RH (90-100%), ±0.1 °C over -24 to 48 °C range Note: Both sensors are enclosed in a 12-plate naturally aspirated radiation shield made by R. M. Young.

Wind direction (wind vane): Met-One 024A. Threshold: 0.45 m per sec (1 mph)

Accuracy: ±5%, Delay distance: less than 1.3 m

Wind speed (anemometer): Met-One 014A. Range: 0-45 m per sec (0-100 mph)

Threshold: 0.45 m per sec (1 mph), Gust Survival: 0-53 m per sec (0-120 mph)

Accuracy: 1.5% or 0.11 m per sec (0.25 mph)

Precipitation (tipping-bucket rain gauge): Texas Electronics TE525MM

Resolution: 0.1 mm Accuracy: ±1% at 5 cm per hr or less.

ET_o is determined using a combination of discrete functions (For more information, see (http://wwwcimis.water.ca.gov/cimis/infoEtoPmEquation.jsp). It is likely that the error terms from individual measures will combine in a non-linear fashion, but the DWR has not assessed the importance of the errors or the relative accuracy at any given station. However, these estimates are considered robust in determining crop water demand and unless there are flags associate with sensor failures, these data will be considered adequate.

Soil Data

Initial soil data will be determined by using USDA Soil Surveys.

19. Data Management

Data collected by UCCE on irrigation efficiency, run-off volumes, water quality, and soil properties will be collated and managed by the UCCE farm advisor. UCCE will maintain hard copy of all field notebooks and store them at the Salinas Cooperative Extension office. Data used to calculate irrigation runoff will be entered and stored in Excel workbooks on a PC at the UCCE office. The computer will be backed up weekly.

The DANR Analytical Laboratory will record original analytical data in worksheets and in Excel spreadsheets. All paperwork, such as copies of work requests, client communications, chain of custody forms, analytical data and the final report will be scanned as PDF files. The final report will also saved as an Excel file. All files will be backed up on an additional hard drive daily, and to a CD twice per week. Backup CDs will be retained for 10 years. Additionally, an incremental tape backup will be performed daily, and a complete tape backup generated weekly. Tape backups will be retained for three months. Paper records will be retained three years.

UCCE will maintain hard copies of all records for three years. All computer files and records will be stored on a desk top personal computer, which is a Dell Dimension 8200.

GROUP C: Assessment and Oversight

20. Assessments & Response Actions

Project activities such as field techniques, laboratory procedures, and data management will be assessed as follows:

- UCCE will oversee all fieldwork, field training, and ensure that field equipment is inspected and calibrated as scheduled.
- Each event will be assigned an appropriate person responsible for assuring that procedures are followed and that data is accurately recorded.
- The respective laboratory managers will oversee laboratory analysis, training and are also responsible for ensuring that calibrations of laboratory equipment are performed as scheduled when and where applicable.
- Quality control exercises will be conducted as previously described in Section 14.
- Following each sampling event, a quality control checklist will be followed to keep track of when tasks are completed (Appendix C). If problems are detected, such as failure to meet accuracy and precision objectives, immediate action will be taken (see below).

Any problem encountered during assessment may lead to the following responses:

- Equipment calibration prior to scheduled date
- Equipment repair
- Supplemental training for field personnel
- Consultation with project subcontractors
- Re-evaluation of methods

21. Reports to Management

Progress reports will be submitted to the CCRWQCB Contract Manager, Amanda Bern, by project manager, Michael Cahn when the project is 50% complete on Oct 1, 2007 and when 100% complete on Sept 31, 2008. Reports will include descriptions of activities undertaken, accomplishments of milestones, any problems encountered in the performance of the work, and delivery of any intermediate products.

The final report will be submitted to the Contract Manager via one reproducible master and two hardcopies of the final report by 9/31/2008. An electronic (PDF and CD) copy will also be provided. Once the final report is approved, it will be published on the UCCE, Monterey County web site.

GROUP D: DATA VALIDATION AND USABILITY

22. Data Review, Verification, and Validation Requirements

UCCE will evaluate data according to the DQOs. Data that fail to meet these criteria will be placed in two categories and be handled in the following fashions:

1. Fails precision or recovery criteria: These data will be evaluated in relation to other checks to determine the cause. If the data are laboratory errors (handling or analytical), they will be discarded or re-run if matrix (e.g. soil) is still available.

2. Fails to meet accuracy criteria: Data that fail to meet accuracy will be flagged and evaluated in the context of the entire project. Determine the source of the failure will determine the final outcome of the data use. If the analytic results are laboratory error and samples are still available, they will be re-run. If sampling handling is in question (mislabels) and cannot be corrected results will be discarded.

Data meeting all applied data quality objectives, but with incomplete QA/QC practices will be set aside until it can be determined if the data quality has been compromised.

When data does not meet all DQOs they will be used with caution in the effectiveness evaluation and modeling effort. The use of any data with limitations that is deemed usable will be clearly identified and addressed in the final report.

23. Verification and Validation Methods

All data will be reviewed and verified in the following manner:

Field work & data entry

- Field books will be reviewed following each sampling run to make sure all samples were collected and information was accurately recorded.
- All excel entries will be compared to original field books.
- All runoff calculations will be double checked.

Review of the data storage

- All data soil, water volume and quality will be checked by comparing entries in the original field books to electronically stored data.
- Data will be checked by parameter to look for any gaps and outliers. Data will also be reviewed in graphic format.
- Any detected data errors will be flagged in the database, and categorized within the two categories discussed previously in Section 22.

Checking calibration records and DQOs

- Calibration records will be reviewed at appropriate intervals to ensure equipment is currently calibrated before data collection.
- Percent completeness, accuracy, and precision will be calculated and compared to original objectives listed in Section 7.

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24. RECONCILIATION WITH USER REQUIREMENTS

The project's objectives are to determine the extent that polyacrylamide can improve water quality. Using runoff water quality and quantity measurements, we will attempt to determine whether or not water quality has been improved using experimental designs that will be analyzed using conventional statistical tests (e.g. analysis of variance).

The project will conduct replicated field trials in agricultural fields to determine if polyacrylamide added to the irrigation water improved the quality of run-off and reduced the quantity. The experimental design will follow a randomized complete block design with 3 or more replications. The experimental design will be sufficient to test the hypothesis that the management practice reduced run-off and/or reduce nutrient and sediment load in the run-off. Analysis of variance will be used to determine if treatment means are statistically significant. The experimental design will be sufficient to detect differences of 20% or more among treatments. Large differences among treatments are of interest to growers, which would indicate that a tested management practice is highly effective in controlling run-off and improving water quality.

Results of these trials are specific for the soil type, slope, and previous management practices (deep tillage) of the experimental site. The results will indicate if the management practices significantly improve water quality and reduce irrigation run-off. However, the results should not be used to extrapolate the percent reduction in run-off and nutrient loss to locations outside of the experimental site. Background data, such as intensity of precipitation, slope, soil type, will help in interpreting conditions under which the tested practices are most effective.

Appendix A. Curriculum Vita from key participates.

MICHAEL D. CAHN
Water Resources and Irrigation Advisor
University of California, Cooperative Extension
1432 Abbott St
Salinas, CA 93901
831-759-7377, mdcahn@ucdavis.edu

EXPERIENCE
1995-present University of California, Cooperative Extension
1991-1995 University of Illinois, Agricultural Engineering Department
Post-Doctoral Research Associate

EDUCATION
B.S. Soil and Water Science, University of California, Davis,1985
M.S. Agronomy-Soil Science, Cornell University, 1988
Ph.D. Agronomy-Soil Science, Cornell University, 1991

Areas of Specialization

Irrigation management, water quality, salinity, drip irrigation, fertility management of vegetables.

Recent Peer-Reviewed Publications

C.C. Shock, A.B. Pereira, B.R. Hanson, and M.D. Cahn. 2007. Vegetable irrigation. Eds. R.J. Lanscano and R.E. Sojka. Irrigation of agricultural crops, 2nd Edition. ASA CSSA-SSSA Madison WI. pp. 535-606.

P.R. Johnstone, T.K. Hartz, M. D. Cahn. M.S. Johnstone. 2005. Lettuce response to phosphorus fertilization in high phosphorus soils. HortScience 40(5) 1499-1503.

Platts, B.E., M.D. Cahn, R.B. Holden, and M.G. Malanka. 2004. Effects of recycled water on soil salinity levels for cool season vegetables. Ed. R.L. Snyder. Proceedings of the 4th International Symposium on Irrigation of Horticultural Crops. Acta. Hort. 664: 561- 566.

Cahn, M.D. , E.V. Herrero, B.R. Hanson, T.K. Hartz, and E.M. Miyao. 2004. Late-season water management effects on quality and yield of processing tomatoes. Ed. R.L. Snyder. Proceedings of the 4th International Symposium on Irrigation of Horticultural Crops. Acta. Hort. 664: 111- 118.

Madden, N.M., J.P. Mitchell, W.T. Lanini, M.D. Cahn, E.V. Herrero, S. Park, S.R. Temple, and M. Van Horn. 2004. Evaluation of conservation tillage and cover crop systems for organic processing tomato production. HortTech. 14(2): 243-250.

Cahn, M. D., E.V. Herrero, B.R. Hanson, R.L. Snyder, T.K. Hartz, and G. Miyao. 2003. Effects of irrigation cut-off on processing tomato fruit quality. Eds. B. Bieche and X. Branthome: Proceedings of the 8th international ISHS symposium on the processing tomato. Acta Hort. 613: 75-80.

Krusekopf, H.H., J.P. Mitchell, T.K. Hartz, D. M. May, E.M. Miyao, and M.D. Cahn. 2002. Pre-sidedress soil nitrate testing identifies processing tomato fields not requiring sidedress N fertilizer. HortSci. 37(3): 520-524.

Krusekopf, H.H., J.P. Mitchell, T.K. Hartz, D. M. May, E.M. Miyao, and M.D. Cahn. 2001. Pre-sidedress soil nitrate testing to determine yield response to fertilizer applications in processing tomatoes. Proceedings of the 7th international symposium on the processing tomato. Acta Hort. 542: 135-142.

Cahn, M. D., E.V. Herrero, R. L. Snyder, and B.R. Hanson. 2001. Water management of strategies for improving fruit quality of drip-irrigated processing tomatoes. Ed. T. K. Hartz: Proc. 7th Int. Symp. on Processing Tomato. Acta Hort. 542:111-116.

Training Record Sheet

Technique	Trainee (print)	Trainee (signature)	Trainer (print)	Trainer (signature)	Date
Lab Safety Training					
Field Safety Training					
Equipment maintenance					
CIMIS Eto data management					
Soil nitrate analysis					
Irrigation Efficiency					
Runoff Volume					
Runoff WQ					
Soil Sampling					
Water Sample Preservation					
Other:					

Appendix C: QA/QC Checklist

PGE Non-Point Source Funds Grant for North Monterey County					
Sampling Date					
Location					
Sample types:					
	Tasks	Y/N	Initials	Date	Notes
Field Tasks	Check runoff sampling pump for proper functioning				
	Water quality sample field duplicates (5% of the samples)				
	Field samples properly cooled and transported				
Lab Tasks	Samples properly preserved and holding times observed				
	Analysis passed standards, spike, field duplicate and laboratory replicate requirements				
Date Processing	Data entry of field work				
	Data entry of laboratory work				
	Data cross checked				
	Runoff calculations checked				
	Flag and categorize data anomalies or errors				
Other Comments:					

Appendix D: QA/QC Calibration Record Data Sheet

PGE Non-Point Source Funds Grant for North Monterey County

TEMPERATURE METER MAKE/MODEL ______________ S/N________________ THERMISTER S/N _________ _________ THERMOMETER ID. _______________

Lab Tested against NIST Thermometer/Thermister? Yes ☐ No ☐ DATE ___ ___/___ ___/___ ___ ___ ___ ±__________________ °C

Measurement Location: FLOW-THRU CHAMBER SINGLE POINT AT ___________________ft BLW LSD VERTICAL AVG. OF _________ POINTS

---

pH METER MAKE/MODEL ________________ S/N _______________________ Electrode No. __________________________ Type: GEL LIQUID OTHER ________________

Sample: FILTERED UNFILTERED FLOW-THRU CHAMBER SINGLE POINT AT___________ FT B/W LSD VERTICAL AVG. OF___________POINTS

pH BUFFER	BUFFER TEMP	THEO-RETICAL pH FROM TABLE	pH BEFORE ADJ.	pH AFTER ADJ.	SLOPE	MILLI-VOLTS

TEMPERATURE CORRECTION FACTORS FOR BUFFERS APPLIED? YES ☐ NO ☐

BUFFER LOT NUMBERS: pH 7: ___________________________

pH _____: ___________________________

CHECK pH _____: ___________________________

BUFFER EXPIRATION DATES: pH 7: ____/___________________

pH____: ____/___________________

CHECK pH____: ____/___________________

SPECIFIC CONDUCTANCE Meter Make/Model ______________________ S/N _____________________ Sensor Type: DIP CUP FLOW-THRU OTHER _______________

Sample: FLOW-THRU CHAMBER SINGLE POINT AT _______________ ft BLW LSD VERTICAL AVG. OF ____________ POINTS

STD VALUE µS/cm	STD TEMP	SC BEFORE ADJ.	SC AFTER ADJ.	STD LOT NO.	STD EXPIRA-TION DATE

AUTO TEMP COMPENSATED METER ____________

MANUAL TEMP COMPENSATED METER _________

CORRECTION FACTOR APPLIED? YES ☐ NO ☐

CORRECTION FACTOR = ______________

Appendix E : UC DANR Laboratory Work Request Form (Example)

DANR ANALYTICAL LAB
Cooperative Extension
Hoagland Annex
University of California
One Shields Avenue
Davis, CA 95616-8627
Phone: 530-752-0147
Fax: 530-752-9892
e-mail: danranlab@ucdavis.edu

DANR ANALYTICAL LAB
Work Request

Client:
Client ID:
Phone:
E-Mail:

Lab Use Only (Rev 1/1/02)
Work Request # 03 5146
Date Received SEP 23 2002
Date Logged In SEP 23 2002
KC 15586 to JS 15602
Extr Frz Bag Wet Air
Dry Transfer Grd Regrind
Hot Warm Room Temp
Cool Cold Slushy Frozen
☐ Special Handling AC

Copy To:
Phone:
E-Mail:

If changes are made to this information, indicate if the change is ☐ *permanent or* ☐ *one time*

BILLING ACCOUNT #:

SAMPLE INFORMATION: *(Number each sample container consecutively beginning with #1.)* **# of Samples** *(100 max)* 17

Date Sampled: 9/99 Commodity (Type of Crop):

Type of Material: Soil Grower/Location: Project Title:

SAMPLE DESCRIPTIONS: ☐ No ☒ Yes: *E-mail an attachment (Excel 97 or earlier, or text file). One column only. Report displays only the first 7 characters.*

SAMPLE DISPOSITION: *Select one option. (If no option is selected, the samples and containers will be discarded 30 days from the report date.)*

☐ **DISCARD** my materials 30 days from the report date.
☒ **RETURN my materials** (My UPS third party authorization number is ______________)
☐ My materials will be **PICKED UP** after the report has been reviewed, (not later than 30 days from report date.) Contact for pick up: ☐ Client ☐ Copy To

SAMPLE PREPARATION: ☐ **GRIND MY SAMPLES.** I understand there is an additional per sample charge for this service.

NOTES *(including any missing samples):*

ANALYSES REQUESTED. Circle or mark the check box to indicate requested analyses.

SOIL TESTS (Is your sample imported? ☒ No ☐ Yes----If yes, attach a copy of the USDA permit and our questionnaire to this Work Request)

FERTILITY: N C TKN NO_3-N NH_4-N Bray-P Olsen-P SO_4-S Zn Mn Fe Cu X-K X-Na X-Ca X-Mg

SAT PASTE EXT: SP pH EC SAR ESP Ca Mg Na Cl B K HCO_3 CO_3 SO_4S

PHYSIO CHEM: CEC OM $CaCO_3$ LiR BD Moisture Retention: (1/3 1 5 10 15 atm)

TOTALS: Zn Mn Fe Cu Cd Cr Pb Ni Se

GROUP TESTS:
☐ **Soil Salinity** [SP, pH, EC,Ca, Mg, Na, Cl, Bicarbonate, Carbonate]
☐ **Extractable Micronutrients** [DTPA: Zn, Mn, Cu, Fe]
☐ **Exchangeable Cations** [X-K, X-Na, X-Ca, X-Mg]
☐ **Particle Size Analysis** [Sand/Silt/Clay]
☐ **Total Nitrogen & Carbon** [N, C]
☐ **Nitrate and Ammonium** [NO_3-N, NH_4-N]
☐ **Soil Fertility** [NO_3-N, Olsen-P, X-K]
☐ **Total Micronutrients** [Total: Zn, Mn,Cu, Fe]

PLANT TESTS

C N P K S B Ca Mg Na Cl Zn Mn Fe Cu Se Si
NO_3-N NH_4-N PO_4-P SO_4-S Al As Ba Cd Cr Co Pb Hg Mo Ni V

GROUP TESTS:
☐ **Nutrient Panel A** [N, P, K]
☐ **Nutrient Panel B** [P, S, B, Ca, Mg]
☐ **Nutrient Panel C** [Zn, Mn, Fe, Cu]
☐ **Total Nitrogen & Carbon** [N, C]
☐ **Nitrate & Ammonia** [NO_3-N, NH_4-N]
☐ **Extractable N-P-K** [NO_3-N, NH_4-N, PO_4-P, K]

FEED TESTS Protein ADF @ 3% ADF @ 8% DM TDN NDF Ash Lignin Starch Carb TNC

☐ **WATER TESTS** *or* ☐ **WASTE WATER TESTS** *(indicate which sample type)* *(a special handling charge may apply)*

pH EC TKN NO_3-N NH_4-N SO_4-S SAR ESP Hardness HCO_3 CO_3 TDS TS TSS Alkalinity

SOLUBLES: P K Ca Mg Na Cl B Zn Mn Fe Cu

TOTALS: P K S Ca Mg Na B Zn Mn Fe Cu Al Cd Cr Pb Mo Ni Se Si

GROUP TESTS:
☐ **Water Suitability** [pH, EC, SAR, Ca, Mg, Na, Cl, B, Bicarbonate, Carbonate]
☐ **Bicarbonate & Carbonate** [HCO_3, CO_3]
☐ **Soluble Salts** [K, Ca, Mg, Na]
☐ **Soluble Micronutrients** [Zn, Mn, Cu, Fe]

OTHER ANALYSES REQUESTED (specify):
IF NECESSARY, IDENTIFY SAMPLE TYPE:

Work Authorized By: ______________________ ☒ Mail or Shipping Company ☐ Hand Delivered By: ______________________
Signature (Required) of Client / Responsible Party Date Signature Date

* sent new WR 9/25/02

Appendix E: UC DANR Data Report Example

SUBMITTED BY:	example only		WORK REQ #:	
DANR SECTION:	UCCE	http://danranlab.uca	# OF SAMPLES:	24
COPY TO:			DATE RECEIVED:	09/23/04
COMMODITY:			DATE REPORTED:	10/26/04
DRY MATTER:	Results not corrected for moisture content.		DANR CLIENT #:	
				24

Sample Type: SOIL   Date Sampled: 1995, 1999;

SAMPLE #	DESC	X-K [SOP 360] ppm	X-K [SOP 360] meq/100g							
1	FA A1 99	1148	2.9							
1 dup	FA A1 99	1157	3.0							
2	FA A6 99	1000	2.6							
3	FA A8 99	980	2.5							
4	FA B3 99	810	2.1							
5	FA C1 99	822	2.1							
6	FA C4 99	691	1.8							
7	FA C5 99	732	1.9							
8	FA C8 99	661	1.7							
9	FA D6 99	668	1.7							
10	FA E2 99	737	1.9							
10 dup	FA E2 99	730	1.9							
11	FA E4 99	659	1.7							
12	FA E8 99	628	1.6							
13	FD A2 95	572	1.5							
14	FD A4 95	376	1.0							
15	FD A6 95	372	1.0							
16	FD A8 95	288	0.7							
17	FD B3 95	398	1.0							
18	FD B4 95	401	1.0							
19	FD B5 95	406	1.0							
20	FD B6 95	436	1.1							
20 dup	FD B6 95	422	1.1							
21	FD B8 95	323	0.8							
22	FD C3 95	439	1.1							
23	FD C5 95	480	1.2							
24	FD C7 95	338	0.9							
24 dup	FD C7 95	344	0.9							

Method Detection Limit:	1	0.1							
Blank Concentration:	0	0.0							
Standard Ref as Tested:	1036	2.7							
Standard Ref Acceptable:	1053±80	2.7±0.2							
Standard Reference:	NORD	NORD							

NOTE: The SOP # (Standard Operating Procedure number) is a reference to the laboratory method used.
The SOP heading in this Excel file is linked to the method summary on the Laboratory website.

NOTE: No result within this report is accurate to more than 3 significant figures. More figures may be present due to software roundin

Checked and Approved: *{electronically signed by Traci Francis}*
Traci Francis, Laboratory Supervisor

Reviewed and Approved: *{electronically signed by Dirk Holstege}*
Dirk Holstege, Director

Please address questions regarding these results to Lab Director Dirk Holstege at (530) 752-0148 or dr

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