Third Quarterly Progress Report

of

BENTONITE SEALING INVESTIGATIONS

For the Period

of

August 1, 1960 to November 1, 1960

by

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Prepared for the

Southeastern Colorado Water Conservancy District

and the

Colorado Water Conservation Board

Colorado State University Experiment Station
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INTRODUCTION

This report contains several condensed but detailed tabulations of information, which at this early stage in the resource-evaluation and application-research-and-development work are of a tentative incomplete nature[1]. Widespread interest in the work and numerous inquiries for information make it desirable to present a fairly detailed summary of work at this time. Common questions include:

1. Procedure--what are the best procedures for canal or reservoir sealing work with local clays?

2. Quality--what are the specifications for a clay, satisfactory for sealing purposes?

3. Results--what results have been produced in the field trials with local clays?

As a partial answer to the above questions, consider the information compiled by the early efforts of the bentonite (or clay) sealing project at CSU, in cooperation with many irrigation organizations, individuals, and clay producers.

SAMPLING AND EVALUATION OF SAMPLES

Tables I and II summarize the results of the initial sampling and laboratory testing of bentonites or clays from locations as shown on Map I.

In the laboratory evaluation work, samples of clays are being tested that have been collected both (a) by CSU project people, and (b) by interested individuals or prospectors. We are especially encouraging the latter type of sampling and will be glad to furnish additional details of what to look for to any interested parties. An Extension Service circular, Testing Bentonite for Sealing Purposes (No. 205-A), is available at most County Agent offices in Colorado (and in Wyoming as well--Circular No. 161).

The test procedures used in the laboratory evaluation work have involved existing procedures to the maximum extent possible, but in order to fully characterize and evaluate the clays or bentonites from a canal and reservoir sealing standpoint, the development of new test procedures, including major modification of existing procedures, has been necessary. A brief description of the test procedures used in the evaluations to date is included at the bottom of Table I. More complete details of the test procedures can be obtained, if desired, by writing to us.

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[1]Tentative in a sense that the work is in its beginning stages--having been fully funded starting July 1, 1960.

Testing with procedures, in addition to those outlined in Table I, is planned and will be completed as time permits.

EVALUATION OF FIELD TRIALS

Table III summarizes briefly the results of the evaluations, to date, of field trials at locations as shown on Map 2.

While the table is essentially self-explanatory, it is very brief (perhaps even fragmentary). Detailed records are being compiled on each of the jobs included in the table. Thus, if additional information relating to any particular trial is desired, or if you have additional information to supply for any trial, please write us.

Additional evaluations are planned, both for the trials in the present table and for new trials or other trials not included in this summary.

DISCUSSION OF RESULTS AND FUTURE PLANS

As mentioned in the two preceding quarterly reports, the objectives of the CSU bentonite project are (a) to inventory the clay resource of Colorado, and (b) to develop methods of utilizing the local clays in sealing canals and reservoirs in Colorado. Thus, the two important justifications for this State-funded work relate to (a) development of new mineral industry, and (b) conservation of water. Thus, while the market potential aspects are not involved directly in many research studies, they are definitely involved in this inventory, research and development project -- organization of the bentonite project work clearly reflects this influence.

Clay inventory--with the valuable assistance of many cooperators (individuals, companies, districts), the initial sampling efforts by the CSU project have revealed a good range of available clay (bentonite?) deposits (See Map I). As a result of this, we are convinced (a) that a significant potential of clay deposits is available for development in Colorado, and (b) that the initial sampling efforts as outlined in this report have covered only a small fraction of the total potential. Because of the magnitude of the clay resource inventory work remaining to be completed, plans are being made for continuing this work by the CSU Geology Department in the next fiscal year--provided funding is available. The field work is planned for the summer and the clay mineral identification (including X-ray and D-T analyses) for the winter. Chemical testing of the better clay samples by the CSU Soils Department is also planned.

TABLE I: SUMMARY OF TEST RESULTS (PART I) FROM INITIAL LABORATORY EVALUATIONS OF COLORADO CLAY SAMPLES

Sample No.	Name and Location	Colloidal Yield			Grit Content			Filter Loss Test (ml/min)[2]			Filter Cake Stability			Mixability Index				Swell Index (%)			
		0-45%	45-65%	Over 65%	Over 10%	10-5%	Under 5%	0-10	10-50	Over 50	Poor	Fair	Good	0-25	25-50	50-75	75-100	0-50	50-100	100-150	Over 150
S28-1	Fox-Dilley-- N. of Canon City	39.5				8.8		5.1					x				77.5		97.8		
S28-2	Fox-Dilley-- N. of Canon City	39.6				7.9		4.8					x		34.9				88.0		
S31-1	Wyble-- N. of Wellington		57.7				1.8	8.6				x			32.8					108.0	
S31A-3	Wyble-- Near Creede	36.2					3.0	5.3					x		32.5				78.0		
S33-1	Monroe-- N. of Ft. Collins			73.3			3.1			189.0	x						82.7			143.0	
S33-2	Monroe-- N. of Ft. Collins			78.2			2.0	9.9				x			47.1						162.8
S36-4	Schrader-- N. of Ft. Morgan		52.3				1.7		26.7		x				47.0					132.0	
S36-5	Schrader-- N. of Ft. Morgan		57.6			5.5			44.3		x						77.9		99.0		
S37-2	Strainland-- N. of Golden		56.2		12.8[1] 41.4				15.5			x		12.3				30.0			
S37-5	Marshall-- N. of Golden		50.0				1.8		23.7		x					68.7		50.0			
S42-1	Rump-- SW of Grand Junction		47.2			9.4		1.5					x	14.7							170.5
S43-1	Burton-Tuttle-- W. of Aspen	36.0				7.0			17.1			x			46.9				55.0		
S44-4	Butterfield-- S. of Las Animas			66.1			1.8	1.2					x	8.5							253.0
S45-1	Wagner-- Near Las Animas		55.6			7.9			10.3			x			38.2					130.0	
S47-1	Moss-- Near Westcliffe	24.3			12.2[1] 35.8				40.1		x						78.0	25.0			
S48-1	Mumma-- W. of Salida	30.6			11.1		2.4[1]	4.3					x				89.7			110.0	
S49-3	Lamberg-- SE of Salida	35.6				6.7		2.6				x					77.7		90.0		
S52-1	Warren-- N. of Ft. Collins			67.7			3.7			172.0	x				36.4				60.0		
S52-18	Warren-- N. of Ft. Collins		56.8				2.2			162.2	x						98.9		75.0		
S53-1	White Rose-- Near Carr		47.5				0.9			129.3	x				30.0			30.0			
S54-1	Brick Plant-- S. of Ft. Collins	35.5					0.8		45.9		x			21.4				30.0			
S55-1	Clover Basin-- SW of Longmont	29.9					0.8			52.0	x			19.4				46.0			
S56-1	Cox-- NE of Morrison	26.4				5.4			31.7		x			13.2				10.0			
S60-4	Welte-- N. of Colorado Springs	37.3					3.5			97.0	x					62.1		30.0			
S62-1	Wisenhunt-- Near Castle Rock		52.4				2.1		12.3			x		12.6				40.0			
S62-2	Wisenhunt-- Near Castle Rock	43.1				5.2			10.4			x		10.9				20.0			
S63-1	Last Chance-- SW of Akron	41.9					1.7		19.7			x		24.3					57.8		
S64-1	Harvey-- W. of Canon City	44.4			18.8					304.0	x				38.1			40.0			
S67-2	Bennett-- N. of Golden		49.5				0.2	6.8					x	16.8				40.0			
S68-1	Lindsey-- N. of Golden	33.4					2.8	5.7					x			66.7		30.0			
S71-1	Highway 63-- N. of Akron	34.3			16.4				42.5		x				25.7			25.0			
S72-1	Peach Valley-- E. of Delta		60.8			7.3			15.1			x			46.1					132	
S73-2	Mahan-- Near (?) Pueblo	31.7					3.2		32.5		x						82.4	50.0			
S74-1 and 2	Schrader-- N. of Ft. Morgan	36.2					1.1			112.3		x			32.7				70.0		
S00-5	Wyoming bentonite			86.8			2.8	0.9					x								627

[1]With extra washing

Compiled by R. W. Hansen and C. C. Smith

Supplemental Procedure Notes

Sample Preparation--All samples are registered for identification, oven-dried at 100°C, and a test portion crushed to pass a U.S. No. 8 sieve.

Colloidal Yield--is the percent of sample that will remain suspended or dispersed in water after 24 hours. A high yield normally means a high clay content, and usually a high sealing potential.

Grit Content--is the percent of sample left on a U.S. No. 200 seive after washing. A low percentage of grit is desired for most sealing applications.

Filter Loss--is the loss* in ml./min when 400 ml. of a 2% mixture of bentonite in water is placed in a pressure cell, subjected to an air pressure (equal to 34' of water), and filtered through a standard filter paper. A low rate of loss is desired.

Filter Cake Stability--is obtained by subjecting the clay coating left on the filter paper from the Filter Loss test to a small jet of water. This gives an approximate idea of the resistance to erosion of the clay sediment.

Mixability Index--is obtained by dividing the weight of sample lost (after a standard washing test) by the original weight. A high index indicates easy mixing.

Swell Index--is obtained by measuring the increase in volume when a dry sample of known bulk volume is saturated or completely wetted. Some swell is desirable but not too much.

*For comparison note that a:
1/8-inch layer of -40 Ottawa sand had a seepage rate equal to 1440 ml./min
1/8-inch layer of local sandy soil had a seepage rate equal to 1003 ml./min
Filter paper alone had a seepage rate equal to 651 ml./min

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TABLE II[1]: SUMMARY OF TEST RESULTS (PART II) FROM INITIAL LABORATORY EVALUATIONS OF COLORADO CLAY SAMPLES

Sample No.	Name and Location	Colloidal Yield				Grit Content		
		Under 25%	25-45%	45-65%	Over 65%	Over 10%	10-5%	Under 5%
S14-1[2]	Fisher--Near Granby			56.4		19.1		
S14-2	Morris--Near Granby		43.0			26.5		
S16-1	Rump--Near Grand Junction			53.8				2.7
S16-2A	Upper Pond's--Near Grand Junction		40.7				9.2	
S16-2B	Lower Pond's--Near Grand Junction			47.6			6.7	
S16-3	Lime Kiln--Near Grand Junction		36.0				7.7	
S16-4	Smith (lower)--Near Grand Junction		33.9				9.7	
S16-5	Smith (upper)--Near Grand Junction				65.3			1.1
S16A-1	Wells (25-30)--Near Fruita		43.2				5.6	
S16A-2	Wells (4)--Near Fruita		26.1				8.3	
S16A-3	Wells (15)--Near Fruita		38.3				6.7	
S16A-4	Wells (25)--Near Fruita		31.9				6.1	
S16A-5	Wells (15)--Near Fruita		39.3				8.0	
S16A-6	Wells (10)--Near Fruita		35.5				5.9	
S17-1	Foster--Near Durango	22.7				22.8		
S19-1	Winder--Near Craig	18.3				14.8		
S21-1	Lost Canyon--Near Gunnison	20.1				34.2		
S22-1	Strafford--Near (?) Grand Junction		25.7					0.5
S23-1	Schrader--Near (?) Fort Collins	18.5						2.6
S24-1	Flora--Near (?) Durango		32.6				6.6	
S24-2	Flora--Near (?) Durango			59.4				0.7
S25-1	Dilley--N. of Canon City	17.8					8.9	
S25-2	Dilley--N. of Canon City		30.0				5.0	
S26-1	Brown--S. of Las Animas				81.8			3.2
S27-1	Johnson--Near Nathrop	8.8				very high		
S28-3[2]	Fox-Dilley--N. of Canon City		37.0				9.1	
S28-4	Fox-Dilley--N. of Canon City			49.3				2.0
S28-5	Fox-Dilley--N. of Canon City		30.2				5.8	
S28-6	Fox-Dilley--N. of Canon City		43.8				6.0	
S29-1	Pachek--Near Salida	24.7						1.8
S30-1	Hopkins--Near Center	24.9				39.3[3]		
S31-2	Wyble (Ash ?)--	Flocculated					8.2	
S32-1	Davidson--N. of Canon City		34.3				8.7	
S34-1	Kessler (Red)--Near Howard		26.1					0.9[3]
S34-2	Kessler (Pink)--Near Howard	22.9						0.8[3]
S34-3	Kessler (White)--Near Howard	20.2				28.4[3]		
S34-4	Kessler (Green)--Near Howard	14.2				51.4[3]		
S34-5	Kessler (Mailed)--Near Howard		27.7					2.6[3]
S34-6	Kessler (Mailed)--Near Howard	22.5						1.4[3]
S35-1	Embry--Near (?) Pueblo	7.0				49.9		
S36-1	Schrader (Pawnee) N. of Ft. Morgan			48.9				2.6
S36-2	Schrader (Pawnee) N. of Ft. Morgan		43.7					2.6
S36-3	Schrader (Pawnee) N. of Ft. Morgan			54.5				2.5
S37-1	Rocky Flats--N. of Golden	15.7				49.7		
S37-3	Plainview--N. of Golden	15.0					5.6	
S37-4	Rocky Flats--N. of Golden		28.6			12.5		
S38-1	Norton--Near LaPorte			62.2				0.2
S38-2	Norton--Near LaPorte			46.7				1.4
S39-1	Standley Lake--Near Arvada		25.4			17.8		
S39-2	Standley Lake--Near Arvada		39.7			14.3		
S40-1	Chapman (Mailed)--Near Pl Center	3.3				73.7		
S41-1	Smith--Near Fort Collins	16.8					9.3	
S44-1	Rodgers--S. of Las Animas			50.4			5.7	
S44-2	Rodgers--S. of Las Animas			53.4				4.6
S44-3	Stough--S. of Las Animas			48.0			7.4	
S44-5	School--S. of Las Animas			47.2				3.3
S46-1	McAlpin--Near Redwing		34.6			27.2		
S48-2	Mumma--W. of Salida	18.4				21.4		
S49-4	Lamberg--Near Howard			49.8		22.1		
S50-1	Skinner--Near Golden	7.6				34.6		
S51-1	Smith--E. of Fort Collins		25.6			31.4		
S52-2	Greenacre--N. of Fort Collins	20.7						1.6
S52-3	Warren--N. of Fort Collins	18.0					7.0	
S52-4	Warren--N. of Fort Collins		35.0			16.3		
S52-5	Warren--N. of Fort Collins	20.9						4.6
S52-6	Warren--N. of Fort Collins		31.8			38.7		
S52-7	Warren--N. of Fort Collins	13.6				56.7		
S52-8	Warren--N. of Fort Collins	8.7				77.7		
S52-9	Warren--N. of Fort Collins		33.0			17.5		
S52-10	Warren--N. of Fort Collins		31.1			24.6		
S52-11	Warren--N. of Fort Collins			63.2		15.6		
S52-12	Warren--N. of Fort Collins			60.1			8.3	
S52-13	Warren--N. of Fort Collins			48.3			7.4	
S52-14	Warren--N. of Fort Collins		32.0				8.6	
S52-15	Warren--N. of Fort Collins	9.8				46.9		
S52-16	Warren--N. of Fort Collins			55.4			9.7	
S52-17	Warren--N. of Fort Collins			51.6			9.3	
S53-2	Lone Tree Creek--Near Carr		36.0				8.7	
S57-1	Robinson--Near Payton	10.8				22.4		
S58-1	Robinson--Near Calhan		29.8			25.1		
S58-2	Robinson--Near Calhan		35.8			25.3		
S59-1	Wands--Near Pueblo	11.3				67.2		
S59-2	Wands--Near Pueblo		27.6			27.0		
S60-1	Welte--N. of Colorado Springs		26.3				9.4	
S60-2	Welte--N. of Colorado Springs		33.2					5.0
S60-3	Welte--N. of Colorado Springs		31.3				6.5	
S61-1	Harris--Near Castle Rock	21.3				30.3		
S64-2	Harvey--Near Parkdale		28.7			18.0		
S64-3	Harvey--Near Parkdale	23.9					8.4	
S65-1	Harris--Near Kiowa		26.6			18.9		
S66-1	Pallaoro--Near Morrison	24.2				41.7		
S67-1	Bennetts--N. of Golden	6.4				82.1		
S69-1	Harris--Near Laporte	9.3				65.4		
S70-1	Yahn--Near Iliff	9.2				43.4		
S70-2	Yahn--Near Iliff	14.8				25.8		
S70-3	Yahn--Near Iliff	10.6				57.9		
S70-4	Bauer--Near Iliff		28.9			12.7		
S73-1	Bauer--Near Iliff	12.9				65.3		

Compiled by R. D. Dirmeyer, Jr., and C. C. Smith

1 See Table I for remaining test results in this same series.
2 Samples S14-1 through S27-1 tested prior to July 1960--S28-3 to S73-1 tested after July 1960
3 Required extra washing.

MAP I--LOCATION MAP OF CLAY OR BENTONITE SAMPLES

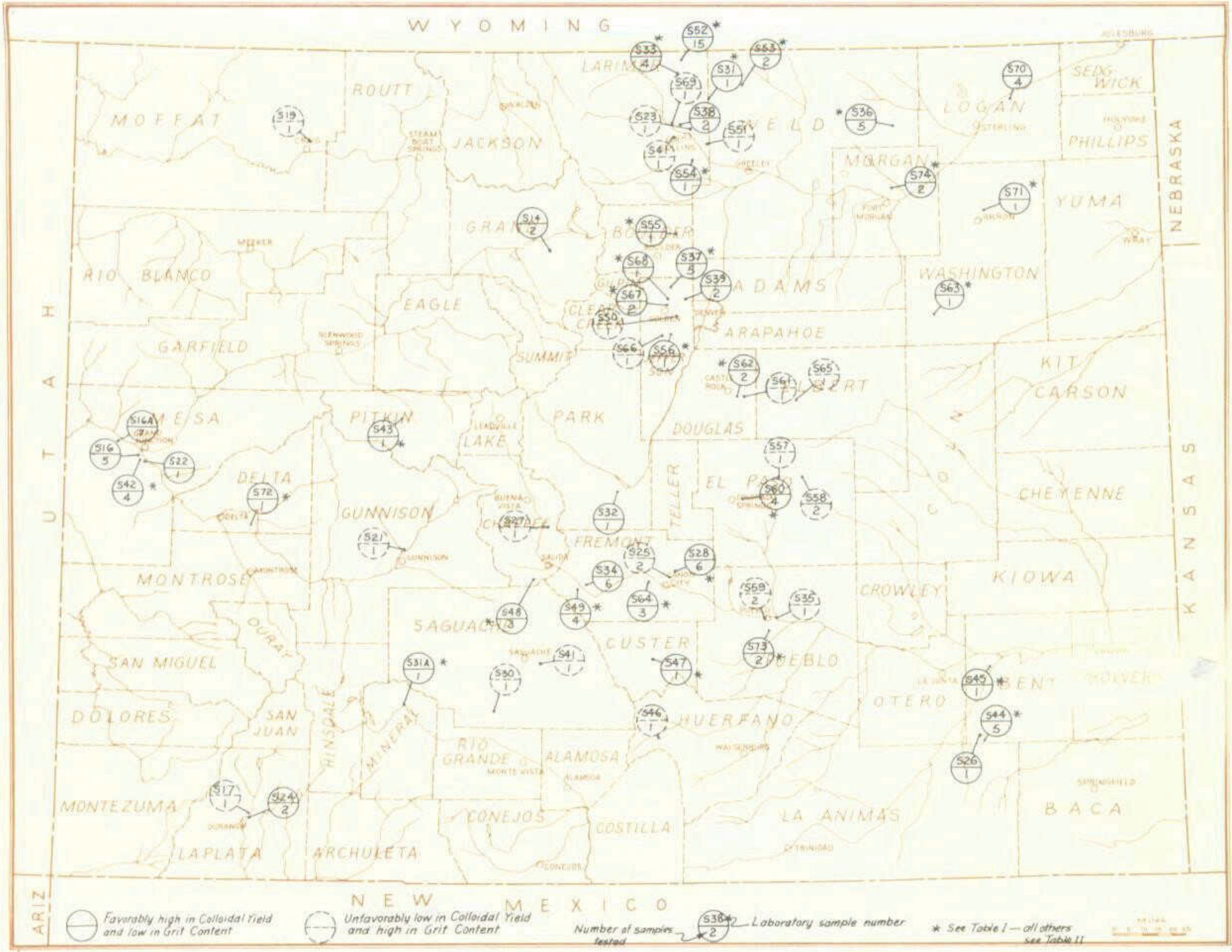

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TABLE III

SUMMARY OF PRELIMINARY RESULTS FROM FIELD TRIALS WITH COLORADO CLAYS

No.	Job Title Location	Capacity Grade	WP^1 L^2	Bed Material	Before[3] Losses	Install. Date Amt. of Bent.	Method of Application and Costs	Results
T1	Climax Canal No. 1 NE of Climax	100-20 cfs medium	9 ft 5700 ft	Rocky	*	* 91 ton (S-49)	*	*
T2	Wellington Lake Canal SE of Bailey	40-10 cfs medium	13 ft 3000 ft	Decomposed granite	20%-June (measured)	July 1960 36 ton (S-49)	Multiple dam - dump truck backed up ditch - 15 dams - $17.50/ton	Apparently very good - evaluation to be made in spring
T3	Cottonwood Creek Buena Vista	60 cfs-July steep	22 ft 16,000 ft	Cobbles and sand	(est.) 15%	July 1960 100 ton (S-49)	30-40-30 ton dams in upper part of creek - mix/crawler tractor	Bentonite dispersed and carried thru well - (est) 5% loss now
T4	Kelly Ditches S. of Buena Vista	2-8 cfs steep	4 ft 13,000 ft	Rocky	(est.) 25	June 1960 28 ton (S-49)	12-multiple dams placed and mixed/crawler tractor	Good - (est.) 5-10% loss after treatment - follow up in spring
T5	Saylor Seep Ditch S. of Buena Vista	2 cfs steep	4 ft 4000 ft	Rocky	100% Aug.	Sep. 1960 24 ton (S-49)	5-multiple dams--near upper end, placed and mix/front loader	Good, Sept., 1/4 cfs out of 1/3 cfs now getting thru to end of ditch
T6	Twin Silos Ditch W. of Buena Vista	4 cfs steep	3 ft 8000 ft	Rocky	(est.) 95%	June 1960 26 ton (S-49)	4-multiple dams--upper half, 1 load at head gate, $9/ton	Good, (est.) loss 5-10% after treatment
T7	Tegler Ditch W. of Buena Vista	10 cfs steep	4 ft 4000 ft	Rocky	(est.) 20%	Apr. 1960 4 ton (S-49)	Material placed in dams over upper half of ditch, $9/ton	Good, (est.) 5% loss after treatment
T8	Irwin Ditch W. of Buena Vista	10 cfs steep	4 ft 5000 ft	Rocky	(est.) 20%	Apr. 1960 6 ton (S-49)	Material placed in dams over upper half of ditch, $9/ton	Good, (est.) 0-5% loss after treatment
T9	Lee Diversion Ditch W. of Buena Vista	4 cfs steep	3 ft 3000 ft	Rocky	(est.) 50%	Apr. 1960 25 ton (S-49)	Bentonite sluiced in at 4 points over upper half	Good, (est.) 10% loss after treatment
T10	Esgar Ditch Buena Vista	2 cfs medium	3 ft 2600 ft	Rocky-gravel	(est.) 40%	June 1960 4 ton (S-49)	Majority sluiced into flow at upper end or upper half	Good, 10-15% loss (est.) after treatment
T11	Dry Creek Diversion SW of Buena Vista	2 cfs very steep	2 ft 8000 ft	Rocky	100%	July 1960 20 ton (S-49)	Bentonite dumped into flow at at upper end, $9/ton	Fair, 80% loss after treatment, additional bentoniting planned
T12	Pioneer Ditch SW of Nathrop	9 cfs steep	4 ft 4000 ft	Rocky	(est.) 40%	May 1960 42 ton (S-49)	Sluiced in at upper end and dams near mid-point of ditch	Good, (est.) 5-10% loss after treatment
T13	Branch of Post Ditch NW of Salida	5 cfs medium	8 ft 1300 ft	Rocky	(est.) 30%	June 1960 5 ton (S-49)	10-multiple dams, dispersion ponded with rock dams, $9/ton	(Est.) 5-10% loss after treatment, seep areas dried up below ditch
T14	Missouri Park Ditch NW of Salida	70-10 cfs medium	10 ft 34,000 ft	Rocky-gravel	100% loss of 10 cfs	Aug. 1959 203 ton (S-49)	27 multiple dams, upper 1-1/2 miles received 100 tons, $7/ton	Excellent installation, 1-1/2 cfs will carry thru 7 mile stretch
T15	Sunnyside Ditch N. of Salida	40-15 cfs medium	10 ft 3000 ft	Gravel-sandy	5-10 cfs (est.)	Apr. 1960 69 ton (S-49)	30 ton in multiple dams, 40 ton sluiced-head end, $9/ton	(Est.) stopped 75% of total seepage loss
T16	Pass Creek Diversion W. of Poncha Springs	6 cfs medium	4 ft 21,000 ft	Loose-rock shale	4 cfs in 1/2 mile	1948 24 ton (S-49)	Placed near head end, added where concentration decreases	14% loss of 4 cfs over 4 miles (measured)
T17	John Boyce Pond Maysville	1/2 AF - -	- - - -	Loose-sand gravel	(est.) 50% in 12 hrs	1957 1/4 ton (S-49)	Distributed and spread manually with shovel	Practically no seepage loss after treatment
T18	Everett Stock Pond N. of Salida	Stockwater pond	- - - -	Peat-gravel	100%	1959 1 ton (S-49)	Spread manually with shovel	Bentoniting developed enough water for 50 head of cattle
T19	O'Brien Diversion Ditch NW of Crestone	9 cfs steep	6 ft 19,000 ft	Rocky-sand gravel	4 cfs in 3/4 mile	Nov. 1959 136 ton (S-49)	35 multiple dams, 81 ton, 55 ton, head end $12/ton	Good results, 1 cfs out of 4 cfs will carry 3-1/2 miles now
T20	Shellabarger Ditch No. 1 NE of Moffat	10 cfs steep	6 ft 11,000 ft	Gravelly-sand	(est.) 30%	1959-1960 50 ton (S-49)	Multiple dams placed upper part of ditch (est.) $12/ton	Good results, 5-10% loss after treatment
T21	Coors Farm Lateral NE of Center	8 cfs 4 ft/mi	7 ft 3000 ft	Gravel sand	(est.) 10%	July 1959 * (S-49)	6 multiple dams and part sluiced in at head end	Good (est.) 3-4% loss after treatment
T22	Coors Farm Lateral NE of Center	7 cfs 4 ft/mi	7 ft 1300 ft	Gravel sand	Similar to T21 site	Aug. 1959 16 ton (S-49)	8 multiple dams; V-ditcher run thru several times to mix, spread	Good, extensive seep areas along ditch bank - dried up
T23	Arthur Benson Ditch NE of Del Norte	3 cfs medium	4 ft 1500 ft	Cobbles	(est.) 50%	Aug. 1960 13 ton (S-49)	Multiple dams, greatest amount near high loss area, $14.50/ton	Very good, (est.) 5-10% loss after treatment
T24	Showalter Pond S. of Poncha Pass	6-1/2 AF - -	- - - -	Shaley-gravel	(est.) 50% per day	1959-1960 117 ton (S-49)	2 lbs per sq ft, leveled with tractor and blade, $9/ton	Majority of seepage loss stopped
T25	Sangre De Cristo Pond Mosca	1/2 AF - -	- - - -	Sandy-loam	100% in 24 hrs	Oct. 1959 18 ton (S-49)	Spread, leveled manually compacted, rubber tire roller, $14.75/ton	Fair, 100% loss in approximately 1-month
T26	Sangre De Cristo Pond Hooper	1/3 AF - -	- - - -	Sandy-loam	100% in 10 hrs	Nov. 1959 15 ton (S-49)	Spread and leveled manually, no compaction	Poor, 100% loss in approx. 2-wks. re-treatment planned/compaction
T27	Parlin-Quartz Ditch N. of Parlin	32 cfs medium	9 ft 3000 ft	Sandy	*	Oct. 1959 37 ton (S-49)	8 multiple dams, additional mixing with crawler tractor	Seepage areas below ditch dried up or reduced
T28	Garden Park Ditch N. of Canyon City	9 cfs steep	4 ft 4000 ft	Rocky-sandy	(est.) 30%	May 1960 32 ton (S-28)	Majority of material dumped in near head of ditch	Good, (est.) 5-10% loss after, seep areas dried up below ditch
T29	Nelson-Culifer Ditch N. of Canyon City	2 cfs medium	3 ft 3000 ft	Rocky-sandy	(est.) 50%	May 1960 16 ton (S-28)	Multiple dams, mix manually with shovels	Good, (est.) 5-10% loss after treatment
T30	Fountain Mutual Ditch NE of Fountain	5 cfs medium	4 ft 6500 ft	Sandy	(est.) 20%	July 1960 ± 20 ton (S-28)	Bentonite added with front loader tractor near head end of ditch	Material dispersed into water readily--after losses not avail.
T31	Redlands 2nd Lift Ditch W. of Grand Junction	13 cfs flat	11 ft 2600 ft	Sandy-clay	17% for system	Mar. 1960 40 ton (S-42)	Material distributed 1/2" thick with truck and chute set-up	Fair, seepage reduced initially, some seepage beginning again
T32	East Mesa Ditch S. of Carbondale	28 cfs medium	15 ft 500 ft	Rocky	(est.) 3 cfs	Apr. 1960 60 ton (S-42)	Spread on bottom and bank, back-hoe mulched 6-8", compacted	Good, extensive seepage area below elevated section dried up
T33	Goodman Storage Pond SE of Howard	8 AF - -	- - - -	Rocky-gravel	2 ft drop in 24 hrs	Apr. 1960 160 ton (S-34)	Spread on bottom with tractor and blade	Loss reduced to 4-inch drop in 24 hrs
T34	Adamson Storage Pond SE of Howard	5 AF - -	- - - -	Cobbles-rocky	New pond	Apr. 1960 80 ton (S-34)	Spread on bottom with tractor and blade	Loss reduced to 4-inch drop in 24 hrs
T35	West Burlington Ext-Canal SW of Hudson	40-10 cfs flat	12 ft 50,000 ft	Sandy	35-70%	Sept. 1960 52 ton (S-37)	40 ton, head end; 6 ton below mid-point; 6 ton, near end	*
T36	Smith Farm Pond E. of Fort Collins	8 AF - -	- - - -	Clay-sand	1 ft drop in 24 hrs	Oct. 1960 120 ton (S-33)	Spread with front loader tractor, manually on bottom and sides ±1/2"	Installation not complete*
T37	Brace Pond No. 1 NW of Center	10 AF - -	- - - -	Gravelly	*	Jan. 1960 120 ton (S-40)	Material leveled with land leveler mulched with renovator - releveled	Fair, water surface drops approximately 1 ft in 10 days
T38	Brace Pond No. 2 NW of Center	12 AF - -	- - - -	Rocky	*	Jan. 1957 300 ton (S-40)	Material leveled with land leveler mulched with renovator, releveled	Fair, water surface drops approximately, 1 ft in 10 days

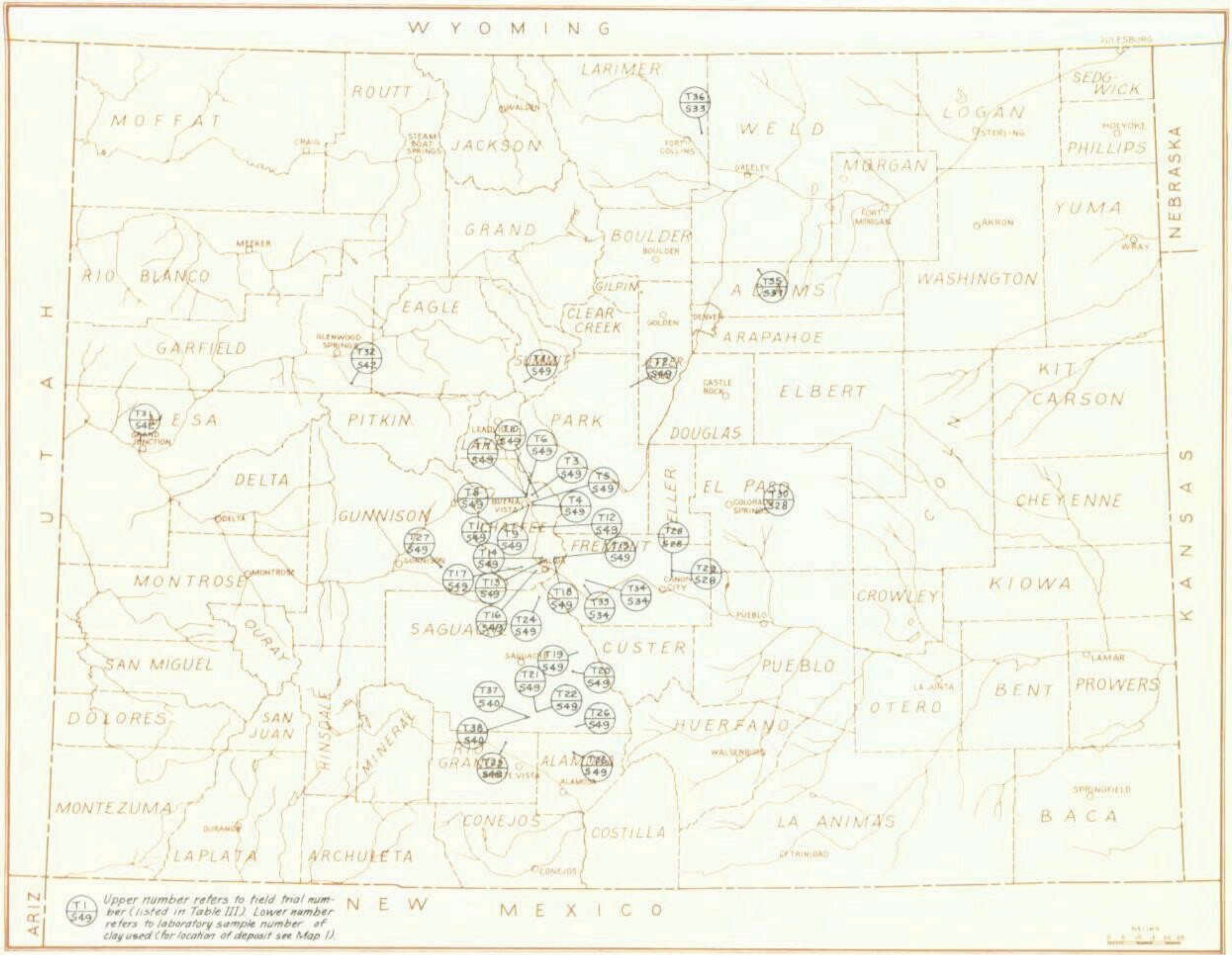
Compiled by M. M. Skinner

*Information not available at date of compilation

WP^1 (average wetted perimeter) x L^2 (length of treated section) x A (application for bentonite = total amount of bentonite required.

[3]Losses considered over length (L)

MAP II--LOCATION MAP OF CLAY SEALING TRIALS



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1023

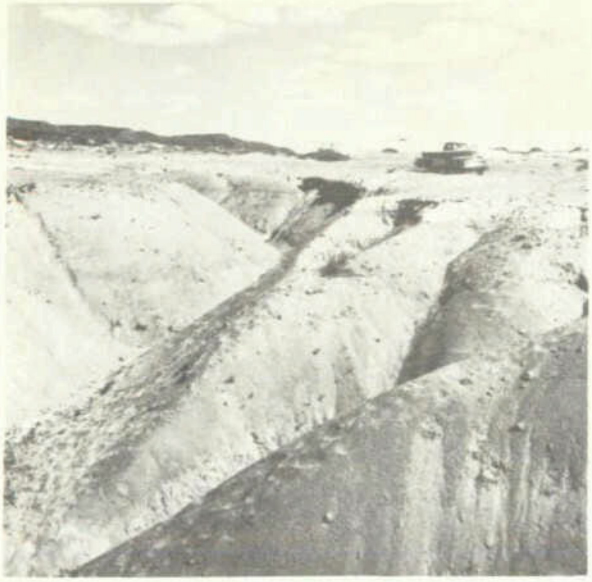

Photo 1--Potential clay deposit (S-52) north of Fort Collins, Colorado. Badland topography with little or no vegetation cover, typical of better bentonite outcrops.

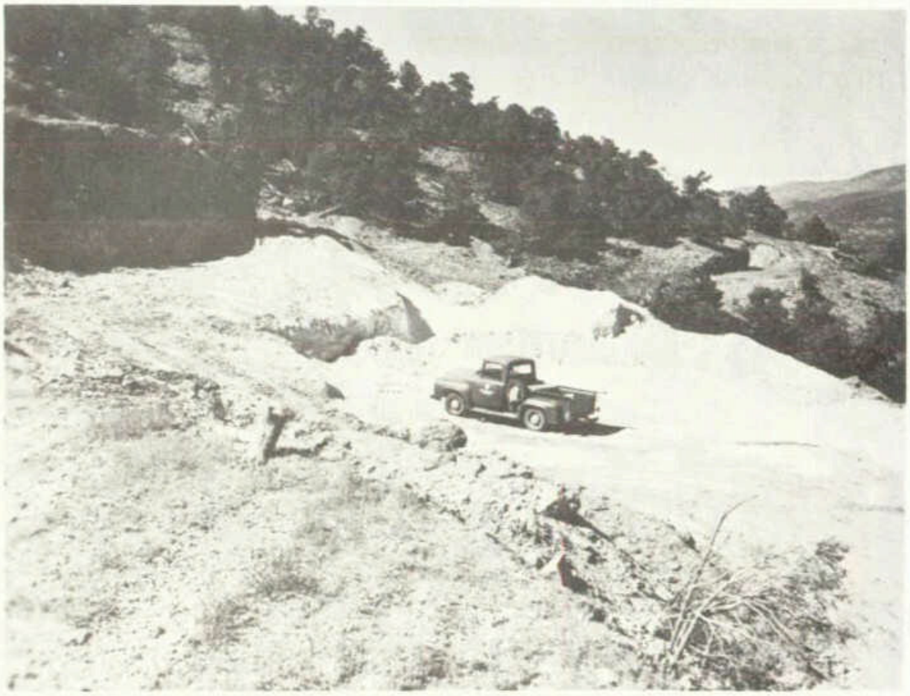

Photo 2--Developed clay deposit (S-49) near Howard, Colorado. Clay deposit has been stripped of overburden so that air-drying of clay can take place. In-place moisture content of clay or bentonite deposits has ranged as high as 50 percent; by air-drying in the pit this can be reduced to 15 to 30 percent.

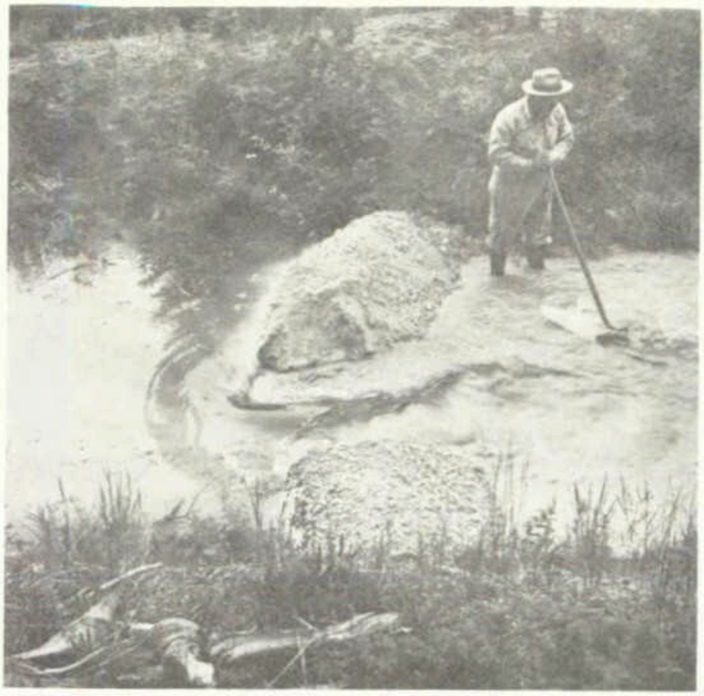

Photo 3--Most common method of application consists of placing dams of bentonite in dry canal, then running in small head of water and washing bentonite down canal.

Photo 4--The bentonite can be shovelled into the water as the dam is washed out, but in some cases, as above, a small bulldozer has been used.

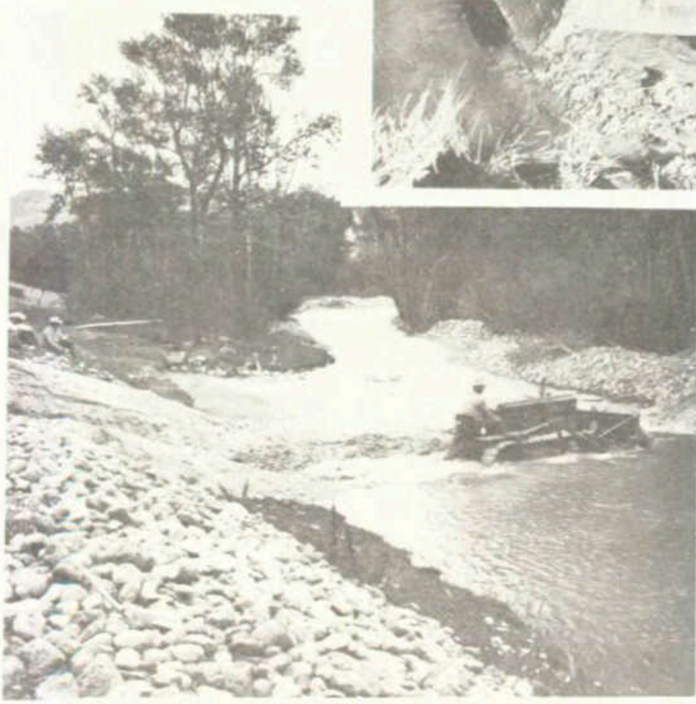

Photo 5--Several high loss natural channels have also been sealed by washing bentonite downstream with the water.

Photo 6--In several instances, the dams of bentonite have been spaced along a canal and then spread with a V-ditcher rather than with water.

Photo 7--Bentonite has been used for sealing small ponds or reservoirs. It is spread in a layer 1/2 to 2-inches thick over the pond area, worked into the sub-soil, and compacted, if possible.

Photo 8--In the evaluations carried out by the bentonite project, inflow-outflow measurements have been obtained when possible.

Laboratory evaluations--In addition to the laboratory identification work mentioned above, the clay samples are also being tested to determine their sealing potential (See Tables I and II). While general agreement has been noted between the laboratory test results and the field trial results (See Table III), some descrepancies have been found. Excellent materials from a lab test angle have produced poor sealing results in field trials. Conversely, clay materials rated poor in the laboratory have produced excellent field trial results. Undoubtedly, part of the problem is related to the need for better test procedures; thus, new and modified procedures are being developed. The general objective of the work is to develop simple economical lab test procedures that can be used for clay specification purposes. However, it is also obvious that the correlation problem between lab and field also reflects a need for improved field trial procedures.

Procedure development trials--As may be seen in Table III and Map II, the field trial phase of the procedure development work is well advanced for a relatively few clays in several restricted areas of the State. For example, consider the canal (multiple-dam) and reservoir (blanketing) work with the S49 clay in the area surrounding Salida. As time and funds become available, work in new areas of the State will be initiated. However, since the trial work is funded and organized at local level, it is important to realize that the presence or absence of trials in any particular area of the State depends largely on the local interest in initiating such work--from the standpoint of either or both (a) the owners of canals, and (b) the producers of clays. Past project experience indicates that finding contractors or irrigation districts willing to invest their ingenuity and funds in field trials is not normally a problem; nevertheless, the local interest is necessary before the trial work will materialize. For a general idea of the installation procedures utilized in development work to date, see Photos 1 through 8. Detailed procedure write-ups are planned and will be prepared when the results and evaluations for any particular method warrant such publications. Several publications, subject to change as additional evaluations are completed, are available now upon request.

Quality of clay--Another important part of the development work is concerned with the clay itself. Producing a suitably uniform clay product of acceptable quality for sealing purposes is a tougher problem than commonly appreciated. While it is true that the sealing quality and consequently also the reputation of good local clays have been damaged by careless mining and production methods, in fairness to the clay producers, it should be pointed out that they are faced with several important unresolved problems. For example, many clay deposits are extremely variable--in quality, in thickness, and in lateral extent. Perhaps the most pressing problem, however, is the absence, at present, of suitable specifications for canal and reservoir sealing clays. Of the various problems, the specification problem is probably the most important: removing that problem would remove the major uncertainty of the present quality control procedures. Actually, however, sufficient experience information for a State-wide specification is not now available, but as a helpful interim arrangement, tentative specifications for areas with an ample experience background with local clays could be prepared. The CSU project will gladly assist in such local determinations (by County ACP committees, etc.) of specifications for the clay quality, and installation procedures as well.

Skilled applicators--The development of people skilled in the use of local clays for sealing of canals and reservoirs is being accomplished in several different ways. For example, in some areas, the clay producer will also haul and install the bentonite or clay. Actually, the bulk of the favorable work has been installed on this basis. In some areas, the larger irrigation districts prefer to do their own mining, hauling, and installation work. In other areas, especially where the irrigation group has limited equipment, local dirt-moving contractors are assisting in the development work. In any case, continuity of effort from the mining to the installation process is important.

The market potential--In summary, the major market potential of interest to this project relates to water conservation--specifically, to the sealing of leaky canals and reservoirs.[1] As a result of the initial sampling efforts, we believe that ample quantities of suitable clays can be found and developed within a 100-mile radius of every major irrigated area in Colorado. However, to development, this market and its water conservation potential will require coordinated efforts of mining, procedure development, installation, and evaluation. Major problems that must be overcome, more or less concurrently, include (a) development of installation procedures to fit the local clays to the local canal and reservoir conditions, (b) development of local contractors or irrigation districts with men skilled in the sealing applications of the local clays, (c) development of clay deposits so as to insure porduction of clays of resonably uniform and known characteristics for sealing purposes, and (d) acceptance of methods and materials (as developed) for USDA-ACP cost sharing program.

[1] Other important potential markets beyond the scope of this project include (a) foundry sand additive, (b) brick and tile clay, (c) desiccator (moisture control) materials, (d) filter (decolorizer) materials, and (e) drilling mud (oil well) use.