US Army Corps of Engineers

(Albuquerque District)

Floodwater Lessons Learned

Socorro Diversion Channel

PDH: 3 Hours

Don Soards, P.E.

PDH Now, LLC.
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PDH*NOW* Socorro Diversion Channel – 3 Hour

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Floodwater Lessons Learned:
Socorro Diversion Channel

1. Course Overview

This PE online continuing education course satisfies 3-hours of engineering continuing education requirement for Professional Engineer license renewal.

One thing common to all engineering disciplines is protection against flooding. Our systems need to work when it rains.

This course in Floodwater Lessons Learned Socorro Diversion Channel Lessons Learned is intended to encourage the engineer to consider the big-picture result of field performance of many projects over many decades.

The engineer's duty is to make things work. Following instructions, complying with the law, and using current best practices are usually good enough for the present. But the engineer's task to make things work in the future. This requires making projections about future conditions and use. While engineers prefer hard facts, we are sometimes forced to work with "soft data" that require evaluating many possible options. During this evaluation, we use legal requirements and best technology as tools.

When I headed the Albuquerque District's Inspection of Completed Works (one of three major programs I had as Chief of Emergency Management for a dozen years), I noticed the same design/construction errors being repeated. The US Army's version of Total Quality Management (TQM) was Total Army Quality (TAQ). Under TAQ, the process of continuous improvement was building, feedback, and improved building.

The problem was a lack of feedback because flood control structures may sit for decades without being tested by significant flooding. I strove to compensate for this lack of immediate feedback by having studies made of the histories of over one hundred projects constructed by the Albuquerque District Corps of Engineers since 1948. I selected Professor Richard J. Heggen, a hydrology/hydraulics teacher at UNM, to write many of these, including Socorro Diversion Channel Lessons Learned. His interesting and entertaining lecture style is reflected in his writing.

2. Learning Objectives

Upon successful completion of this PE continuing education course, the participants will be able to:

- Recognize many defects in existing flood control structures.
- Review plans to avoid those defects.
- Consider how the life of flood control structures may impact current engineering systems.
- Inspect flood control projects.

3. Summary

In this Professional Engineer online PDH course, we examined key features of flood control and bank protection projects that worked over time and a number of those that faced challenges during their long life. Suggestions for improvement were made for many of the problems encountered.

Reference Socorro Diversion Channel Lessons Learned by Professor Richard J. Heggen

Socorro Diversion Channel
Lessons Learned

The Project

Title: Socorro Diversion Channel Project, Socorro, New Mexico
Sponsor: City of Socorro
Contract: DA-29-005-CIVENG-63-2
Final Inspection: 1964

The project consists of two independent channels:

Matanza Diversion	West to east; 2030 feet concrete lined; 1030 foot dike; 7175 feet of spoil levee. See Fig. 1.
Socorro Diversion	Approximately 21,000 feet north to Nogal Canyon confluence; approximately 7000 feet east to Rio Grande; 4316 feet concrete lined; 523 feet grouted heavy stone; 410 feet dumped heavy stone; 34680 feet dikes and levees. See Figs. 2 and 3.

The project is designed for a Standard Project Flood, approximately a 300-year event.

The Review

While the two diversions are hydrologically distinct, both employ lined and unlined reaches and had pre-existing crossings. From the perspective of Lessons Learned, the two provide a broad data base.

This review pursues general and persistent behaviors. At the level of design detail, the project is too large for specific assessment in this document.

Some project components that work well in one situation do not work in another. Some components that serve one objective are detrimental for another. These dichotomies cause the "What Worked" and "What Didn't Work" cataloging somewhat arbitrary.

What Worked

Overall Performance

The overall project functions as intended. The project sustained a 2.9 inch storm in 1980. Absent the project, portions of Socorro would be inundated.

Matanza Channel

The Matanza Channel appears to be the better structure of the two. Save problems with gages and two joints (see the subsequent sections *Gages* and *Spalling*), the Matanza Channel has required minimal attention.

Photo 1 shows the transition from lined to unlined sideslopes. The sill of grouted boulders, which drops roughly 3 feet, has never been undercut.

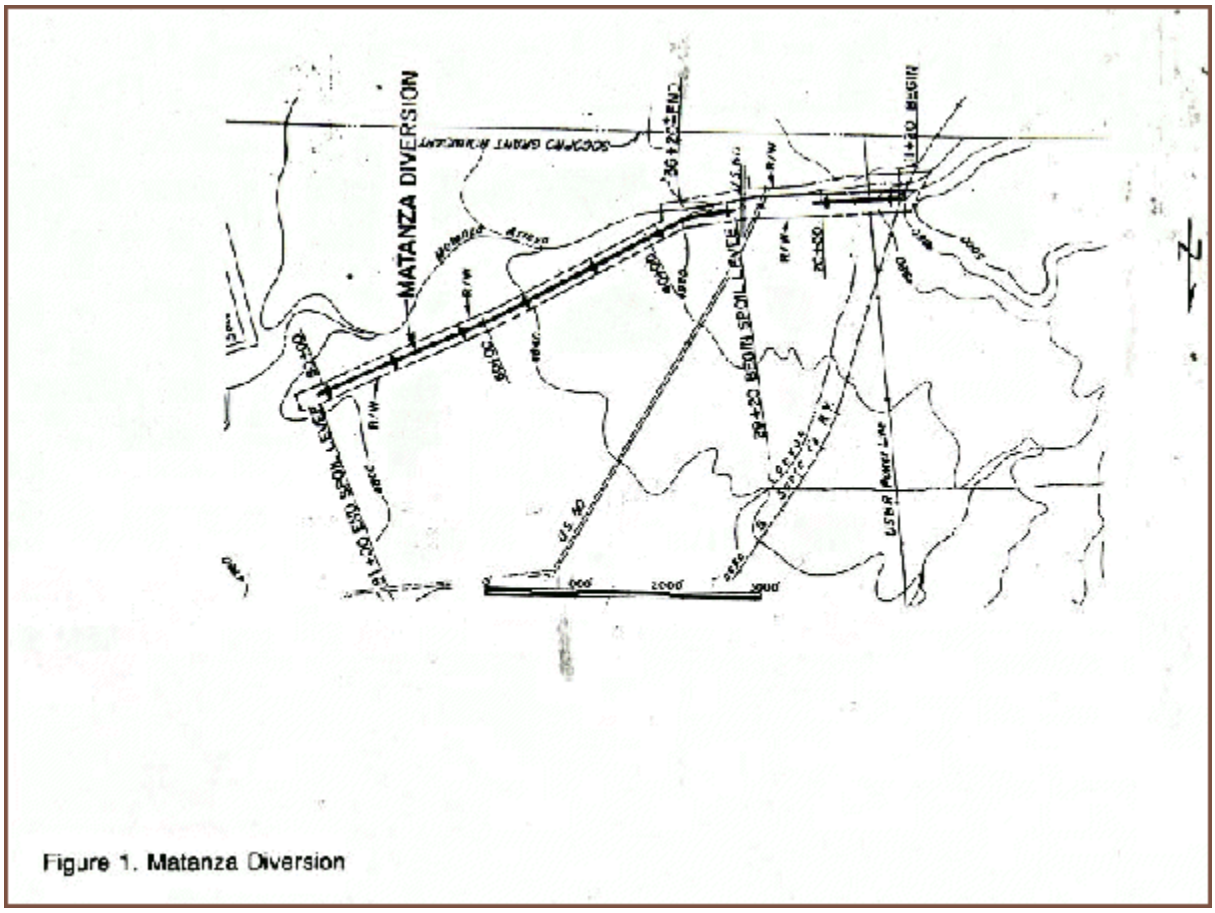


Figure 1. Matanza Diversion

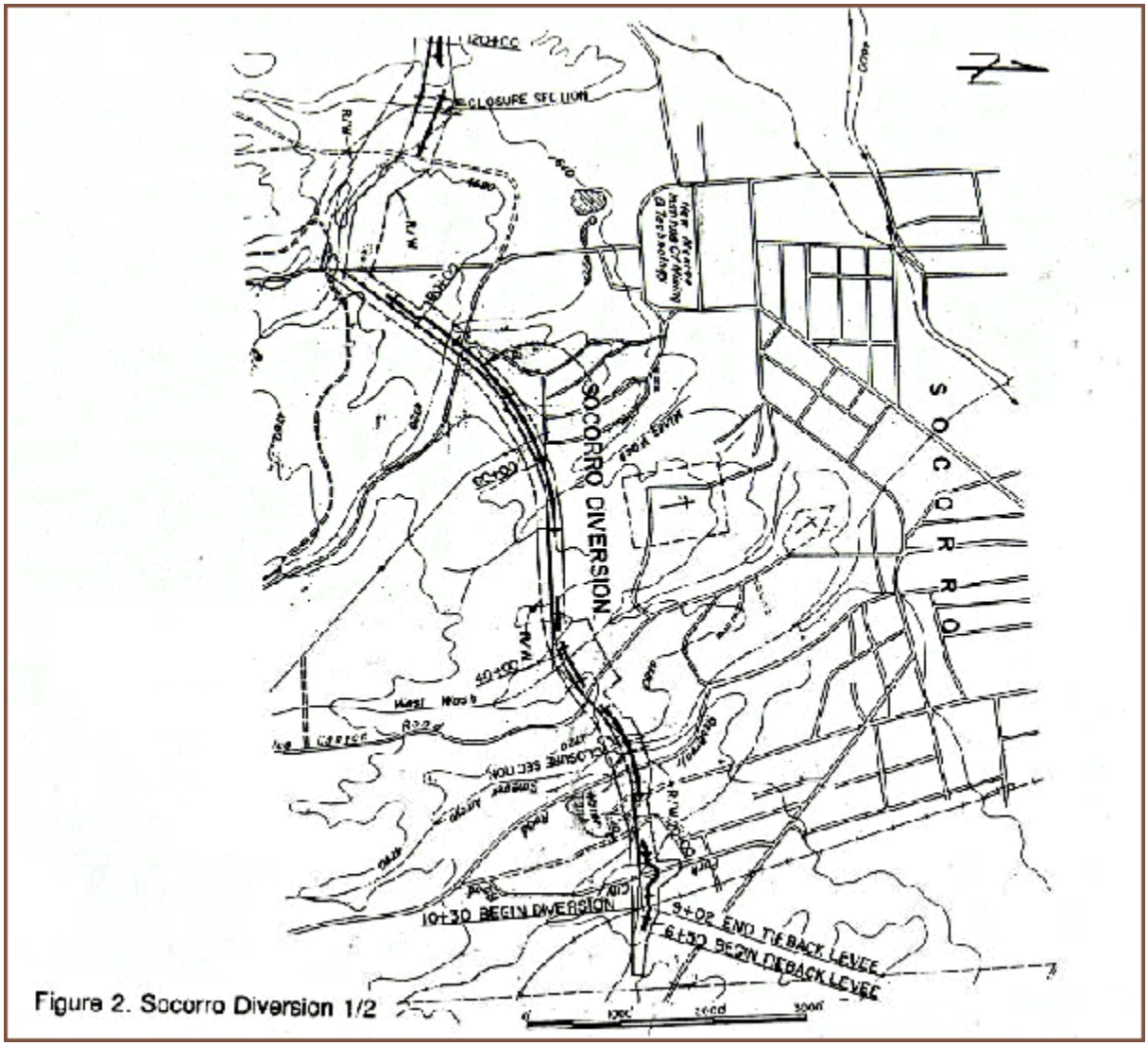


Figure 2. Socorro Diversion 1/2

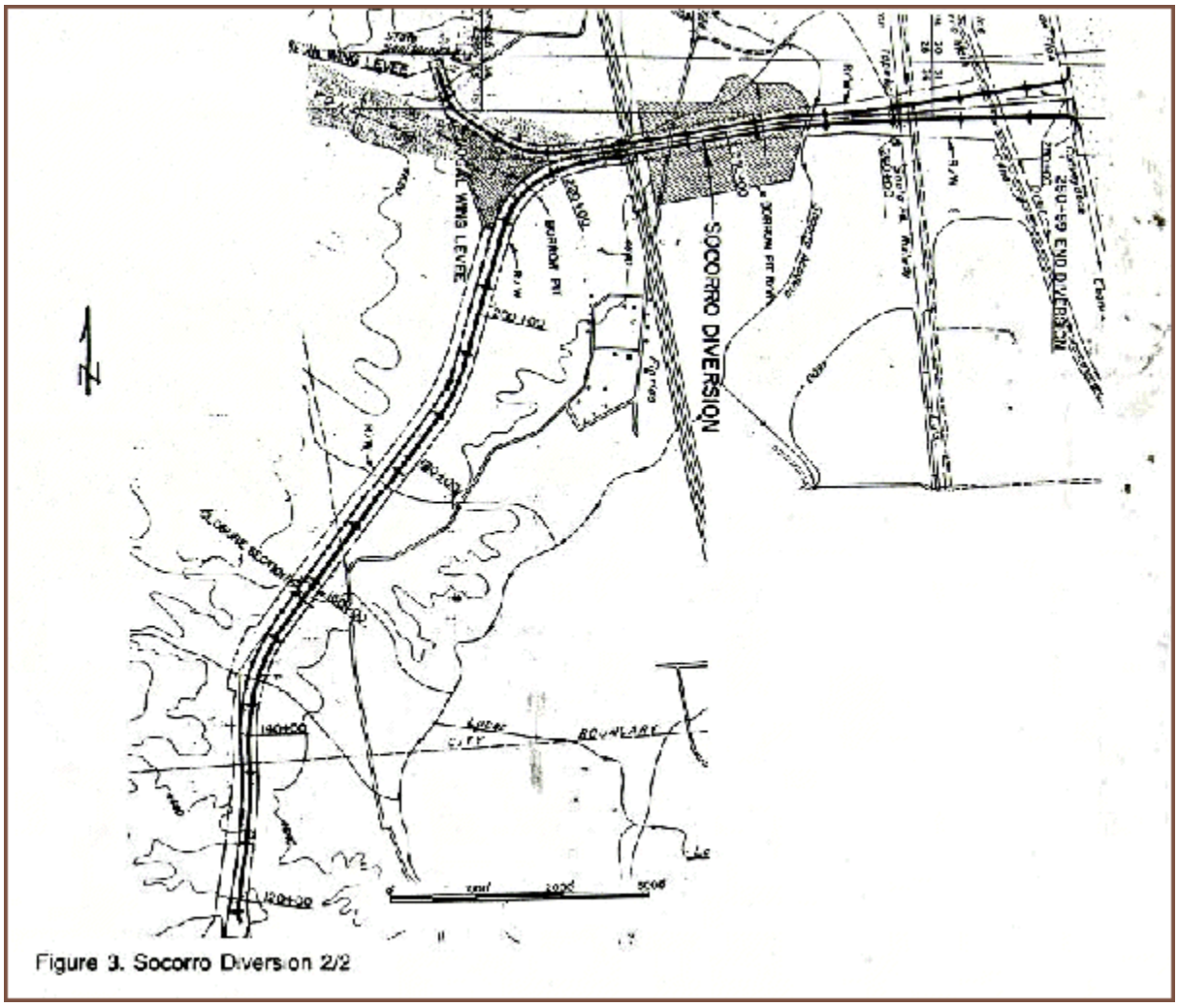
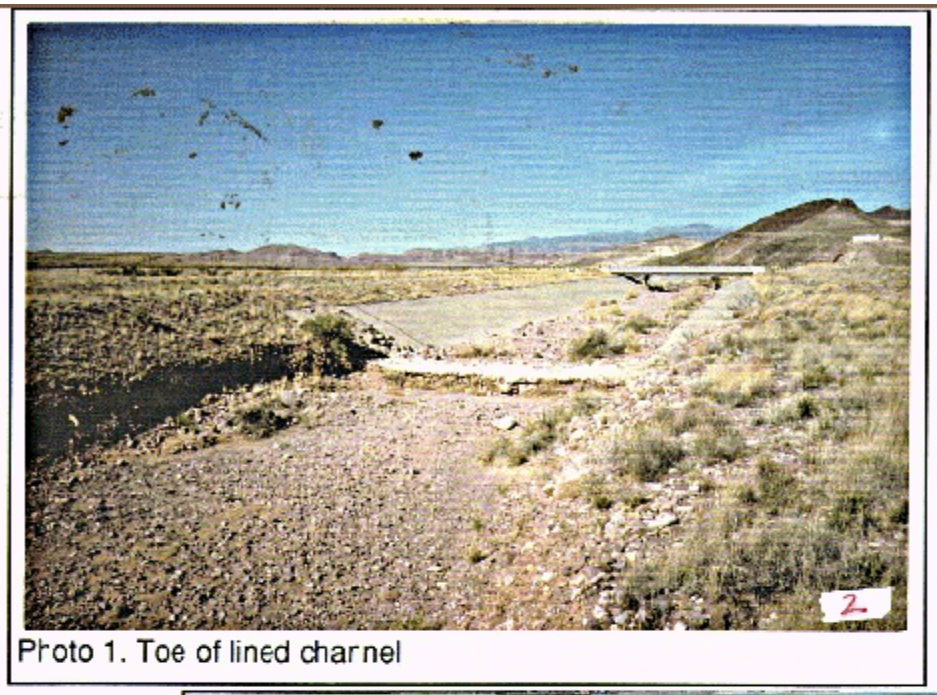


Figure 3. Socorro Diversion 2/2



Proto 1. Toe of lined channel

The "seep willow" in Photo 2 has lined the wall edges for the life of the project, never jeopardizing conveyance capacity.

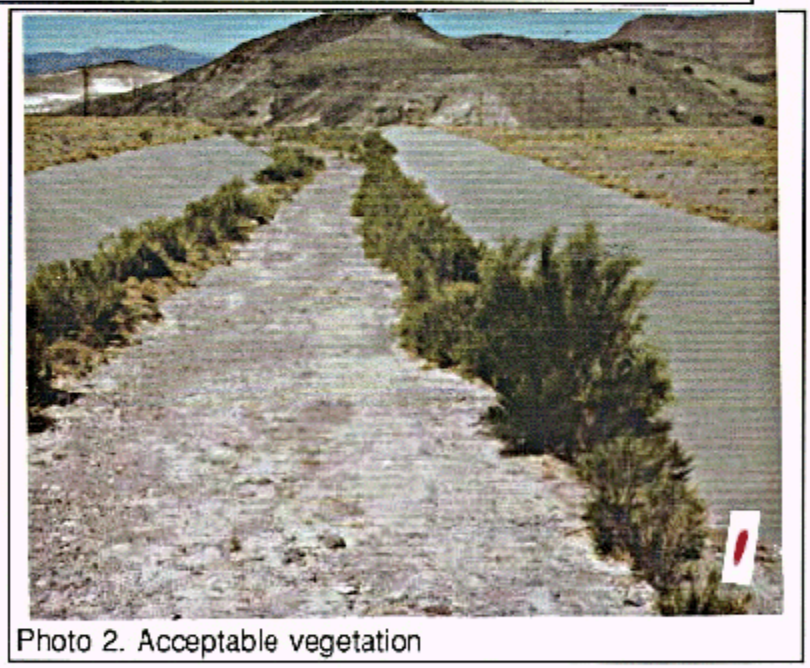


Photo 2. Acceptable vegetation

Pilot Channels

Sediment deposition in the Socorro Diversion outfall is a perpetual problem (see the subsequent section *Outfall Channel*). Pilot channels keep the outflow moving for at least a short term. Silt disposal by water is preferable to silt disposal by diesel. Pilot channels are an effective component of channel management.

Photo 3. Pilot channel

Photo 4. Headcutting induced by pilot channel

Photo 5 documents the result pilot-induced headcutting. Sediment filled the channel to the level of the remaining patches on the left bank. Deposition on the right bank has yet to be eroded.

Photo 5. Pilot channel results

What Didn't Work

Sponsor Responsibility

While the maintenance obligation appears to be currently addressed, the City of Socorro has a long history of failure to satisfy its duties. The inspection folders contain of complaints by the Soil Conservation Service, Bureau of Reclamation, the railroad and private citizens regarding long-term inattention to maintenance. Unfavorable comments by the Corps are pervasive, explicit and reflect frustration. The 15 December 1975 memo by the Acting Chief, Construction-Operation Division, illustrates the issue.

> *Sub: Unsatisfactory Maintenance of Local Flood Protection*
>
> *The Socorro Diversion ..... has been a chronic problem. Continued persuasive efforts by representatives of this office have produced little maintenance action in the eleven years since completion. Sponsor's letter dated 24 June 1975* ['We are aware ... We have found it almost impossible ... We have started ..."] *is a typical response. Inspection of the project on 10 December 1975 revealed that none of the work had been done.*

In a 1981 complaint about debris at a railroad bridge, an irate property owner presumed a voted mil levee for maintenance. The Corps had no knowledge of such an instrument.

The problem seems to have several roots:

(1) The project has exceeded the City's financial and/or engineering capacity.

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(2) Sediment issues tend to interrelate and rarely are resolved by quick repairs.

(3) City staffing has lacked continuity.

The Corps declared the project "no longer capable of providing flood control protection" in 1981. How such declaration affects liability is unknown.

Projects as complex as the Socorro Diversion may be inappropriate for a small organization with limited engineering and reconstruction capacity. The Corps must impress upon the sponsor the extent of the ongoing responsibility. The sponsor should submit an enforceable implementation plan.

Encroachment

Proximity to urbanization and NMIMT have led to persistent encroachments. A small number of proposals were submitted to the Corps for prior approval, per the procedure in the project authorization. A larger number were built without Corps approval. Predictable encroachments were by property owners seeking space on an embankment or roadway. The less excusable encroachments were by the City, NMIMT or utilities.

The City illegally dammed the Smelter Arroyo at its confluence with the Socorro Diversion. The encroachment, shown in Photo 6, is summarized at the 7-year point in two-page *Information Summary* appended to this report.

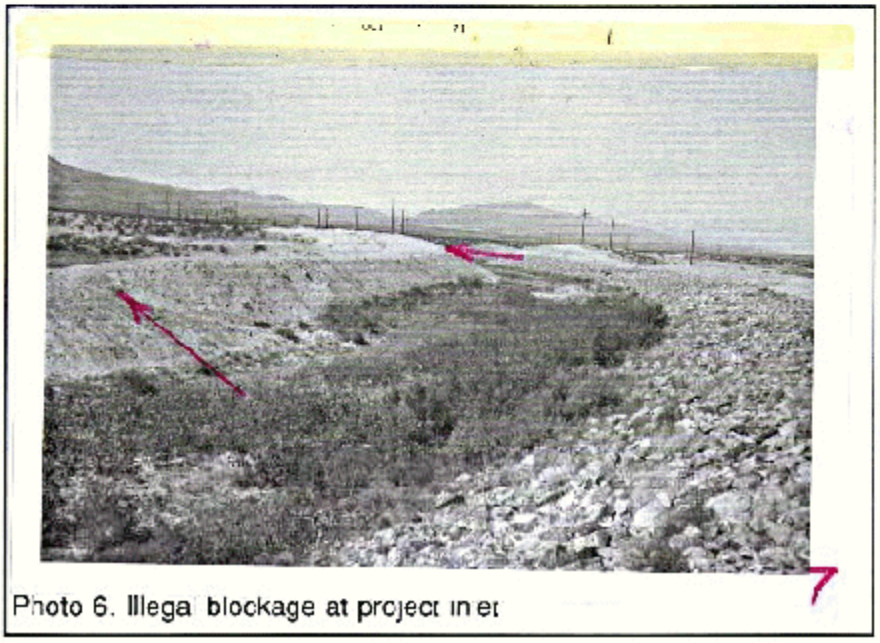

Photo 6. Illegal blockage at project inlet

The City eventually breached the dam, Photo 7.

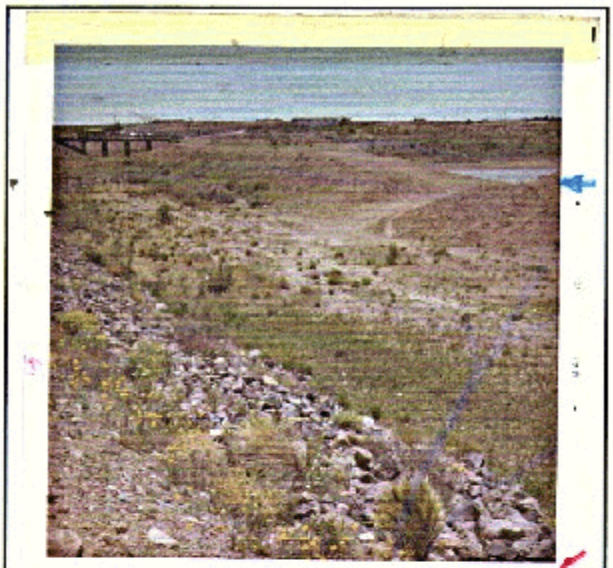

Photo 7. Breached

Photo 8 shows a 4 foot NMIMT landfill in the channel. The institution of higher education knew better.

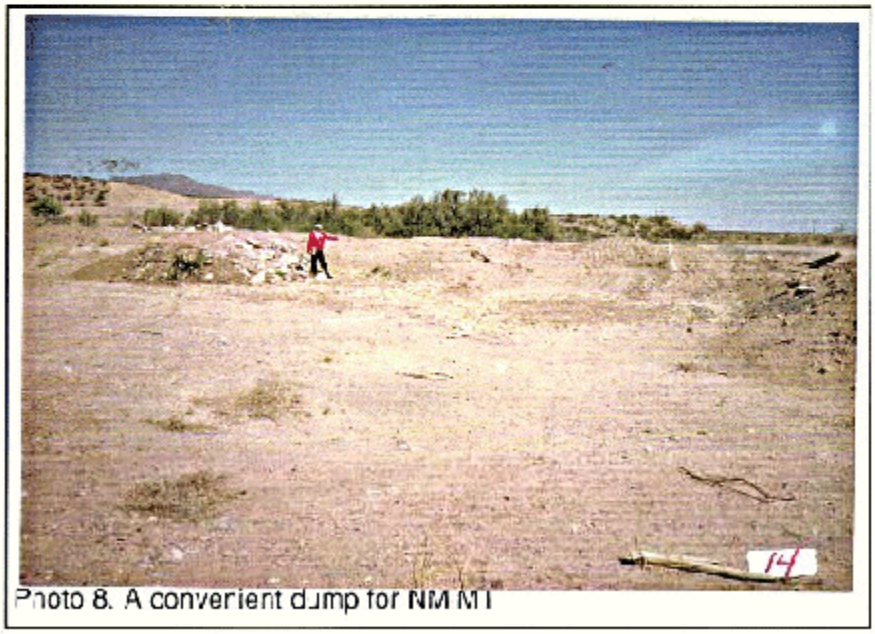

Photo 8. A convenient dump for NMMT

Caught in the act, NMMT denied that the tanks of Photo 9 would be placed in the channel. Photo 10 testifies to denial's veracity.

Photo 9. "We wouldn't do that ", 1972

Photo 10. "Fooled you!", 1973

Cut exceeded fill for a nearby road. Photo 11 shows the solution.

In most cases, demands (a term not in Corps enabling legislation, but more truthful than "advice") by the Corps brought about removal (or at lease documentation for approval) of the encroachment.

Photo 11. Earth bile in channel

Development Pressure

The project has dealt with roads, utility and communication cables, gravel mining and recreational demands. Efforts made to inform the Corps regarding development are often late and frequently inadequate technically.

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Photo 12 shows bank damage by an unapproved gas line crossing of the channel.

Photo 12. Unauthorized utility crossing

The proposed Tierra Access Road to the Nogal Canyon area illustrates the pressure of development. The Environmental Assessment devotes four pages and no maps to surface water hydrology, half the attention paid to traffic noise. The document briefly mentions unspecified local flooding problems, confining its projections to 50-year flow at the roadway. How the Tierra Access Road and facilitated development impact the already-unsatisfactory Nogal confluence (see the subsequent section) is not addressed. The document may satisfy environmental assessment purposes. It is not, however, an analysis against which the Corps can to weigh the consequence of development.

Nogal Confluence

Sediment from the Nogal Arroyo inherently endangers the Socorro Diversion capacity. Original design does not reflect explicit concern for this predictable problem. Cleaning of the confluence and improving the inlet alignment are City priorities. Where vigilance has been applied, the confluence might be thought of as a "What Worked" item. Functionality to date, however, also reflects some good luck. The localized storm that could plug the Socorro Diversion with sediment can occur at any time.

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Inspection notes document the steady migration of the Nogal channel towards, and now nto, the levee that ties down the confluence. Photos 13-15 trace the history.

Photo 13. 75 feet to levee, 1966

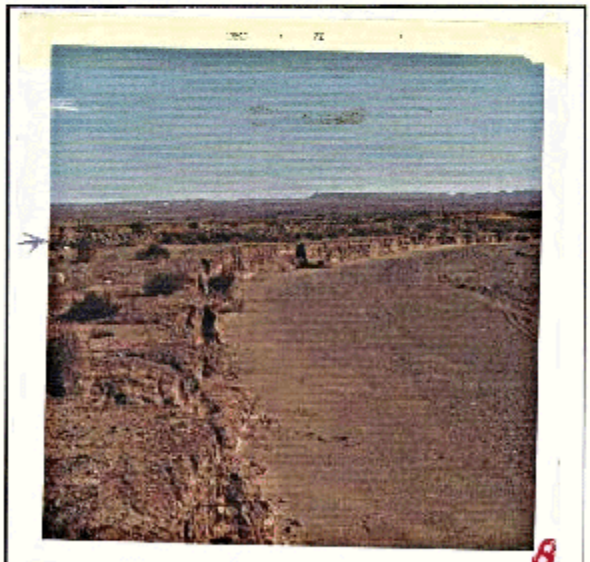

Photo 14. 34 feet to levee, 1972

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Photo 15. Levee attack, 1991

City rock dumping to protect the levee has been ineffective. As with most engineering effort in fluvial geomorphology, a lasting solution requires survey, analysis of design conditions (as opposed to response to yesterday's flow) and integration with the larger project.

Given the lack of outfall grade, there may be no feasible way to eliminate the confluence delta potential.

Outfall Channel

Grade is negligible in the outfall's lower reach. An inspection note spells the reach as "sediment trap". The outfall exemplifies stream competence, the geomorphologic explanation of particle size decrease in the downstream direction. See Photos 16-17.

Photo 16. Rocks as large as 3 feet below Nogal confluence

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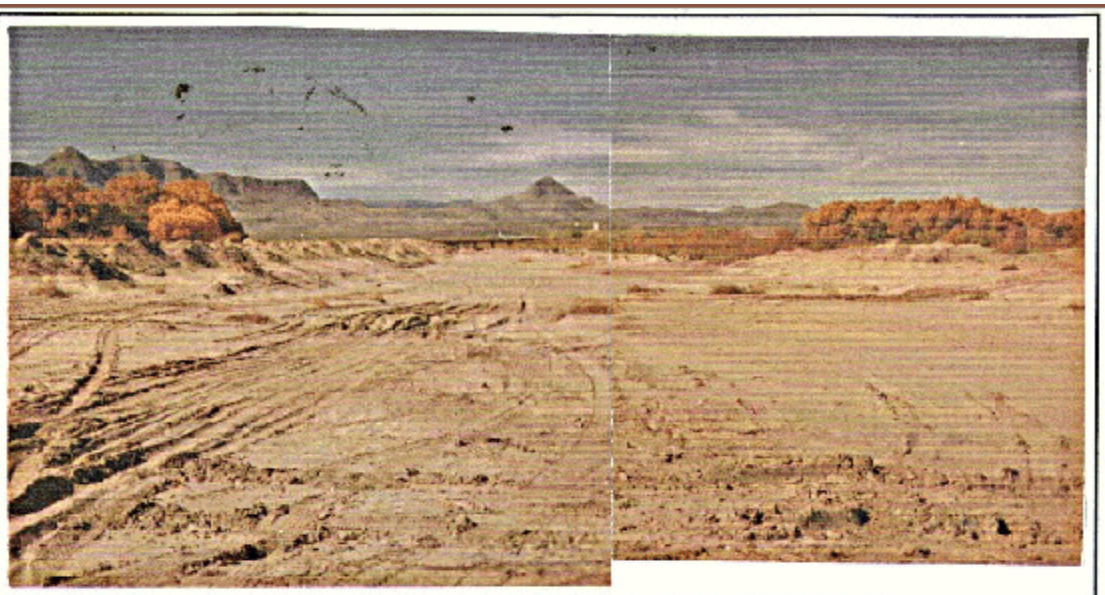

Photo 17. Tens of thousands of cubic yards of silt in outfall to Rio Grande

It is not clear if the original designers hoped that the channel would clean itself. The channel crossings are not sized for extensive accumulation.

The City excavates and digs pilot channels to maintain conveyance to the river. The City has usually done this work on time.

Like the earlier section *Nogal Confluence*, the "cup-half-full" viewpoint might see the outfall as an historical "What Worked." The "cup-half-empty" assessment sees the opposite. Engineering should not rely on timely storms. An unfortunately timed flood will spill from the raised channel. The cup is indeed half empty.

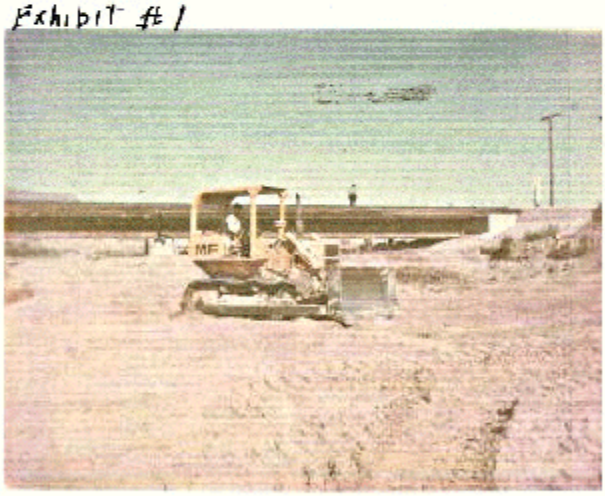

Photo 18. The City at work

Sediment transport at the outfall should be assessed, a task for which the Corps is now better equipped than at it was the time of initial design. Several alternatives merit thought:

(1) As open land is adjacent the channel, a sediment ejector (an Indian technology involving vortex flow) might be effective.

(2) The cross-section might be reshaped, advancing the pilot channel concept from reactive to proactive.

(3) Regular excavation might remain cost effective. The key to resolution lies in quantifying the need and capacity for timely maintenance.

Access

Locked gates appear to which the City lacks a key. Roadway berms by others discourage vehicular trespass. In other places, access is enhanced by those who remove riprap to ramp to drive in and out of the channel. Oriental wisdom warns against of too little or too much of a thing. Photos 19-20 illustrate the extremes.

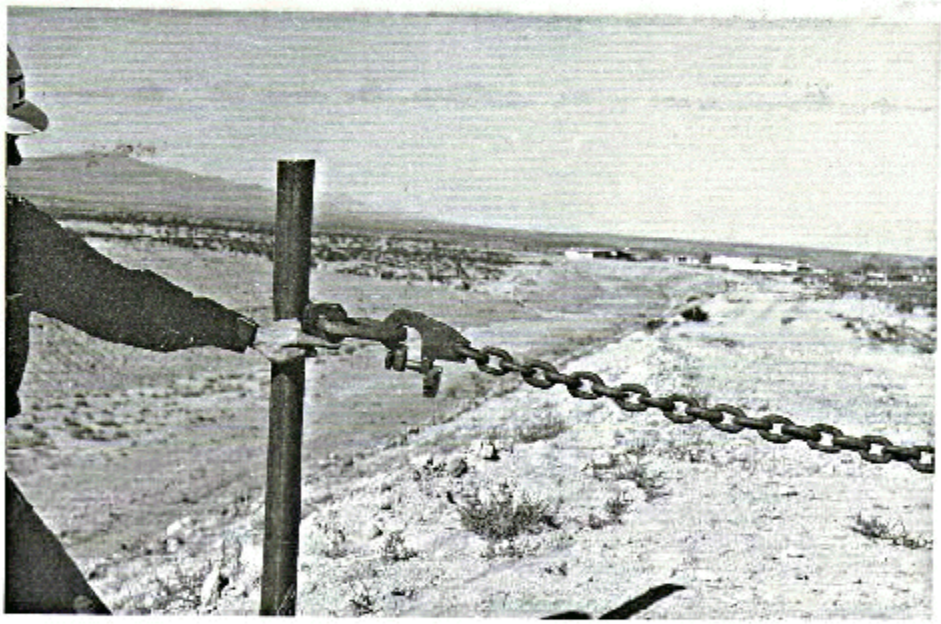

Photo 19. Can't get in. NMIMT has the key

Photo 20. Everyone gets in. Riprap removed.

Photo 21 is an access issue that will be resolved by a large storm.

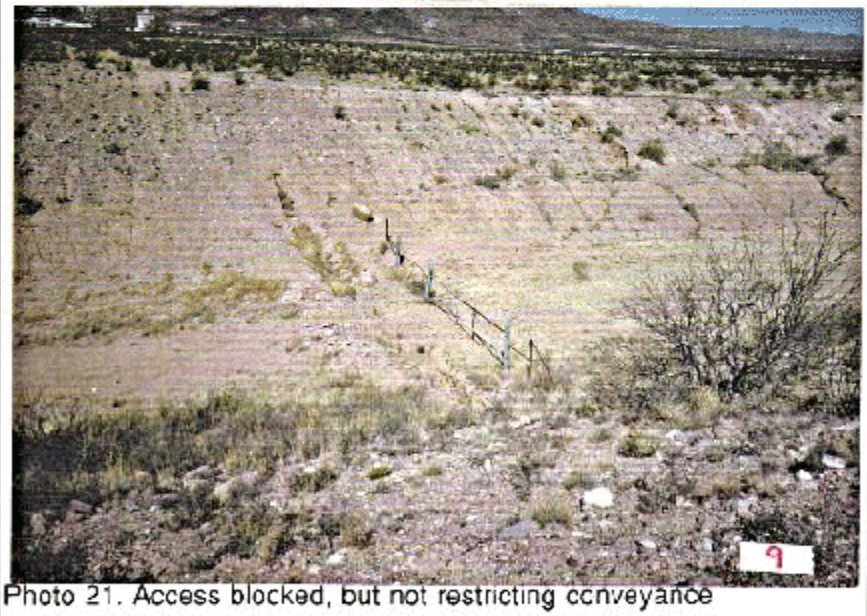

Photo 21. Access blocked, but not restricting conveyance

Piping

Piping is a failure mechanism studied, but perhaps not often seen, by young engineers. The pipes (sometimes seen as sinks) appear as theory predicts, below an embankment holding standing water.

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The head has been from minor local ponding, not flood flow. Photo 22 shows a temporary cross ng pending runoff that piped.

Photo 22. This is the berm that led to the pond that led to the pipe.

Photos 23-24 show a pipe outle: and a sink hole, probably over a pipe.

Photo 23. Piping

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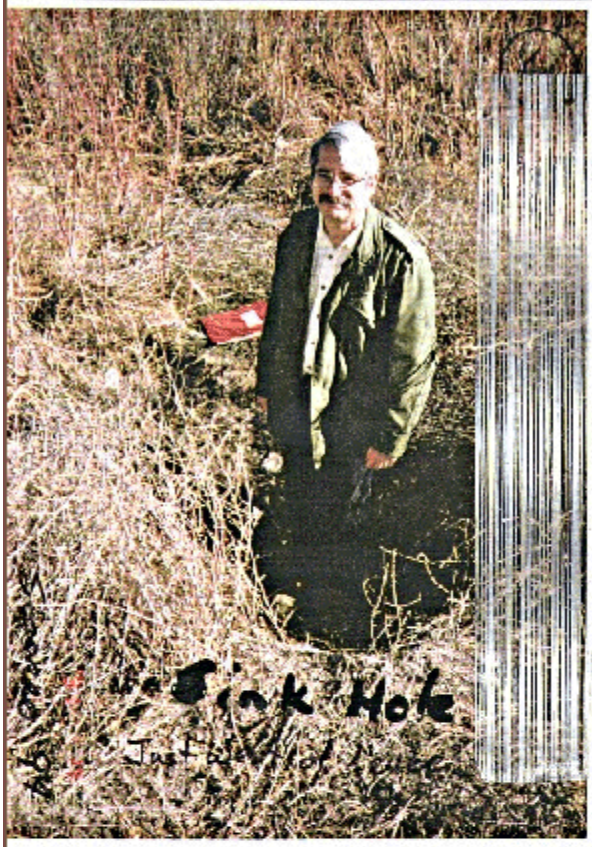

Photo 24. Corps spelunking

The few reported instances do not appear to relate to poor construction compaction. Animal burrowing is probably involved.

In an assessment sense, piping might be seen as evidence for "What Worked" endorsement of inspection vigilance. The pipes were closed before larger problems ensued.

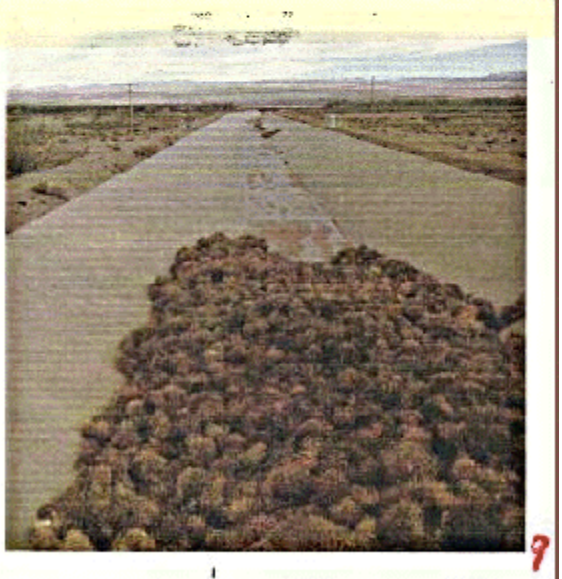

Photo 25. USGS bubbler gage

Gaging

No aspect of the project has a record as sorrowful as that of gaging. Photo 25 shows a USGS bubbler gage that might have bubbled through 8 feet of tumbleweeds in the foreground, but couldn't bubble through sediment that followed.

Photo 26. Mayor and Engineering Division Chief inspect the new gage.

In an inclined peak stage gage, the plate is removed after runoff to inspect the high silt mark. Photos 26-27 speak for themselves.

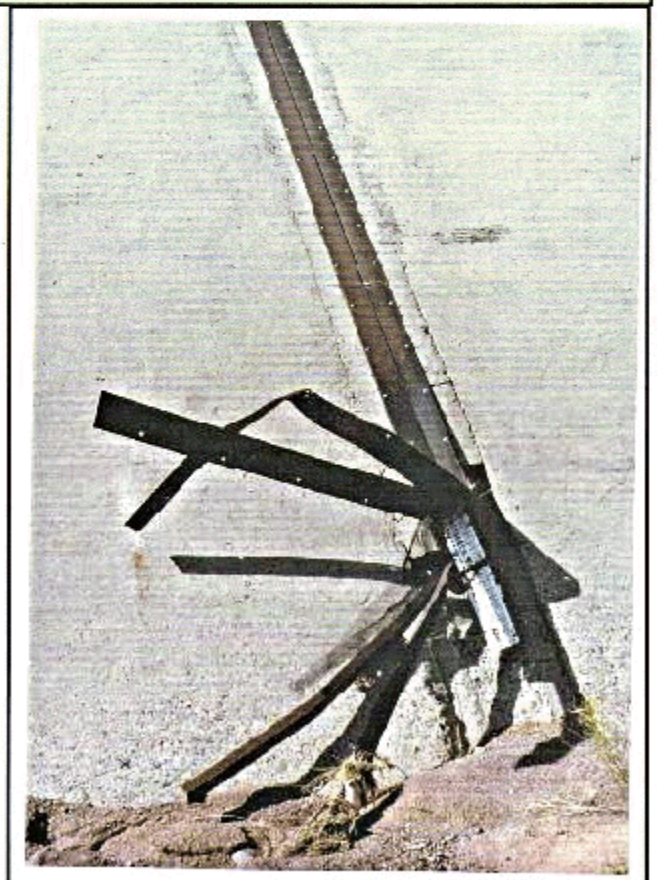

Photo 27. Hey, Mayor! Chief! We had flow!

In a vertical peak stage gage, the pipe cap is removed and a staff gage is removed for signs of silt. Photos 28-29 show such gages in 1966 and 1997.

It is unknown if these gages have been read. Rust speaks to the negative. Boulders in a major event would rencer them into horizontal peak stage gages.

Photo 28. USGS peak stage gages, 1966

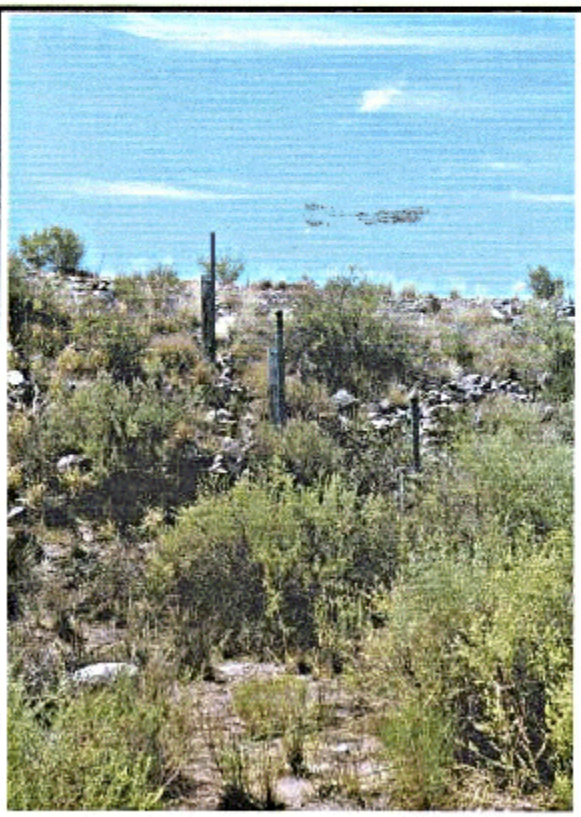

Photo 29. USGS peak stage gages, 1997

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Weepholes and French Drains

Weephole brass caps are prone to theft (as many as 44 at a time) and they require backwashing, as shown in Photo 30. The backwashing has not been continued.

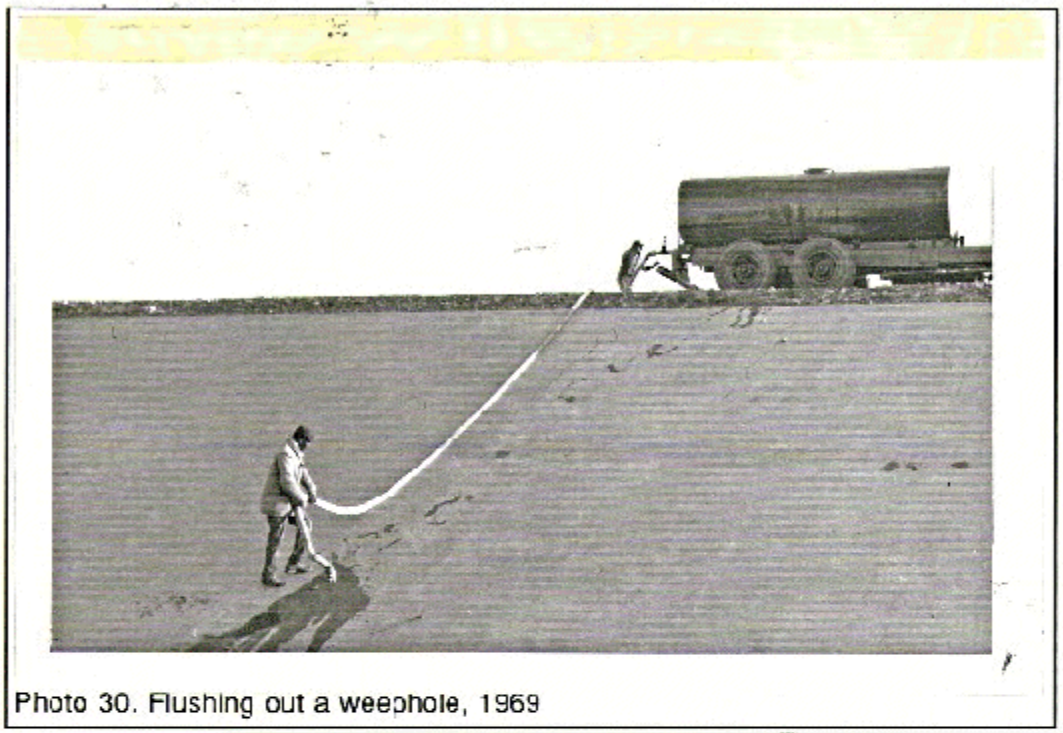

Photo 30. Flushing out a weephole, 1969

Both weepholes and French drains cause local stress in the concrete, as shown in Photo 31.

As most weepholes are plugged and the channel walls remain, weepholes may be unneeded

Photo 31. Stress fracture

Spalling

Concrete on the north sidewall of the Socorro Diversion and at one expansion joint in the Matanza Channel has spalled due to thermal working.

The Matanza landmark "Problem Joint" has been particularly irksome, as repeated repairs have not alleviated the problem. Photos 32-34 show the situation.

Photo 32. The "Problem Joint", 1972

Photo 33. Repeated repair, 1983

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While concrete should be expected to need redressing on occasion, the repair should last. For recurrent spalling, the Corps may need a joint specification for enhanced reconstruction.

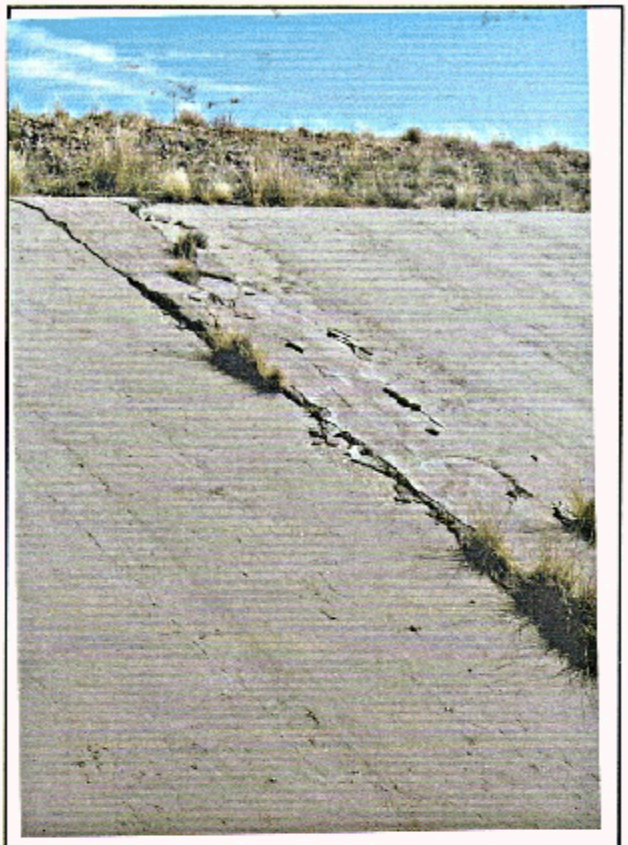

Photo 34. Repeated failure, 1997

A clue to the failure mechanism may lie in the 4-inch vertical differential shown in Photo 35. Differential settling may have initiated the crack, or water through a crack may have caused settlement or heave.

Photo 35. 4-inch displacement

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Vegetation

The channel bed has been watered by arroyo inflow and leakage from adjacent ponds and utilities.

Vegetation requires ongoing removal, a task not always promptly accomplished by the City. Photo 38 illustrates the challenge.

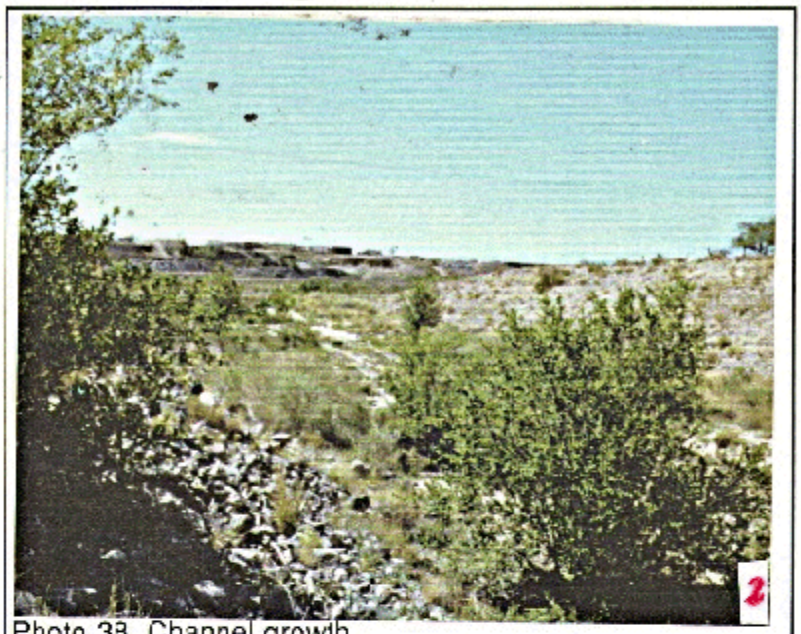
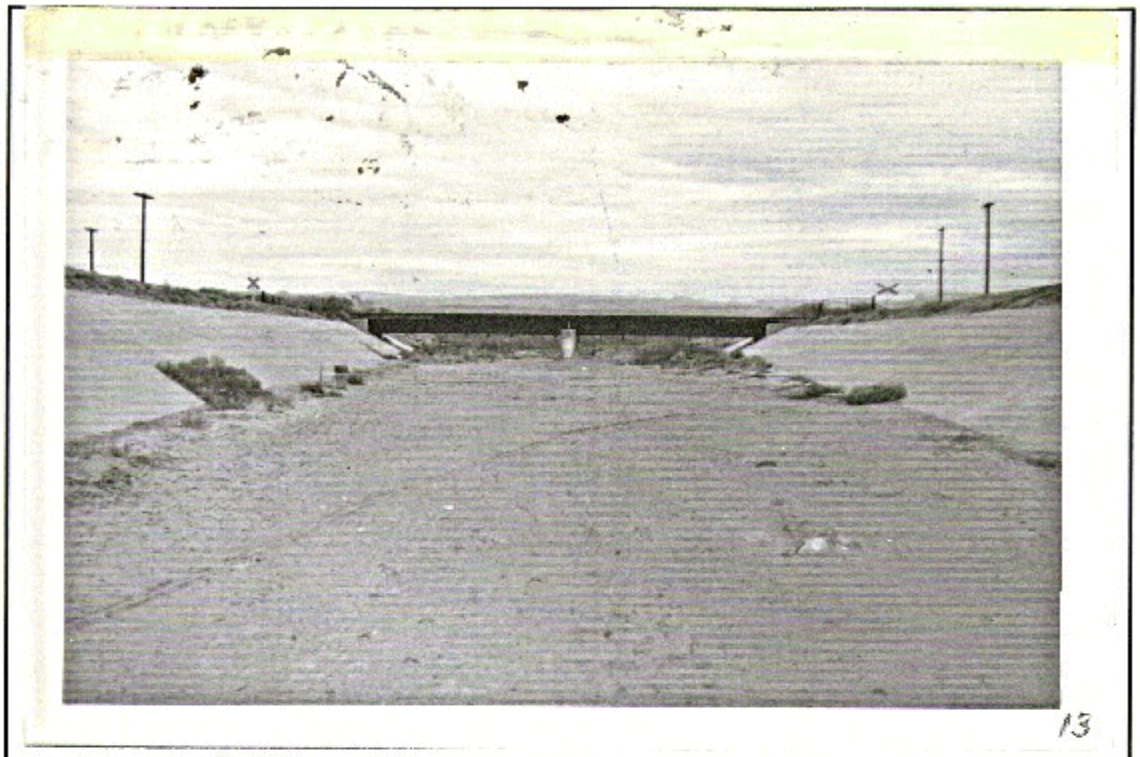


Photo 38. Channel growth

Railroad Bridge

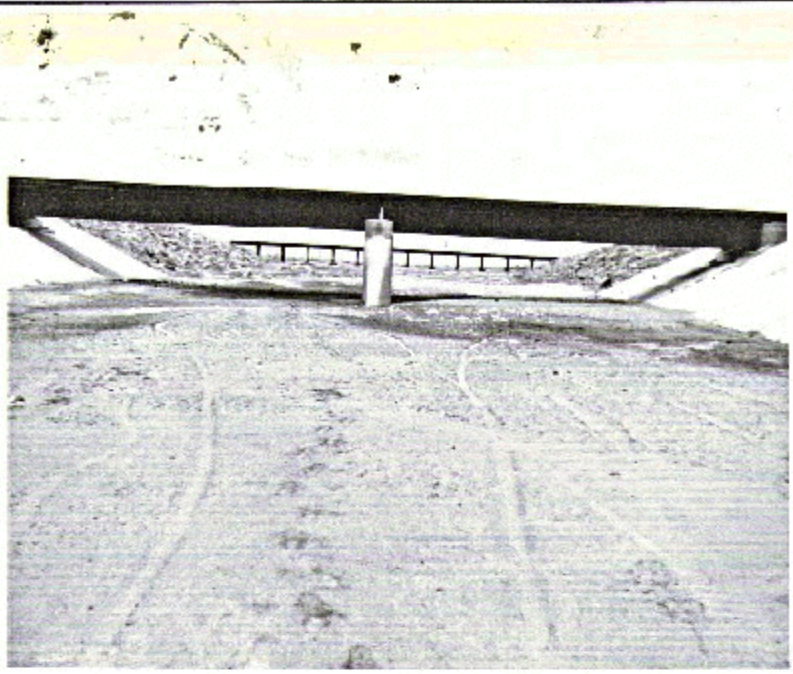
The railroad crossing of the outfall channel serves as a benchmark for deposition. Original clearance was 10.5 feet. The RR series of photos document the years since project construction.



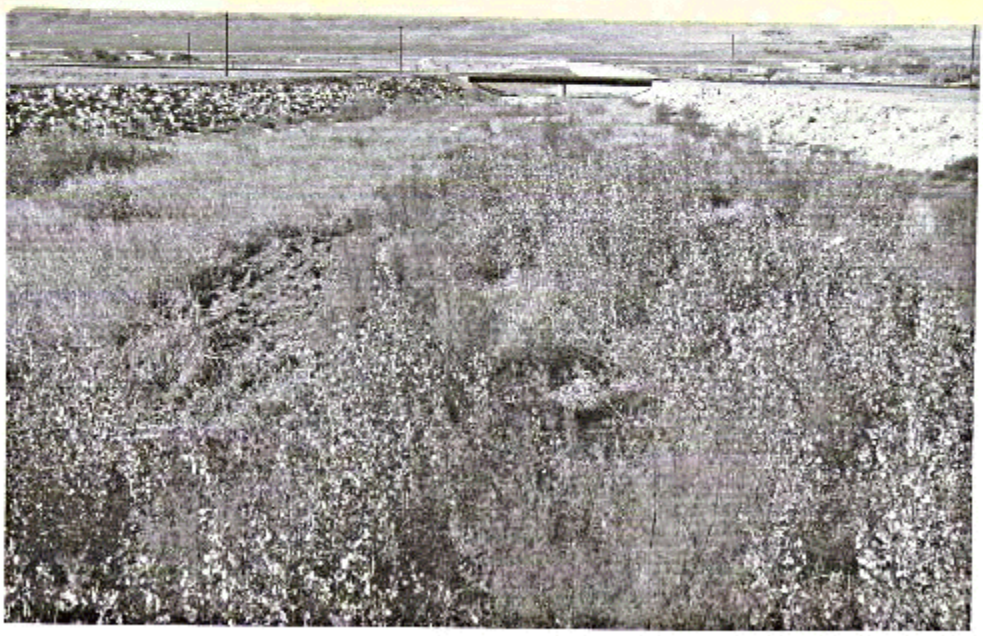
RR Photo 3. 3 December 1969

RR Photo 4. 14 October 1971

Railroad Bridge Photo History



RR Photo 1. 1 March 1966



RR Photo 2. 8 November 1967

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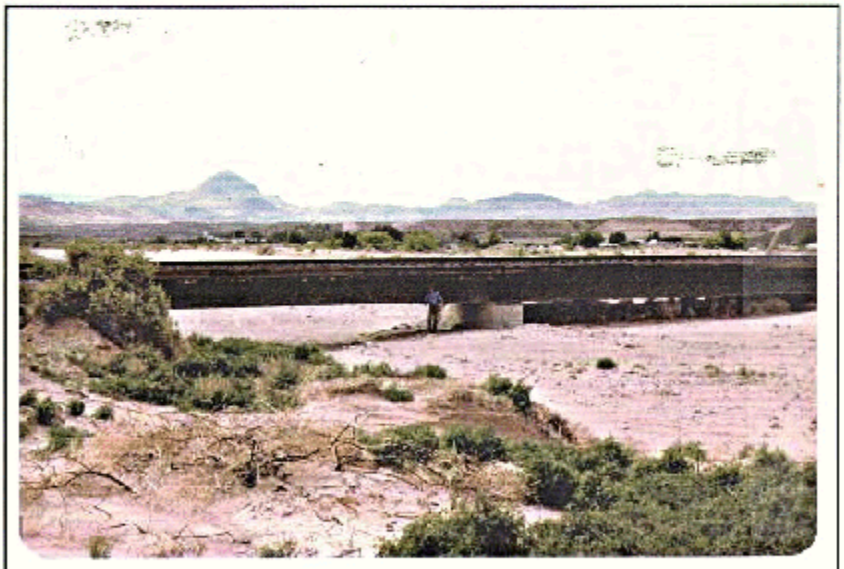
RR Photo 5. 20 August 1973

RR Photo 6. 6 April 1975



RR Photo 7. May 1981

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Gullies

Photos 36 and 37 show the inevitable gullies where local flow runs over an embankment. The latter photo is a particular concern, however, as the gully serves as a playhouse.

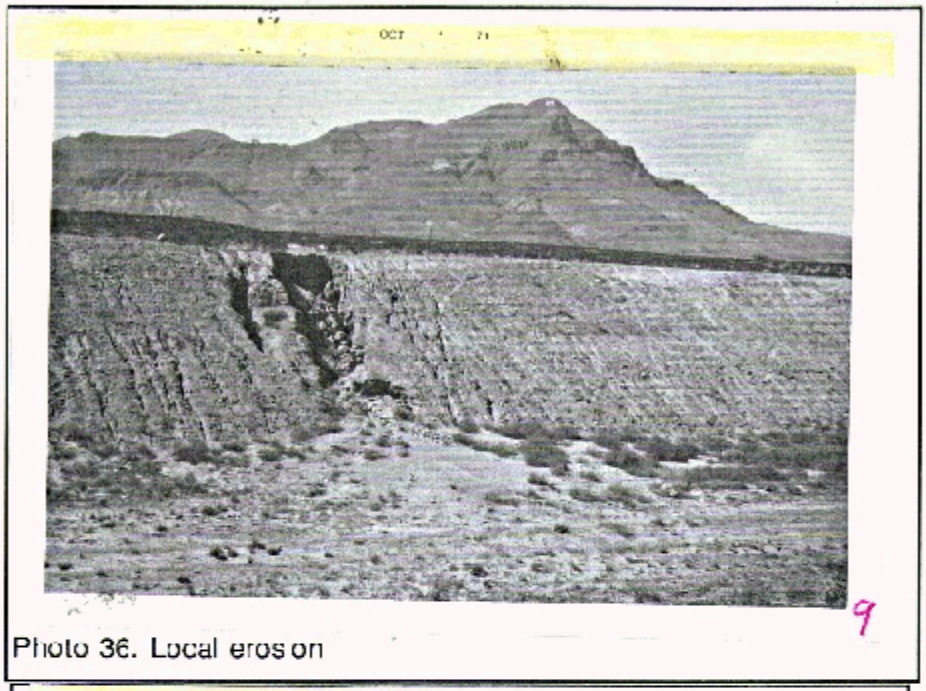


Photo 36. Local erosion

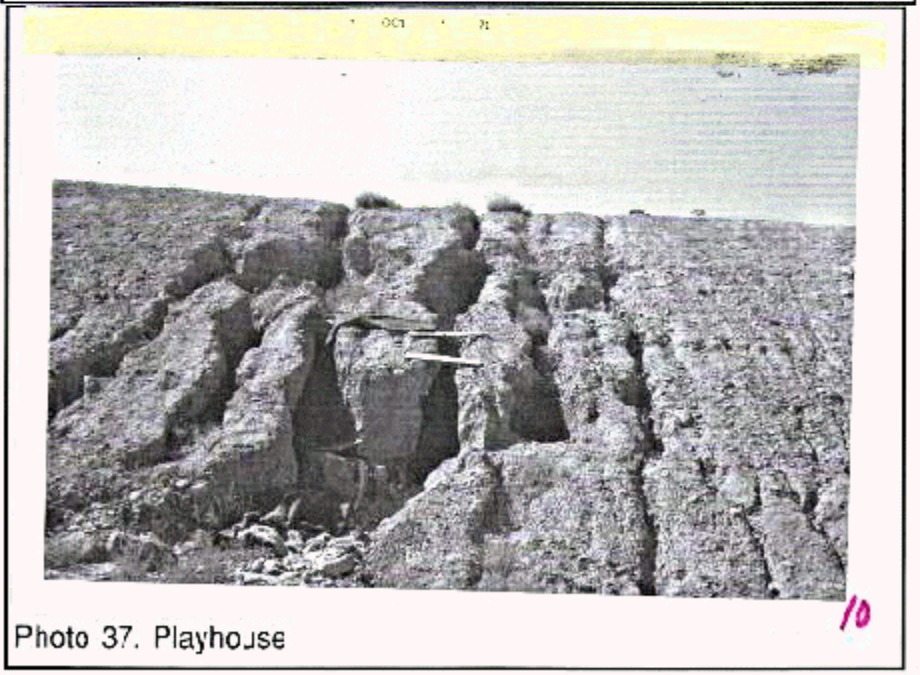
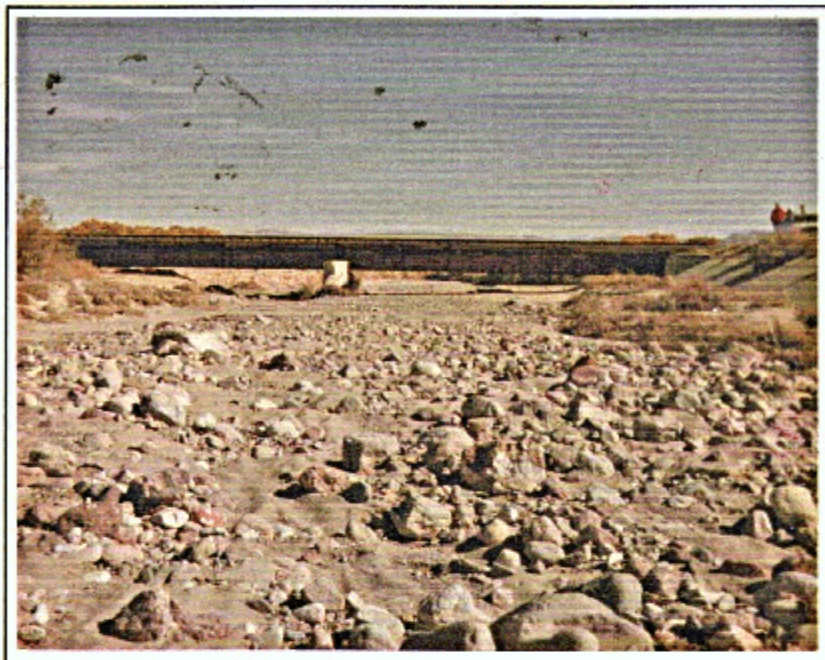
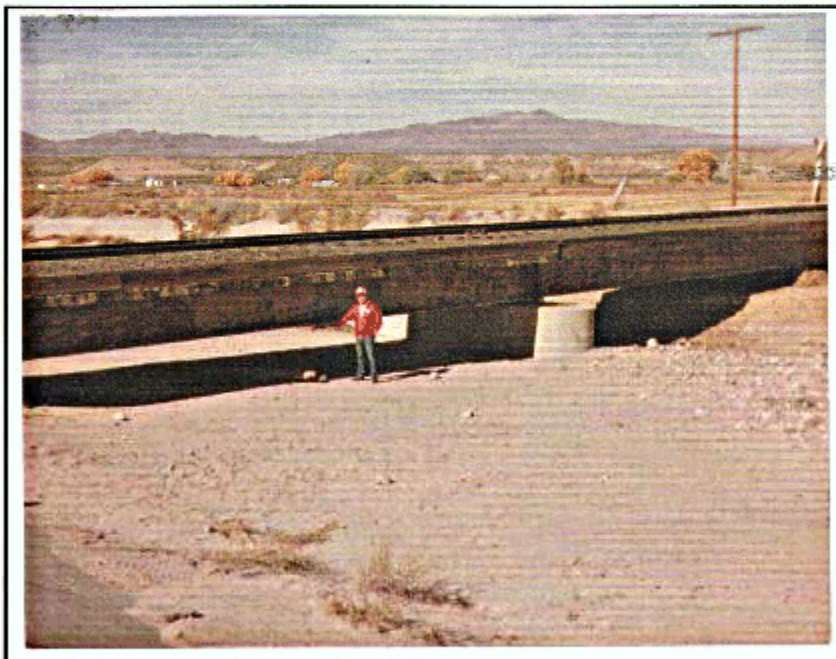


Photo 37. Playhouse



RR Photo 8. 17 November 1981



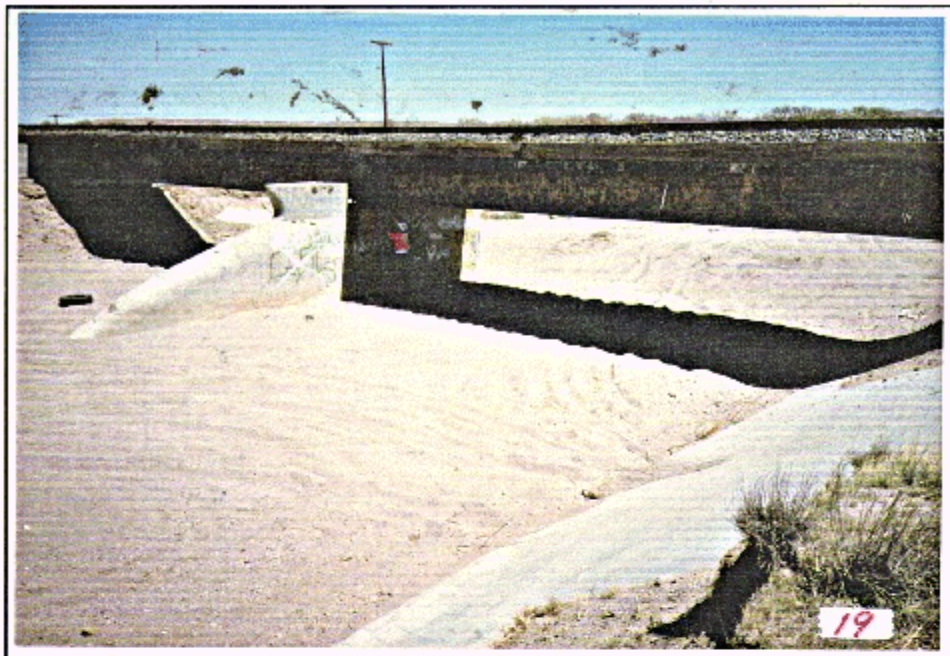
RR Photo 9. 17 November 1981

RR Photo 10. 27 September 1984

RR Photo 11. 6 May 1986

RR Photo 12. 28 June 1989

RR Photo 13. 28 June 1989



RR Photo 14. 10 April 1991

RR Photo 15. 29 April 1992

RR Photo 16. 19 January 1994

RR Photo 17. 25 July 1997


RR Photo 18. 25 July 1997

Inspection Summary Notes:

Items numbered 1-37 are from City inspection form, 1965-73.

"Non-form" items are from inspection narrative.

Entries indicating satisfactory behavior (*e.g.*, "good", "satisfactory", "none", "OK") generally are not reported in summary.

Items lacking any reportable entry are deleted from list.

Inspections lacking any reportable entry for a given channel are deleted from list.

Entries include both Corps and City inspections.

"Socorro Diversion" refers to structures in South-North channel above Nogal confluence.

"Nogal Confluence" refers to structures immediately impacted by junction.

"Socorro Outfall" refers to West-East channel to river

Matanza Diversion		18-Mar-65	17-Dec-65	2-Mar-66	22-Mar-66	28-Dec-66	31-May-67
Embankment , Concrete							
1	Erosion (wind and rain)						
3	Sand Boils						
5	Roadway					Slightly overgrown with tumbleweeds	
6	Channel Walls			Minor cracking			
7	Channel Bottom	Slight scouring	Moderate scour downstream of grouted section		Heavy scour downstream of grouted section		Some wild growth
8	Wild Growth (brush and trees)	Tumbleweeds			Some throughout channel bottom	Slight	On channel bottom
9	Overall			Flows have occurred			
Earth Sections							
11	Erosion			Minor			
13	Wild Growth	Tumbleweeds	Slight		Tumbleweeds		Some
French Drains							
15	Screens						
16	Proper Functioning						
17	Cleanouts						
Non-form							
	Gages			3 installed. 1 bent mental cover			
	Aggradation			Below NM 60			
	Weep holes			2 buried			
	Concrete						
	RR Bridge						

Matanza Diversion		9-Nov-67	13-Feb-69	13-Apr-69	21-Oct-69	2-Dec-69	28-Apr-70
Embankment , Concrete							
1	Erosion (wind and rain)						
3	Sand Boils						
5	Roadway						
6	Channel Walls						
7	Channel Bottom			Scouring below grouted section			Some scouring at grouted section
8	Wild Growth (brush and trees)	Numerous	Grass on crown	Minor	Some	Brush 4 ft high	Slight
9	Overall						
Earth Sections							
11	Erosion						
13	Wild Growth			Minor	Some		Slight
French Drains							
15	Screens			Some clogged	Some clogged	Blocked by blow sand	Slight plugging
16	Proper Functioning	80% plugged	Plugged				
17	Cleanouts		Stolen caps	Missing caps		Missing caps	
Non-form							
	Gages	Damaged				Broken	
	Aggradation	2-3 ft, 5-6 ft	Below RR bridge				
	Weep holes						
	Concrete	Minor cracks, local spalling				Hairline cracks. Repaired joint	
	RR Bridge		Piles deflect flow and constrict				

Matanza Diversion		17-Nov-70	20-Nov-70	26-Apr-71	13-Oct-71	6-Dec-72	14-Dec-72
Embankment , Concrete							
1	Erosion (wind and rain)						Each end of concrete
3	Sand Boils						Along sides
5	Roadway						
6	Channel Walls						
7	Channel Bottom						Rocks and silt
8	Wild Growth (brush and trees)		Minor				
9	Overall						
Earth Sections							
11	Erosion						Some
13	Wild Growth		Some	Little			Along edges
French Drains							
15	Screens		Some Plugged				Some plugged by silt
16	Proper Functioning						
17	Cleanouts	Missing caps	Some caps missing		Missing caps	2 missing caps. ruined fitting	
Non-form							
	Gages	Damaged			Repaired and damaged	Repair not recommended	
	Aggradation						
	Weep holes						
	Concrete	Minor spalling			Spalling	Bad joint	
	RR Bridge					Scour improved conveyance	Debris on upper side

Matanza Diversion		19-Dec-73	13-May-75	6-Apr-76	28-Mar-77	13-Feb-78	14-Dec-79
Embankment , Concrete							
1	Erosion (wind and rain)						
3	Sand Boils						
5	Roadway						
6	Channel Walls						
7	Channel Bottom						
8	Wild Growth (brush and trees)						
9	Overall						
Earth Sections							
11	Erosion	Shifting south.					
13	Wild Growth		Modest grass				
French Drains							
15	Screens						
16	Proper Functioning	Covered					
17	Cleanouts				2 missing caps		
Non-form							
	Gages	Eroded around one gage. Strips loose	Abandoned				
	Aggradation						Aggraded 1 ft
	Weep holes						
	Concrete	Excessive spalling			Failed joint	Slab still working	
	RR Bridge		Removed	Site needs levee filling			

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Matanza Diversion		9-Jun-81	17-Nov-81	18-Mar-83	8-Apr-87	28-Jun-89	9-Aug-91
Embankment , Concrete							
1	Erosion (wind and rain)						
3	Sand Boils						
5	Roadway						
6	Channel Walls						
7	Channel Bottom						
8	Wild Growth (brush and trees)						
9	Overall						
Earth Sections							
11	Erosion						
13	Wild Growth						
French Drains							
15	Screens						
16	Proper Functioning						
17	Cleanouts						
Non-form							
	Gages						
	Aggradation						3-6 ft silt
	Weep holes						
	Concrete	Repaired joint spalling again	Spalling joint	Spalling joint	Joint breaking loose	Joint breaking loose	
	RR Bridge						

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Socorro Diversion		18-Mar-65	17-Dec-65	2-Mar-66	28-Dec-66	31-May-67	9-Nov-67
Embankment							
18	Erosion	Slight	Some backslope			Some on west bank	
19	Settlement						
20	Sand Boils						
21	Seepage						
22	Roadways				Some blading required		Holes in road by burrowing animals.
23	Overall				Considerable growth in channel bottom caused by water tank overflow	Water tank spill diverted	Elm trees
25	Missing Stones						
Timber Bridge							
26	Clear Opening						
Non-form							
	Deposition			Silt from bank cut. Needs local cutoff. Ponding			
	Gages			3 installed			
	Vegetation			Some			
	Smelter Arroyo						
	Tanks						
	Access						
	Concrete						

Socorro Diversion		13-Feb-69	13-Apr-69	21-Oct-69	2-Dec-69	28-Apr-70	17-Nov-70
Embankment							
18	Erosion	Gullies	Scattered	Some scattered	Finger gullies	Slight	Uncontrolled gully from water tank
19	Settlement						
20	Sand Boils						
21	Seepage						
22	Roadways						
23	Overall						
25	Missing Stones						
Timber Bridge							
26	Clear Opening	Damaged in 67. 5.5 ft clearance			4.75 ft clearance		
Non-form							
	Deposition						
	Gages						
	Vegetation	Returning			Salt cedar		
	Smelter Arroyo				12 ft retention structure uncompleted. No Corps review		Dam seems unsatisfactory
	Tanks						
	Access						
	Concrete						

Socorro Diversion		20-Nov-70	26-Apr-71	13-Oct-71	6-Dec-72	14-Dec-72	21-Aug-73
Embankment							
18	Erosion	Some cut in slopes	Some	Small gullies	City repairs lost	Some along west side	
19	Settlement					Spot or two	
20	Sand Boils					Few	
21	Seepage						
22	Roadways	Some gullies eating into levee tops				Some erosion	
23	Overall	Tree growth to be removed					
25	Missing Stones					2 locations. Removed for public assess	
Timber Bridge							
26	Clear Opening			4.5 ft			
Non-form							
	Deposition						Insufficient cleaning.
	Gages					Damaged	
	Vegetation			8-10 ft salt cedar			Tumbleweeds burned.
	Smelter Arroyo			Dam still unacceptable	Not modified		
	Tanks				Look to be soon placed in channel. NMIMT denies.		Tanks installed
	Access				NMIMT has closed more roads.		
	Concrete						Cracks widening and spalling

Socorro Diversion		19-Dec-73	13-May-75	6-Apr-76	28-Mar-77	26-Feb-79	6-Aug-80
Embankment							
18	Erosion						Few gullies
19	Settlement						
20	Sand Boils						
21	Seepage						
22	Roadways						Homeowner encroachment
23	Overall						
25	Missing Stones	Removed for motorcycle access					
Timber Bridge							
26	Clear Opening		Replaced by culverts		Culverts plugging		
Non-form							
	Deposition						
	Gages	Damaged					
	Vegetation		Elms in channel		Mature salt cedar	Established salt cedar	
	Smelter Arroyo	Section lowered. Retains little water	Dam breached				
	Tanks	Removed	Original shape restored				
	Access			Blocked by NMIMT			
	Concrete						

Socorro Diversion		9-Jun-81	17-Nov-81	18-Mar-83	27-Sep-84	8-Apr-87	28-Jun-89
Embankment							
18	Erosion		Gullies used for playhouse	Gullies as play areas			
19	Settlement						
20	Sand Boils						
21	Seepage						
22	Roadways					Ramps have displaced riprap	
23	Overall						
25	Missing Stones						Removed for bridge construction
Timber Bridge							
26	Clear Opening	Driftwood on span					
Non-form							
	Deposition						Dirt piled in channel
	Gages						
	Vegetation		Elms	Salt cedar	10 ft elms		
	Smelter Arroyo						
	Tanks						
	Access			Restricted by NMIMT			
	Concrete						

Socorro Diversion		10-Apr-91	9-Aug-91	1-Apr-94
Embankment				
18	Erosion			
19	Settlement			Sink holes at sewer line
20	Sand Boils			
21	Seepage		Piping at high flows	Piping
22	Roadways			Rills
23	Overall			
25	Missing Stones	Replaced		
Timber Bridge				
26	Clear Opening			
Non-form				
	Deposition			
	Gages			
	Vegetation	Young and few		
	Smelter Arroyo			
	Tanks			
	Access			
	Concrete			

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Nogal	Confluence	2-Mar-66	9-Nov-67	13-Feb-69	2-Dec-69	13-Oct-71	6-Dec-72
Non-form							
	Gages	7 near confluence		Poor condition	Covered with sand		
	Riprap	Toe erosion	Minor damage				
	Levee	Potential breach	Breach possible.				Channel is cutting closer
	Deposition		1-6 ft	Copious amounts			
	Floodway					Spoil dumped in flow path	
Outfall		**2-Mar-66**	**28-Dec-66**	**9-Nov-67**	**4-Jun-68**	**13-Feb-69**	**13-Apr-69**
Embankment , Concrete							
27	Channel Walls		Slight cracking	Numerous cracks. Spalling		Continuous cracks	
French Drains							
35	Screens			All clogged			Some clogged
36	Proper Functioning				Buried		
37	Cleanouts				Stolen caps		
Timber Bridge							
38	Clear Opening					Original 10.3 ft clearance. Now 6 ft	
Non-form							
	Concrete	Hairline cracks and spalling					
	Weep holes	Covered with blow sand					
	Deposition	Above RR bridge		2-4 ft	0-3 ft		
	Vegetation	Some		Native grass			
	Gas line			No Corps approval		Corps' requests unanswered	

Nogal	Confluence	19-Dec-73	13-May-75	6-Apr-76	28-Mar-77	13-Feb-78	26-Feb-79
Non-form							
	Gages						
	Riprap						
	Levee			Bank cut toward levee			
	Deposition	Accumulation	Large quantities		2 ft boulders		100,000 CY confluence. 100,000 CY downstream
	Floodway				City added small deflector dike	Dike untested	
Outfall		**21-Oct-69**	**2-Dec-69**	**17-Nov-70**	**20-Nov-70**	**26-Apr-71**	**6-Dec-72**
Embankment , Concrete							
27	Channel Walls						
French Drains							
35	Screens	Scattered clogging			Some silt covered		
36	Proper Functioning						
37	Cleanouts			44 missing caps			
Timber Bridge							
38	Clear Opening	Some growth			Restricted by silt from Nogal	Silt restricting cross section	Higher sediment
Non-form							
	Concrete						
	Weep holes						
	Deposition		Continues				Clogging outfall
	Vegetation						
	Gas line		Being improved				

Nogal	Confluence	6-Aug-80	17-Nov-81	18-Mar-83	27-Sep-84	8-Apr-87	28-Jun-89
Non-form							
	Gages						
	Riprap						
	Levee		Will be undercut	18 ft from channel	16 ft from channel	Channel a few ft away	Creeping closer
	Deposition		Broad delta		Fans across diversion channel	Major problem below	
	Floodway	Dike failed					
Outfall		**14-Dec-72**	**19-Dec-73**	**13-May-75**	**6-Apr-76**	**28-Mar-77**	**13-Feb-78**
Embankment , Concrete							
27	Channel Walls		Need rundowns				Scalped 1 ft. Many encroachments
French Drains							
35	Screens						
36	Proper Functioning	Covered	Silted over				
37	Cleanouts		Spalling				
Timber Bridge							
38	Clear Opening	4.5 ft	10 ft ditch cut to river	8 ft. Pilot channel abandoned.	7.3 ft. 2-3 ft pilot channel filling with blown sand		6.5-7 ft
Non-form							
	Concrete			Cracks growing		More spalling on north wall	
	Weep holes						
	Deposition					Not removed	
	Vegetation						
	Gas line						

Nogal Confluence		10-Apr-91	28-Apr-92				
Non-form							
	Gages						
	Riprap						
	Levee	Direct attack	Continued undercutting				
	Deposition						
	Floodway						
Outfall		**26-Feb-79**	**14-Dec-79**	**6-Aug-80**	**16-Sep-70**	**17-Nov-81**	**18-Mar-83**
Embankment , Concrete							
27	Channel Walls						
French Drains							
35	Screens						
36	Proper Functioning						
37	Cleanouts						
Timber Bridge							
38	Clear Opening			7.5 ft		Needs excavation	10 ft
Non-form							
	Concrete	Spalling on north side				Cracks continue	
	Weep holes						
	Deposition	Aggrading river works against outfall	4600 CY/yr. Less than expected		500 cfs. Large deposits	Ineffective cleaning and trenching	
	Vegetation						
	Gas line						

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Nogal Confluence							
Non-form							
	Gages						
	Riprap						
	Levee						
	Deposition						
	Floodway						
Outfall		**27-Sep-84**	**28-Jun-89**	**10-Apr-91**	**28-Apr-92**	**1-Apr-94**	
Embankment , Concrete							
27	Channel Walls						
French Drains							
35	Screens						
36	Proper Functioning						
37	Cleanouts						
Timber Bridge							
38	Clear Opening						
Non-form							
	Concrete						
	Weep holes						
	Deposition	Rio Grande 7-8 ft lower. Time to pilot	Tens of thousands CY removed	No pilot channel	Pilot working	Accumulates	
	Vegetation				Excessive		
	Gas line						

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Collier's copy

30 Sep 70

Information Summary

Smelter Arroyo Dam, Socorro Diversion Channel

1. This work was first seen, photographed, and reported 12 February 1969. The report recommended we "consider the work being done in Smelter Arroyo".

2. Letter, D.E. to City, 1 April 1969: We told the City this work is an encroachment, prohibited in the O&M manual. We asked for "a complete set of plans".

3. Letter, City to D.E., 15 April 1969: Response to above letter. No mention of subject dam.

4. Letter, D.E. to City, 28 April 1969: We again asked for "a complete plan of this work".

5. Letter, City to D.E., 13 May 1969: Mr. Senn stated "the dam is being mapped, plans will be sent you when completed".

6. The dam, now complete, was photographed and reported on 2 December 1969. The report recommended we "evaluate the desirability" of the dam.

7. Letter, D.E. to City, 6 January 1970: We again asked "please have a copy of the plans forwarded -----".

8. Letter, City to D.E., 2 February 1970: Response to above letter. No mention of subject dam.

9. Letter, D.E. to City, 12 February 1970: We again asked for "a set of these plans".

10. Letter, D.E. to City, 8 May 1970: We again asked for "plans of the earth dam".

11. Letter, City to D.E., 25 May 1970: Plan was submitted. Copy of entire plan is attached.

12. The contour lines on the City plan coincide exactly with the Corps drawing. So do the "right-of-way" and "channel flow" lines. The dam crest elevation and levee crest elevations coincide (4718 feet). The channel floor elevation is shown as 4704 on both places.

It is apparent to me that little or no mapping was done and that the City has a full size Corps drawing on hand.

13. At Smelter Arroyo, the design capacity of the Socorro Channel increases from 3800 to 5100 c.f.s., inferring a contribution from Smelter Arroyo of about 1300 c.f.s. The figures used in the Design Memo for Standard Project Flood (for Smelter Arroyo) were around 1700 c.f.s. Watershed area is 1.19 Sq.mi.

Spillway capacity cannot be computed from the plans submitted by the City, but it appears to me to be far below the 1300 to 1700 c.f.s. value.

15. The plan does not show any riprap areas, stability analysis, drawdown provision, and other salient data. Mr. Senn, the designer, is reputed to be a Registered Engineer (New Mexico).

16. Jim Constant tells me the State Engineer requires review and prior approval for all dams over 10 feet high, or impounding over 10 acre-feet of water. This work exceeds both of these figures.

17. Summarizing, the subject dam:

a. Is an encroachment.

b. Probably has insufficient spillway capacity.

c. May be of inadequate design.

d. Was built in violation of Corps regulations.

e. Was built in violation of State regulations (probably).

f. May severely impair the design performance of the Socorro Diversion Channel.

18. The past 7 years of dealing with the City of Socorro have been most frustrating. Very little has been done as a result of Corps letters and telephone calls. Personal contact has done little better. The Contract 63-2 file documents these comments adequately.

I recommend we take a stiffer posture in this matter, and explore new paths of remedial action.

Frank B. Collins

FRANK B. COLLINS
Civil Engineer
Project Operations Branch

++++++++++++++++ **The End** ++++++++++++++

Any questions, please contact info@pdhnow.com

QUIZ for Socorro Diversion Channel

1. A “seep willow” is

a. Unacceptable vegetation because it blocks channel

b. Acceptable of most projects

c. Acceptable for this project because it only takes root at the channel edges

d. Unacceptable because it might grow out into the middle of the channel

e. All channel vegetation must be destroyed to avoid turning into a wetland

2. Channel outfalls that accumulate sediment can be drained by

a. Cutting a pilot channel

b. Planting trees

c. Doing nothing

d. Putting a footpath in the channel

e. Installing a multiuse recreational area

3. Pilot channels in sediment accumulation areas tend to

a. Make great public footpaths

b. Induce “head cutting” that drains sediment accumulation

c. Fill in quickly

d. Save on fuel and labor cost to remove sediment

e. “b” and “d”

4. Small communities

a. Find maintenance of flood control channels to be an easy task

b. Small communities have little difficulty funding maintenance

c. Small communities usually have experienced engineering staff available

d. Small communities usually have the equipment to haul large amounts of sediment

e. “a”, “b”, “c”, and “d” are false

5. Project sponsors and other nearby public entities

a. Can be counted on to avoid dumping trash in flood control works

b. Will avoid building illegal, unsafe dams

c. Will avoid building obstructions to flow in the channel

d. “a”, “b”, and “c” are false

e. “a”, “b”, and “c” are true

6. Power poles

a. May be placed in a flood control channel since it seldom rains in the desert

b. May partially block flow during a large flood

c. May be knocked down during a large flood by floating debris

d. “b” and “c” are true

e. May be legally be placed in a flood control channel if approved by local authorities

7. Headcut

a. Is an erosional feature of some intermittent and perennial streams with an abrupt vertical drop, also known as a knickpoint, in the stream bed.

b. Has its origins in eighteenth-century France as a practice to encourage inspectors to submit their reports in a timely manner.

c. Can be useful to remove excess sediment.

d. “a”, “b”, and “c” are true.

e. “a” and “c” are true.

8. Local protection flood control projects built by the Federal government and turned over to local sponsors for maintenance

a. Should be inspected by local sponsors annually and after large floods

b. Need to be inspected by an independently funded agency to ensure compliance with project requirements

c. Are in a category of “Set it and forget it.”

d. May be modified by the local sponsors if all local authorities agree

e. “a” and “b”

9. Local land developers

a. Can be counted on to respect flood control project integrity

b. May pressure local authorities for approval of unsafe flood control practices

c. May build in or on a flood control structure without a permit

d. “a” and “c” are true

e. “b” and “c” are true

10. Tributaries to a flood control channel

a. Can erode flood control channel banks

b. May dump huge amounts of sediment during large floods which, could block the flood channel flow

c. “a” and “b” are false

d. “a” and “b” are true

e. Should be ignored during project design because tributary problems are hard to predict

11. Floods can be counted on to wash out accumulated sediment

a. True

b. False

12. Gates across levees that the city (public sponsor) does not have a key for

a. Are necessary to reduce off-road vehicle noise

b. Are acceptable if installed by another government agency

c. May hinder city (public sponsor) access during a levee flood fight

d. “a”, “b”, and “c” are true

e. “a” and “c” are true

13. Piping

a. May cause levee failure

b. May cause sinkholes

c. Can be caused by shoddy construction

d. Can be caused by rodents

e. “a”, “b”, “c”, and “d” are true

14. Steel covered peak flow gages on the sides of sloped concrete channels

a. May get pelted with rocks and destroyed

b. Are tough enough to withstand flow debris abrasion

c. Can be safely read during the flood by carefully climbing down the side of the channel for an accurate reading

d. “b” and “c” are true

15. Vertical peak gages on the side of a flood control channel for three decades Ans. b

a. Shows just how smart the designers were

b. Are lucky to have not gotten knocked flat during a large flood

16. Weepholes in the Socorro concrete channel were not needed

a. True

b. False

17. Concrete patching over cracked concrete flood control channels will be unlikely to endure if the crack was caused by differential settling.

a. True

b. False

18. Trees and large vegetation should be removed from channel floors because

a. They block flow

b. They catch floodwater debris and block flow

c. They slow the water down and may cause sediment to accumulate (reducing channel capacity below design values)

d. “a”, “b”, and “c”

e. “a” and “b”

19. Sediment accumulation under a railroad track near the lower end of the channel before water runs into the Rio Grande should be removed because

a. Sediment accumulation in a flood control channel reduces channel capacity

b. Hikers may injure their heads trying to get under the railroad bridge

c. It looks unsafe

d. Sediment removal is unnecessary

e. The city needs the levee maintenance money for street repairs. So they are exempt from sediment removal requirements

20. Moderate sized gullies in dirt channel walls

a. Give children a safe place to play

b. Can be ignored

c. Should be repaired to avoid compromising channel performance

d. “a” and “b”

e. “a”, “b”, and “c”

21. One photo shows a Corps inspector standing upstream of the railroad bridge with his hand on an arched concrete portion of the railroad pier. The purpose of the arch is

a. To flip floodwaters back into the stream

b. Keep the train and train track from getting wet

c. “a” and “b”

22. The Socorro Diversion Channel is composed of

a. Two independent channels

b. Matanza Diversion and Socorro Diversion

c. Rio Grande and Matanza Diversion

d. Rio Grande and Socorro Diversion

e. “a” and “b”

23. The outlet of the Socorro Diversion Channel

a. Is constantly aggrading (collecting sediment)

b. Is constantly degrading

c. Is a multiuse recreational area

24. The pilot channel in the Socorro Diversion Channel outlet

a. Induces head cutting upstream in the concrete channel

b. Is a necessary maintenance item

c. Furnishes a gentle off-ramp for skateboarders

d. “a” and “b”

25. Reasons for the City of Socorro’s marginal maintenance included a lack of engineering expertise and personnel turnover

a. True

b. False

26. Sediment from tributary flow

a. Usually flows downstream in the main channel

b. Potentially could plug the main channel before the peak flow in the main channel arrives. This could cause channel failure and widespread flooding.

c. Can form a wetland that can require a 404 permit to dredge to restore the main channel to its design capacity.

d. All of the above

27. The channel under the railroad bridge over the Socorro Diversion Channel

a. Has had a consistent flow capacity

b. Has had at least a design capacity

c. Has required massive efforts by the sponsor to clean to even marginal capacity levels

28. Socorro, NM, is the public sponsor for the Socorro Diversion Channels. As such, they are responsible for inspecting, maintaining, informing the Corps of Engineers (who built the project for them) of significant changes, and obtaining permission for any alteration to the structure.

a. True

b. False

29. The Socorro Diversion Channel was designed for a

a. 100-year flood

b. Standard Project Flood (SPF)

c. Probable Maximum Flood (PMF)

d. Flood of Record in Socorro

30. The Socorro Diversion Project was constructed

a. During the 1950s

b. During the 1960s

c. During the 1970s

d. During the 1980s

e. During the 1990s