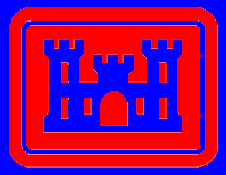
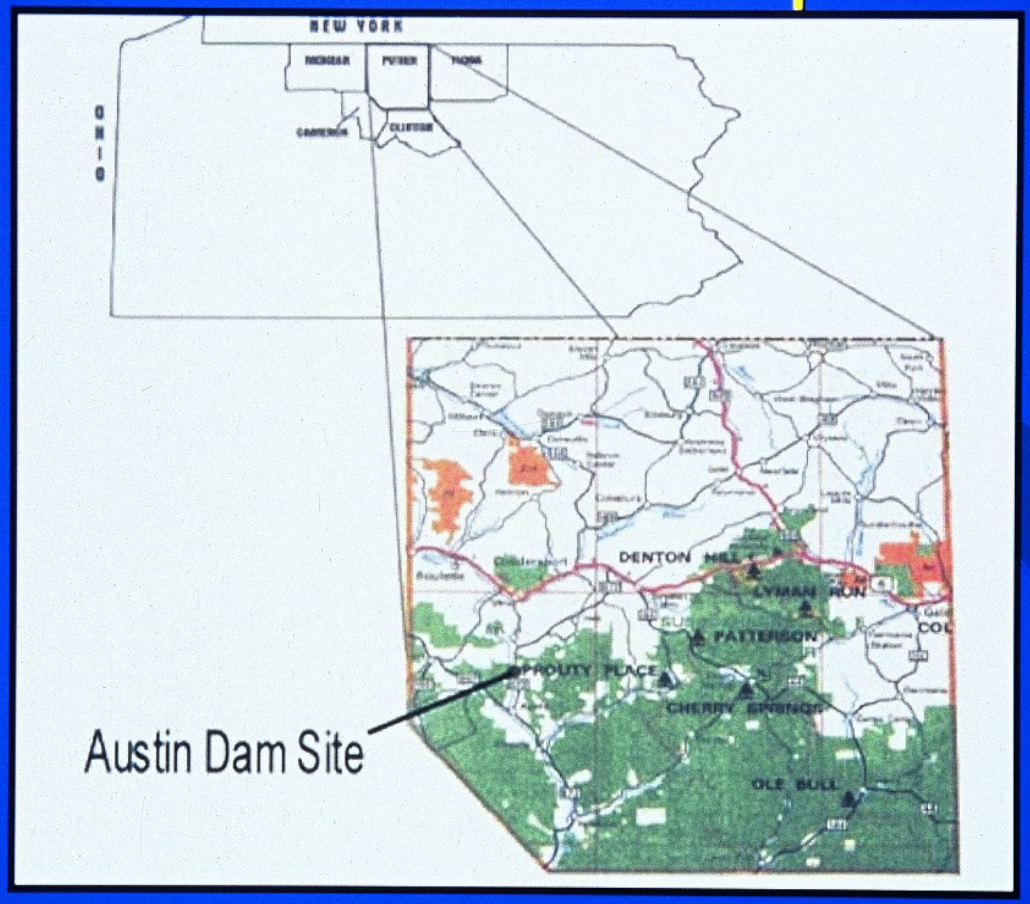


US Army Corps
of Engineers
Pittsburgh District

The Sliding Failure of Austin Dam Pennsylvania - Revisited

Brian H. Greene, Ph.D. P.G.

Location Map



The Austin dam is located 26 miles south of the New York border, and 15 miles from Coudersport, PA (county seat) on Rt. 872.

General Information

- **Type of Dam:** Concrete Gravity
- **Project Engineer:** T. Chalkley Hatton
- **Owner of Dam:** Bayless Pulp and Paper Company
  "Bayless Dam"
- **Construction Material:** Cyclopean Concrete
- **Foundation:** Horizontally bedded sedimentary rocks

- **Date Construction Completed:** December 1909
- **Date of Initial Distress:** Jan 1910 (only 6 weeks later)
- **Date of Final Failure:** September 30, 1911
- **Death Toll:** 78

Austin Dam Statistics

- 544 ft. long
- 60 ft. high(bottom to top
- 30 ft. wide at base
- Cut-off wall 4 ft.thick & 4 ft. deep
- Designed for water depth of 42.5 ft
- 1 ¼ inch steel rods installed 5 ft. inside the vertical face

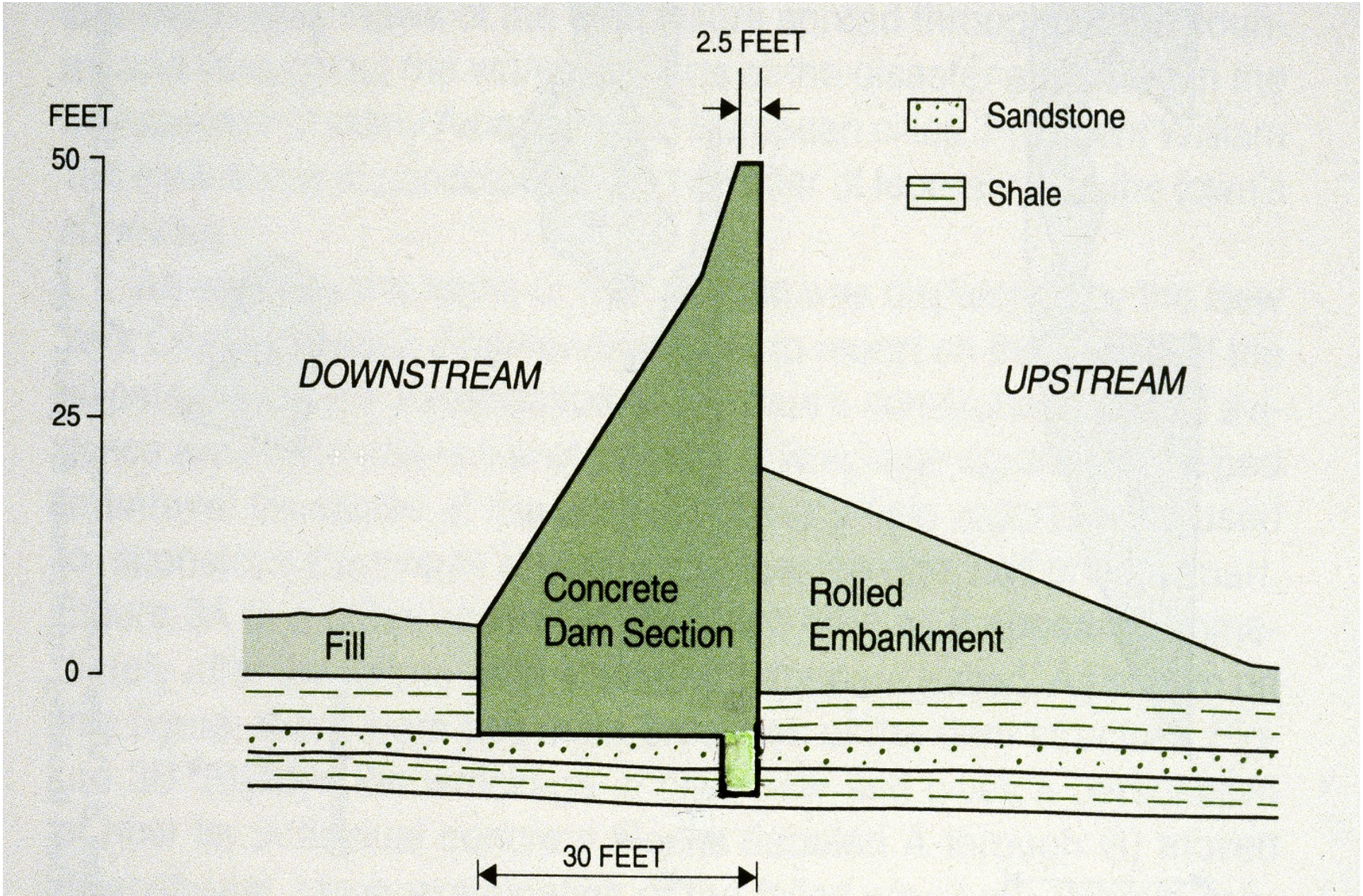
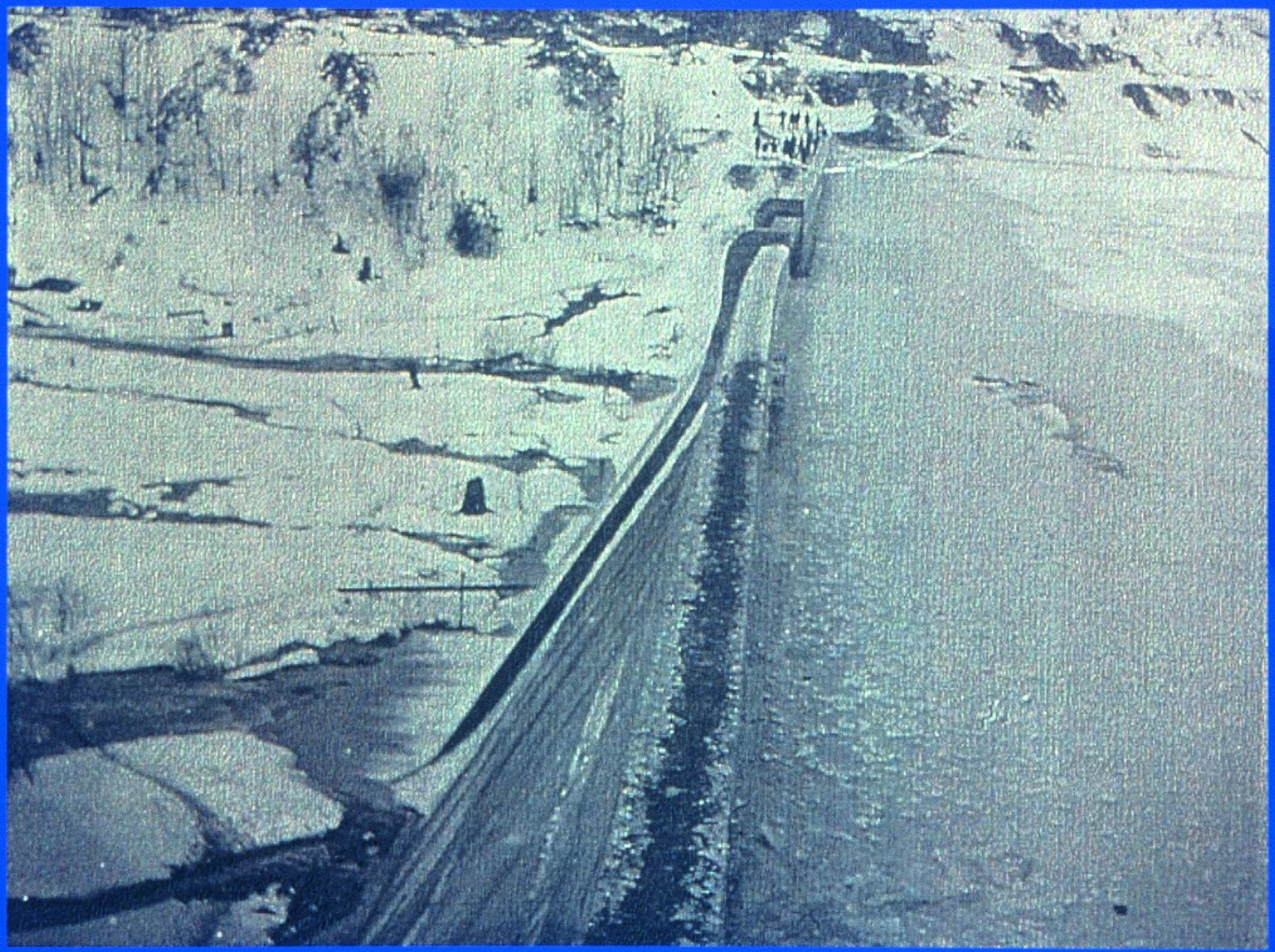


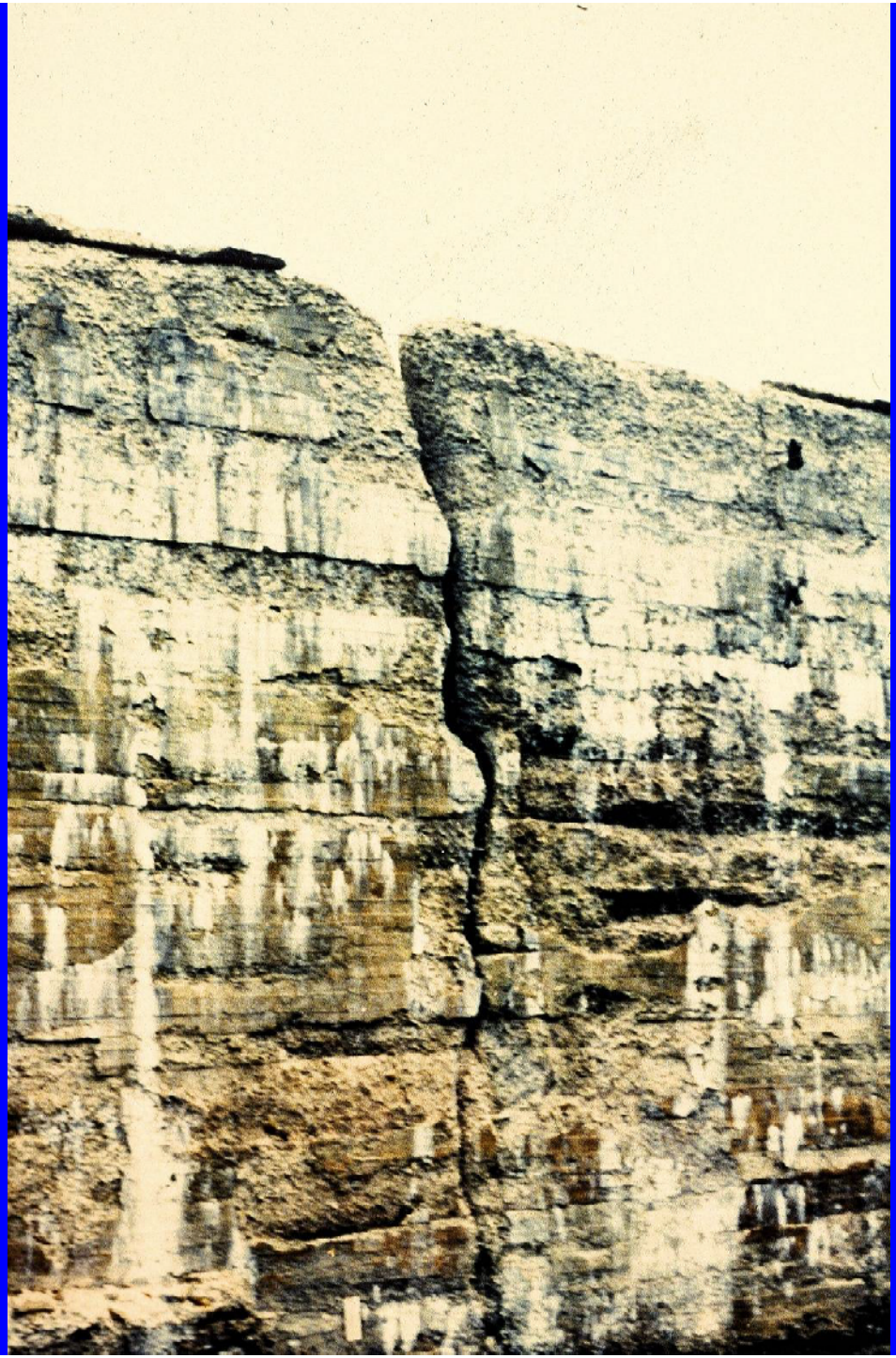
Figure 4. Prefailure cross section of Austin Dam at Block "D."

Leaking Dam

- First filling in January, 1910
- Extensive leaks developed downstream of toe and abutments
- Slid forward 18 inches at base
- Blasting used to drain water
- It was observed that the rock foundation had slid forward with the dam

View West of Sliding Failure






BAILESS DAM

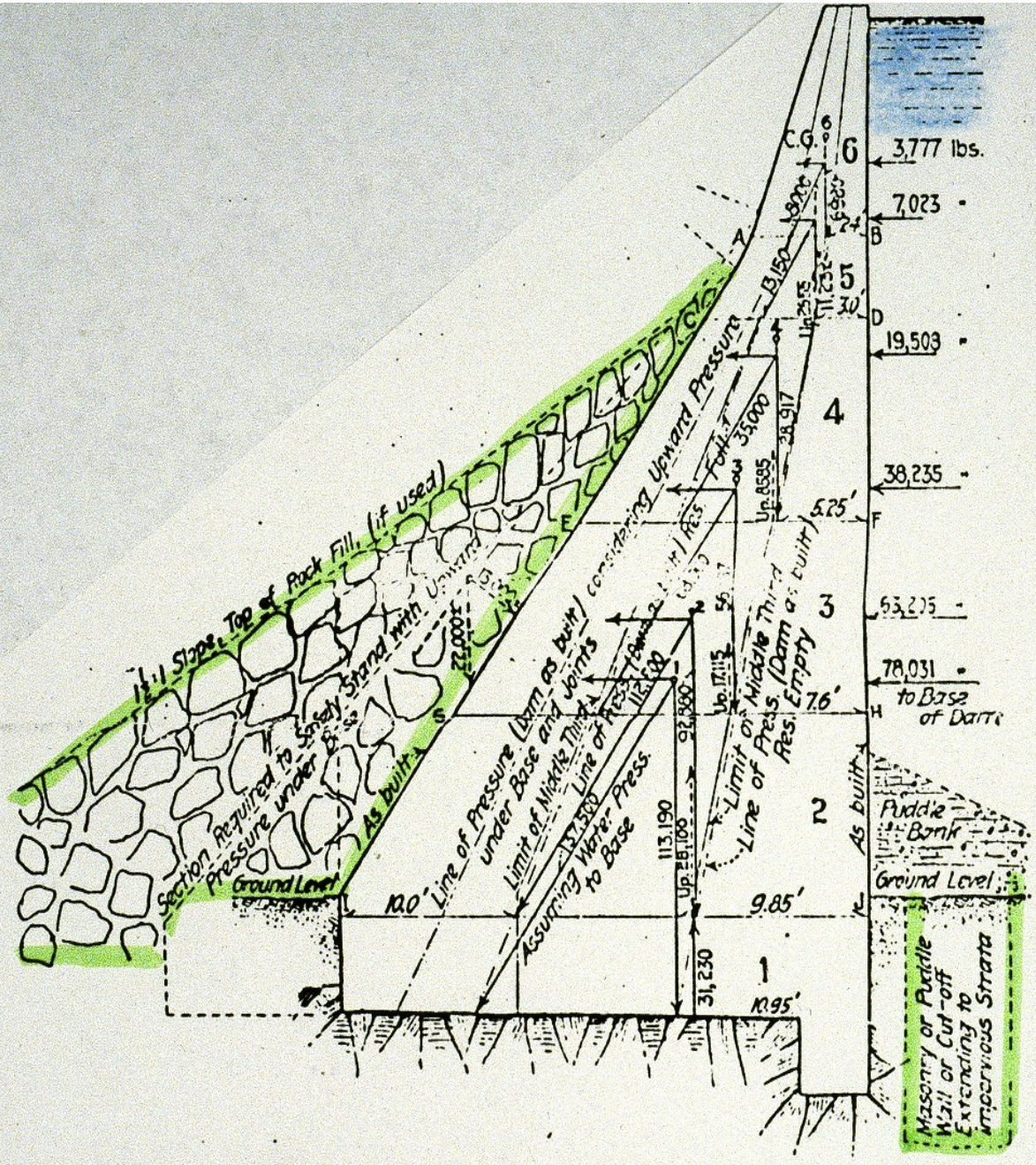
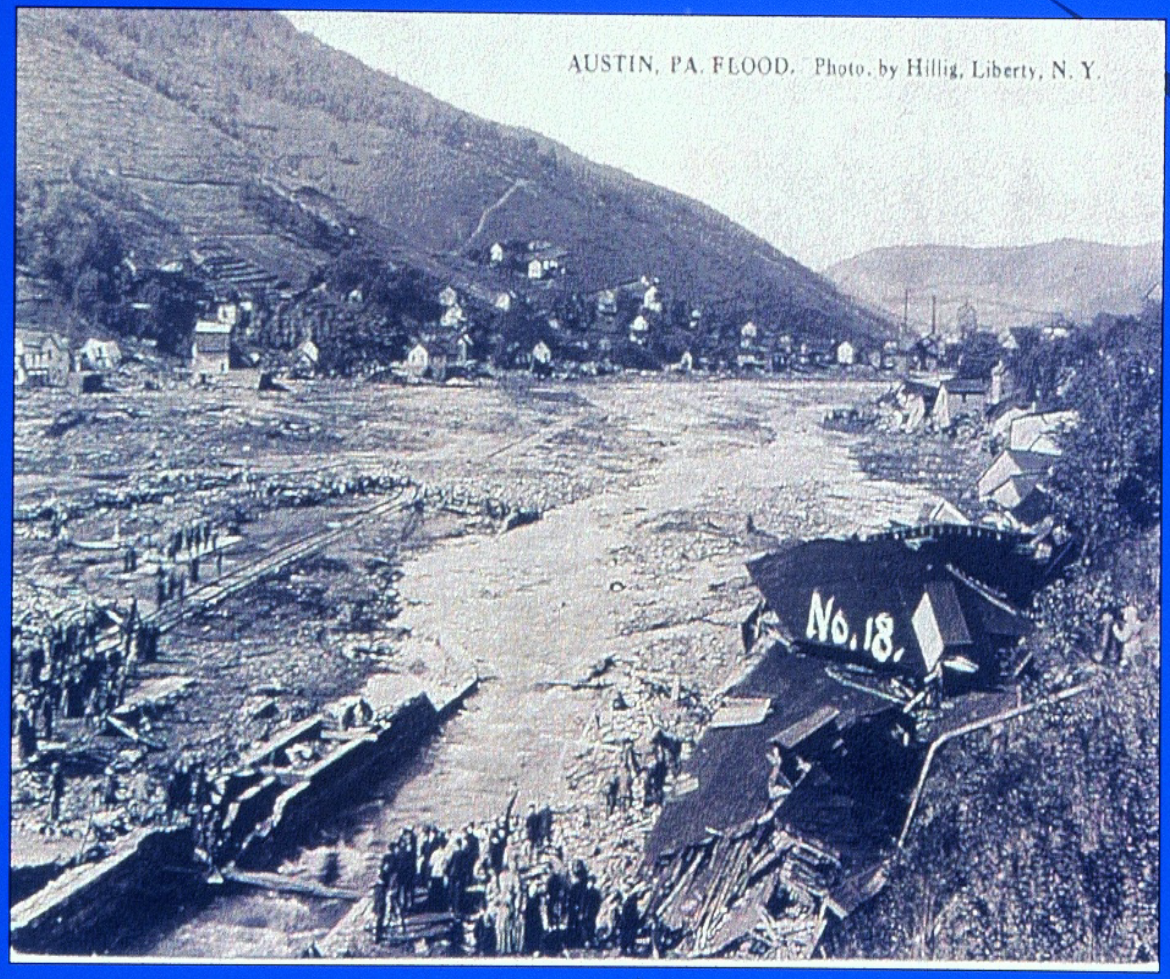


FIG. B.— STUDIES FOR REINFORCING MASONRY DAM AT AUSTIN, PA.
FEB. 14, 1910: E. WEGMANN, CONSULTING ENGINEER.

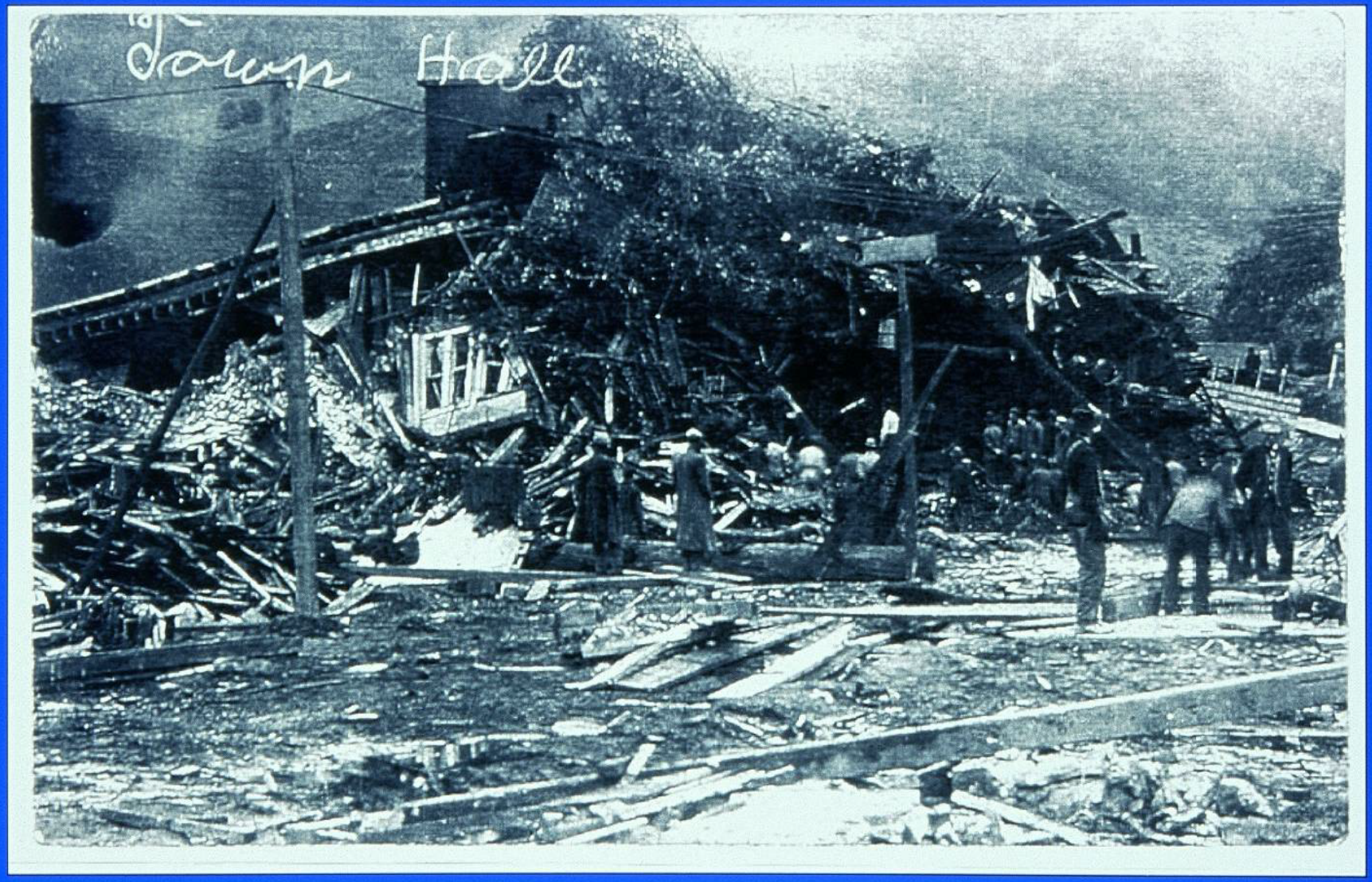
Plan and elevation of the failed dam

Freeman Run valley after failure



- Seven factories destroyed and railroad destroyed
- Damages estimated between 3 to 6 million dollars
- 78 deaths reported
- No definite cause of failure documented

Austin Town Hall after failure



2000-2005 Geotechnical Study and Reconstructed Stability Analysis

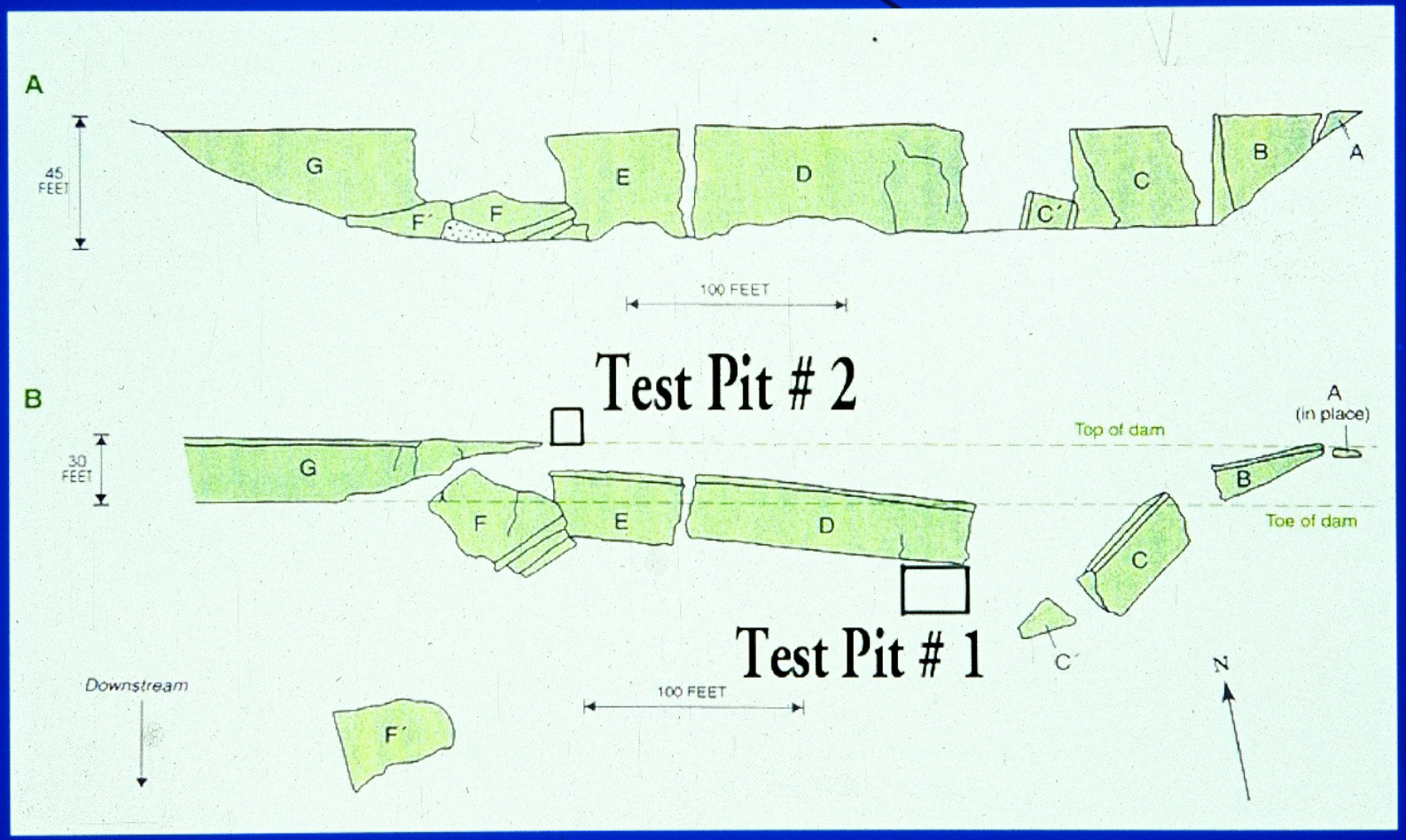
Objectives of Study

- Obtain surface and subsurface geologic information with reference to the suspected modes of failure
- Determine the engineering properties of foundation rock, aggregate, and concrete
- Using the above information, determine the most likely cause of the sliding failure of the Austin Dam
- Investigate the possibility of other modes of failure (overturning and crushing of concrete

Field Methodology

- General geologic column and description
- Description of stratigraphic section at foundation
- Detailed line survey
- Collection of concrete, aggregate, and rock samples for laboratory testing
- Test pitting to explore foundation and hydrolgic conditions

Plan and elevation of the failed dam

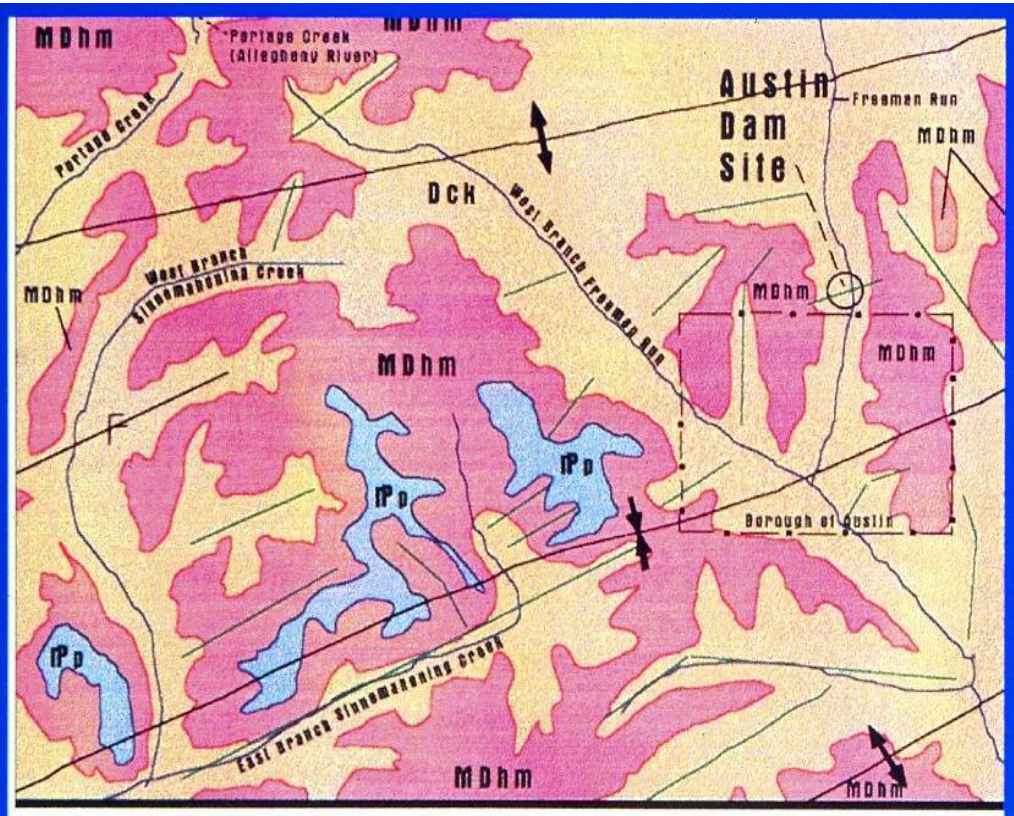


Test pit # 1

- Approx. depth of pit 12.5 ft.
- Water encountered at a depth of 2 ft.
- Sandstone (foundation material) at depth of 9.5 ft.
- Permeability of gravel and sand above sandstone approx. 2.6 cm/s (by recovery method)
- Clear water observed coming from under the dam into the pit

Test pit # 2

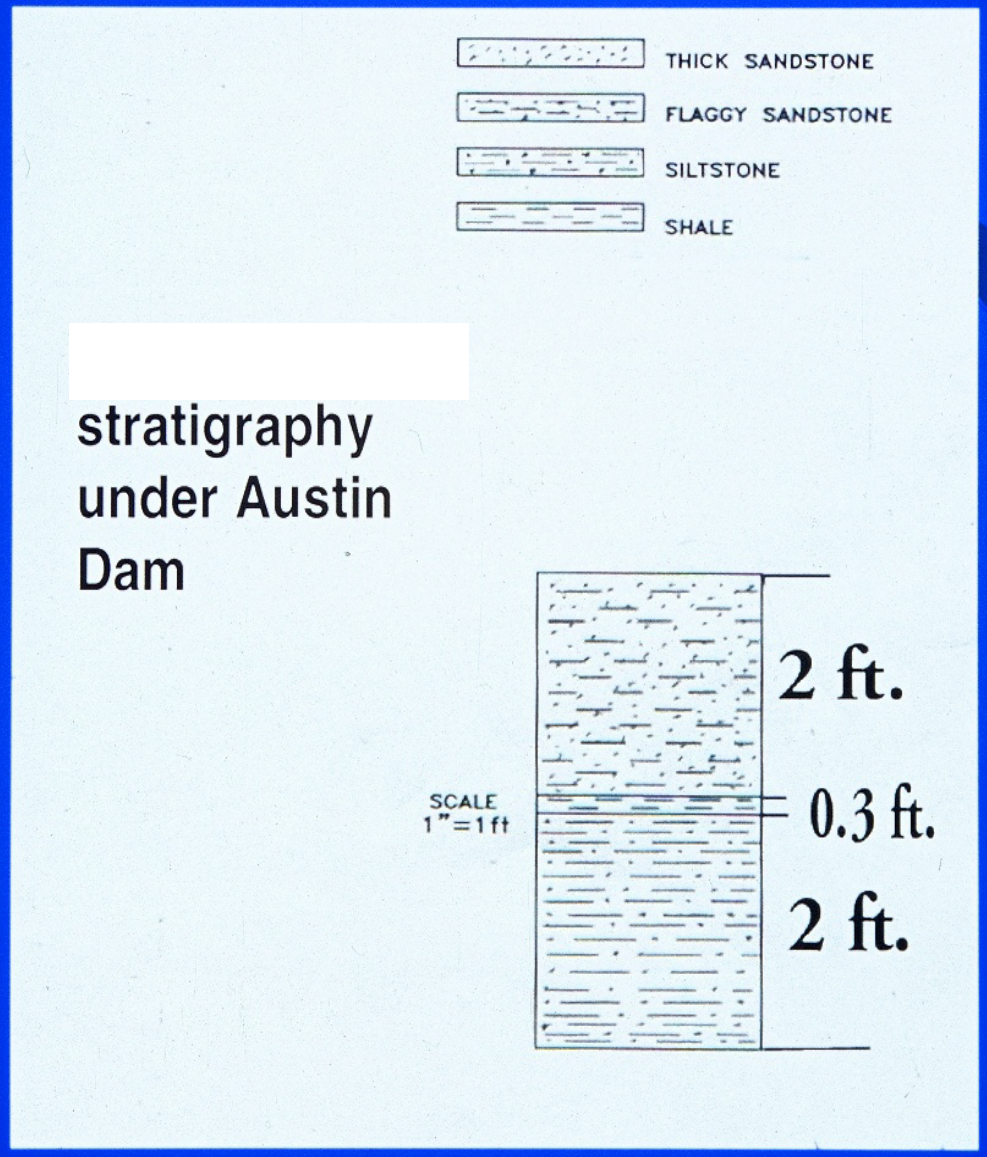
- Approx 8 ft. deep.
- Slow seepage of water.
- 2 ft. of sandstone encountered at an approx. depth of 5 ft.
- Shale found underneath the sandstone, shale interlayered with clay seams.



Geologic Map

- Devonian-age sedimentary rocks
- Main stream trends controlled by jointing
- Tributary stream trends in trellis pattern, and believed to follow subsurface structure

Subsurface (foundation)stratigraphy



Laboratory Methodology

- Index Tests (grain size, Atterberg limits) on soft rocks for classification
- Unconfined compression tests on concrete, foundation rock, and aggregate
- Permeability test on clay blanket
- Direct shear tests on foundation material:
  - concrete against sandstone
  - sandstone against sandstone
  - sandstone against shale
  - shale against shale

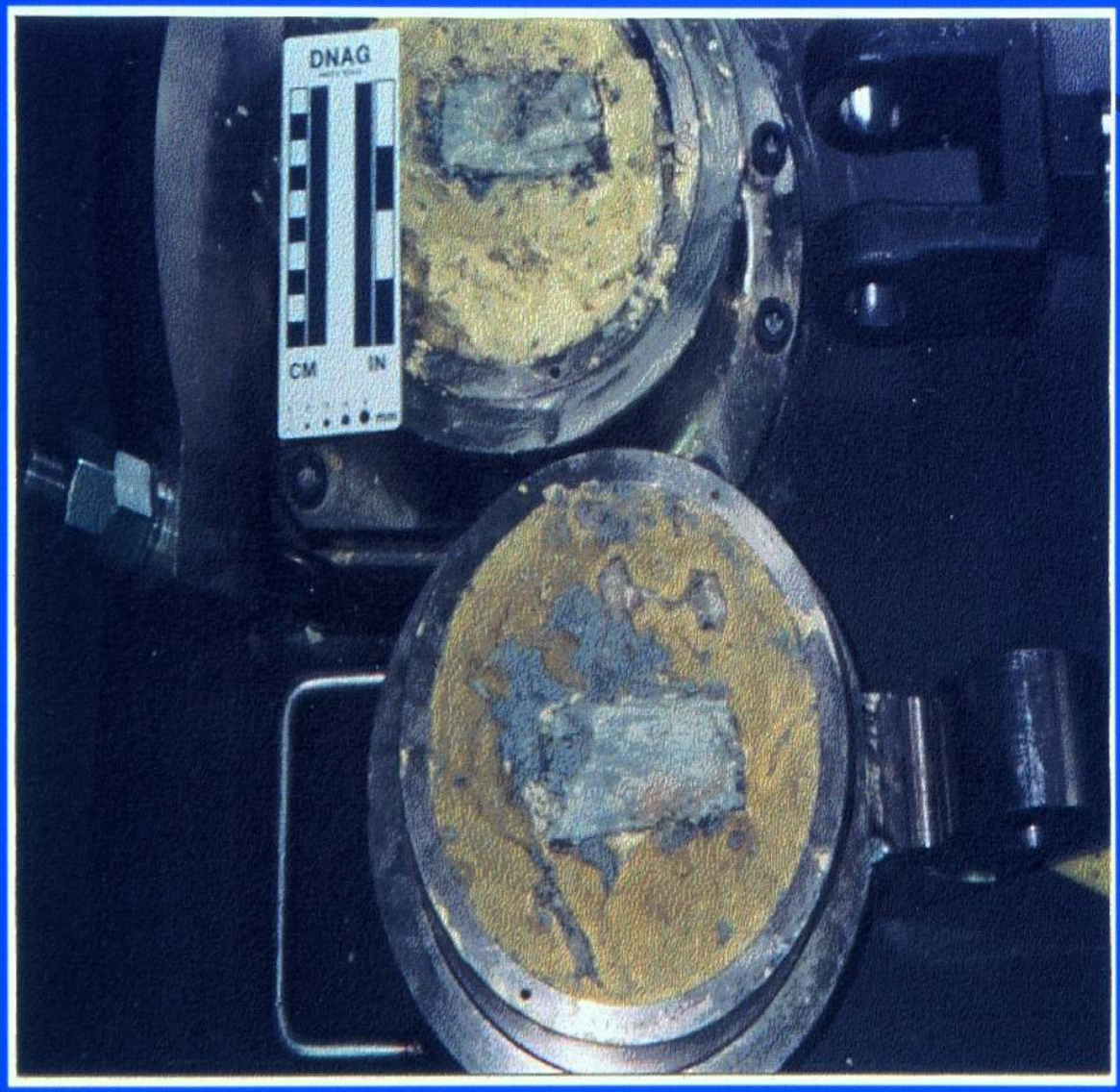
Unconfined compression test results

Material	Uconf. Comp. strength (psi)	Tensile Strength (psi)
Foundation sandstone	23374	
Concrete	3805	349
Cyclopean Aggregate	21107	

Direct shear testing apparatus

Structural Behavior Engineering Laboratories, Phoenix, AZ

Direct shear sample preparation

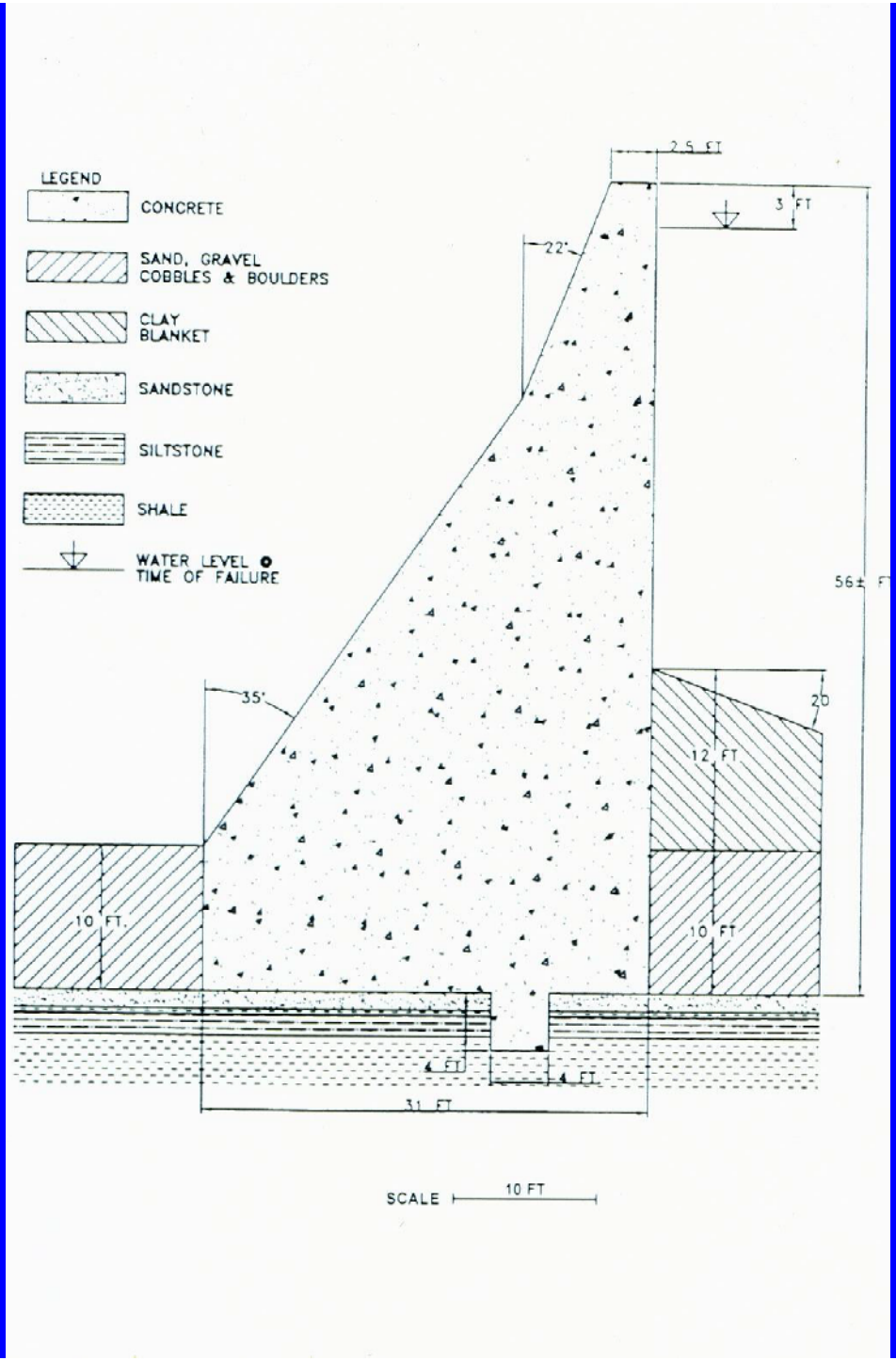


Samples tested according to their stratigraphic order in the foundation of the dam

Results of stability analysis

Shear Strength Test Results

Material	Cohes-ion (lb/ft^2)	Friction Angle (°)	
Concrete over Sandstone	15000	25	
Sandstone over Sandstone	5984	31	
Sandstone over Shale	0	25	
Shale over Shale	3371	25	


LEGEND
CONCRETE
SAND, GRAVEL
COBBLES & BOULDERS
CLAY
BLANKET
SANDSTONE
SILTSTONE
SHALE
WATER LEVEL ⊙
TIME OF FAILURE
2.5 FT
3 FT
22°
56± FT
35°
20
12 FT
10 FT.
10 FT
4 FT
4 FT
31 FT
SCALE
10 FT

Results of stability analysis

Material	Cohes-ion (lb/ft^2)	Friction Angle (°)	Factor of Safety (sliding)
Concrete over Sandstone	15000	25	8.3
Sandstone over Sandstone	5984	31	3.9
Sandstone over Shale	0	25	0.6
Shale over Shale	3371	25	2.4

Results of other stability analysis

Type of Failure	Factor of Safety
Overturning	0.88
Crushing of Concrete	Dam in tension, no crushing possible

Conclusions

- The Austin dam failed on the weak shale layers beneath the foundation sandstone
- The depth of water in the reservoir necessitated the provision of a deeper and wider key trench than was used
- The tendency to overturn (F.S.= 0.88) probably contributed to the sliding failure of the dam

"Never sacrifice safety for cost, no matter how urgent your client may become. He does not recognize the danger and you should. If you can not agree with him, resign your engagement, for sooner or later the reckoning will come."

T. Chalkley Hatton, Project Engineer
1912 in Engineering News