The Invisible Pulses and Pathways for Ecosystem Health –

Inconstant Groundwater Flow, Ephemeral Research Funding, and Fluctuating Public Perceptions

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Acknowledgements

Ben Tobin, Ed Scheck , Larry Stevens, Jeri Ledbetter,
Graduate Students - Jim Fitzgerald, Kim Zukosky, Gregg Paulson,
Undergraduate Students – Jordan Wachholtz, Crystal Wu

And

Many stout hearted graduate students, boatmen and women, and Park Service personnel, Grand Canyon Trust, Don Bills, Abe Springer

Talk Outline

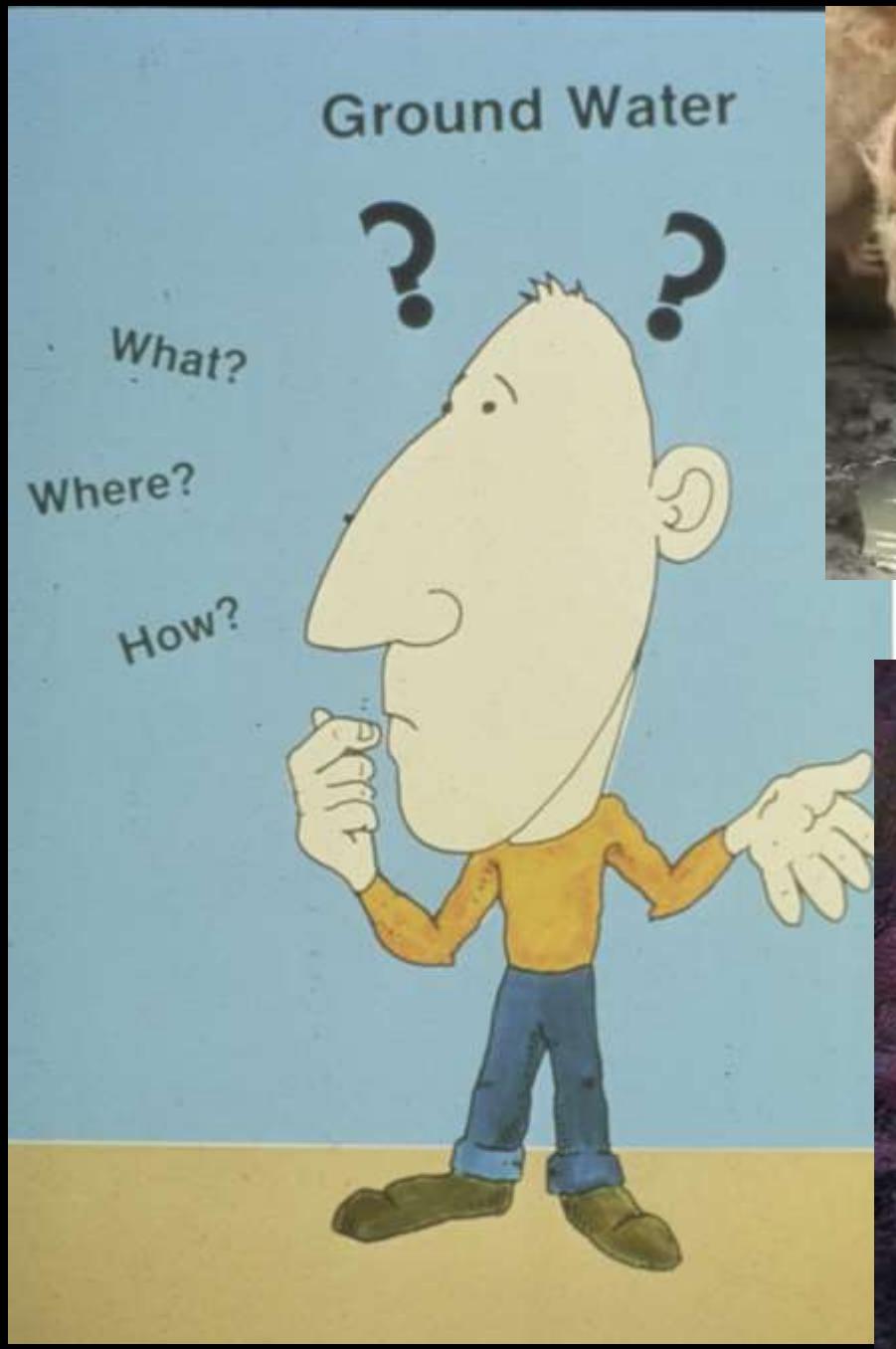
- Hydrogeology and Ecosystems – the Connection
- Invisibility
  - Of springs
  - Of Threats
  - Of Vulnerability
- Funding what we don't see
- Changing public perceptions, changing priorities
- Solutions

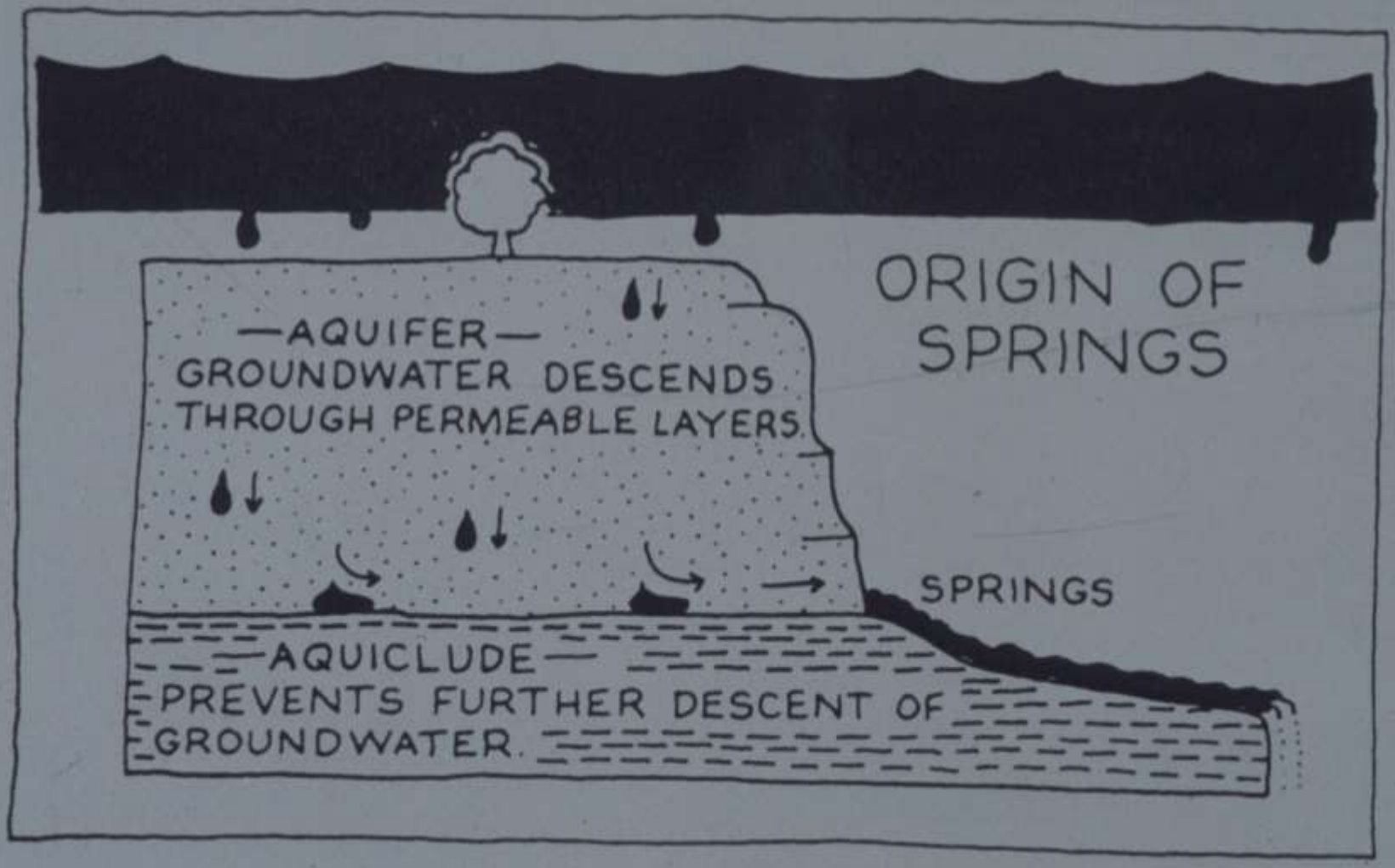
Springs, Hydrogeology, and Ecosystems – The Connection

and Some Questions

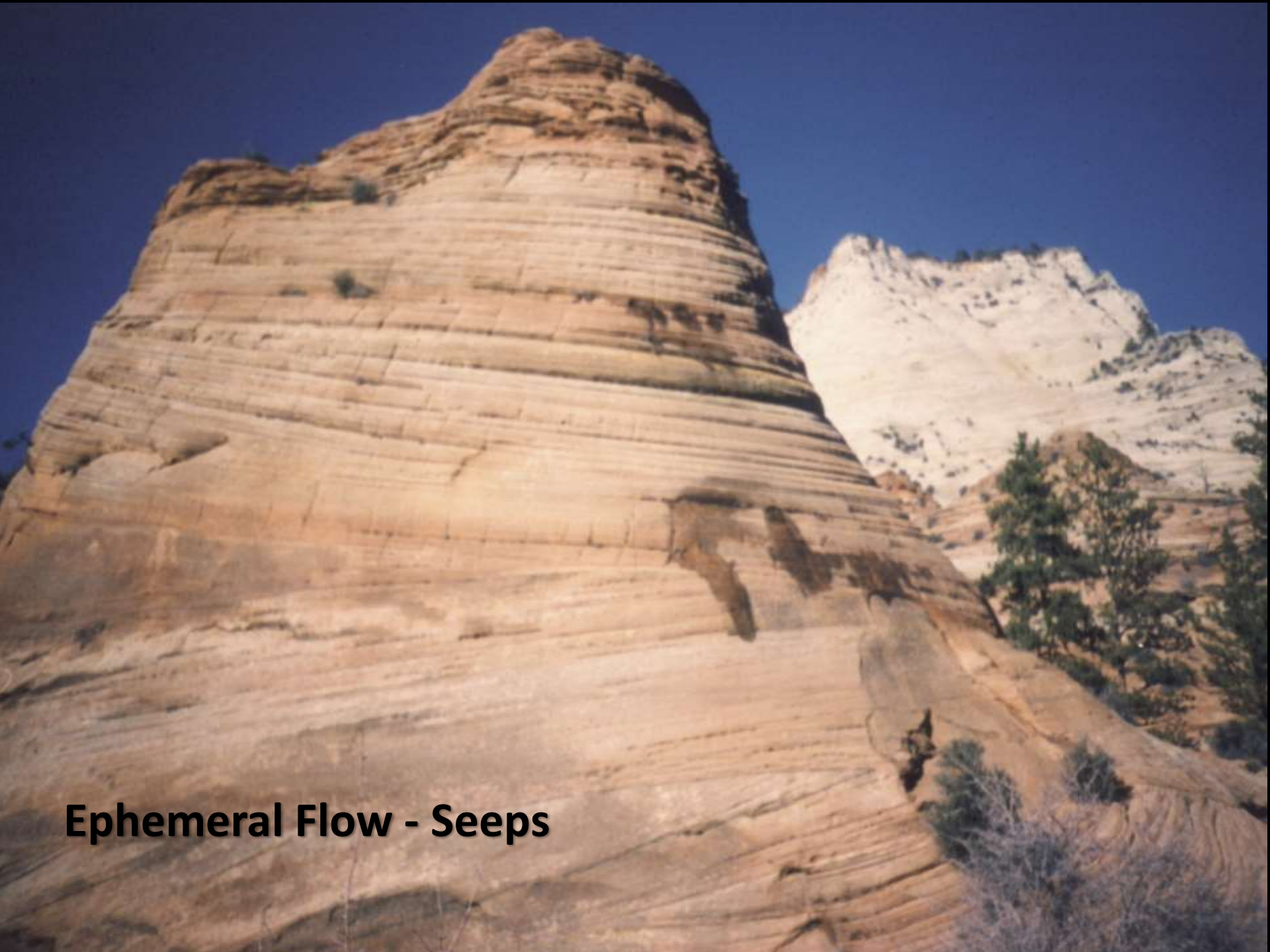
- Location and sustainability of recharge?
- Impact of Groundwater exploitation, Climate Change?
- Groundwater Pathways?
- Groundwater residence time?
- Water Quality?
- Vulnerable Species?

And why is this monkey unhappy?


Ground Water
What?
Where?
How?

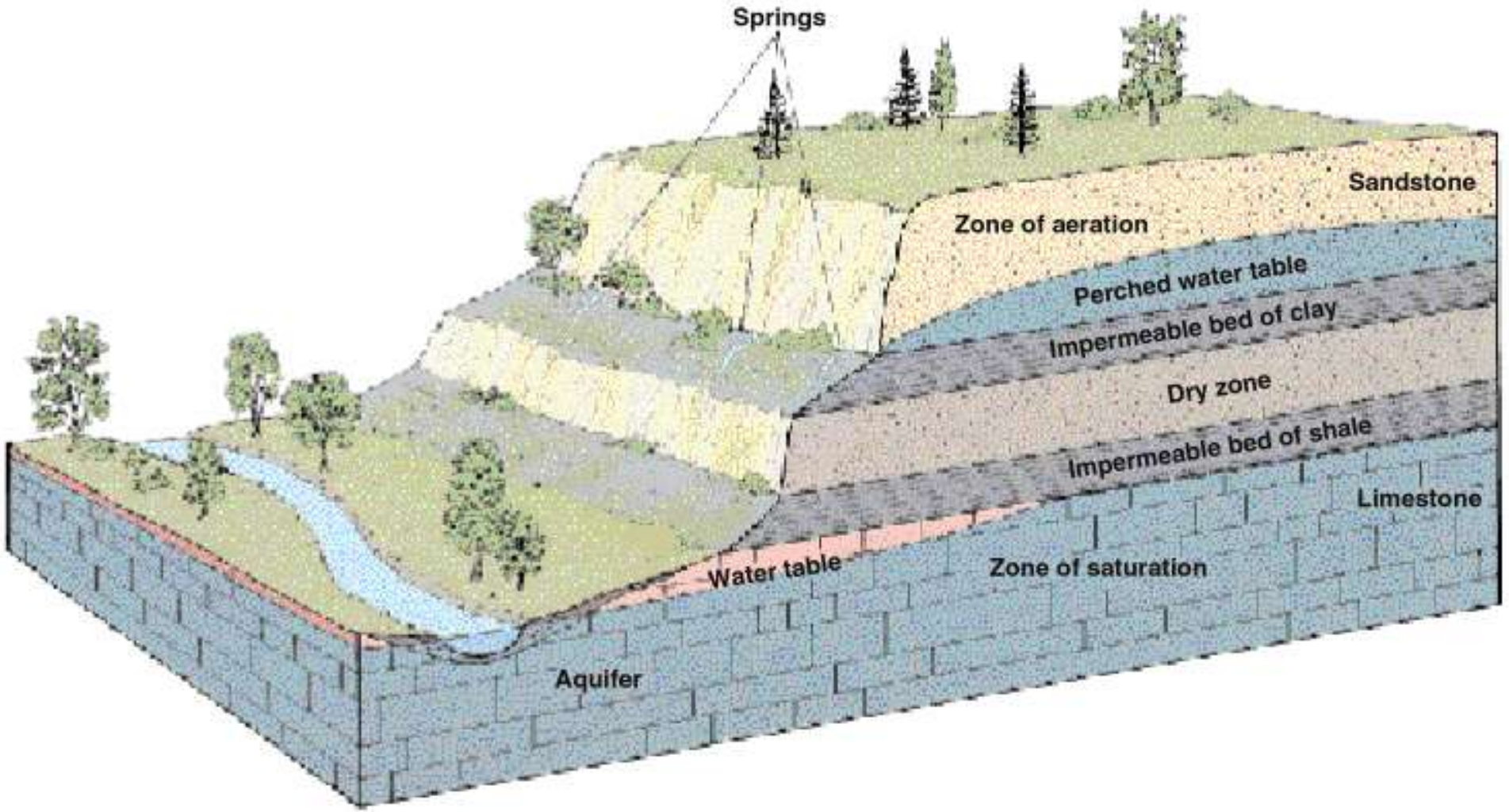

ORIGIN OF SPRINGS
—AQUIFER—
GROUNDWATER DESCENDS THROUGH PERMEABLE LAYERS.
SPRINGS
—AQUICLUDE—
PREVENTS FURTHER DESCENT OF GROUNDWATER.


Invisibility with Time

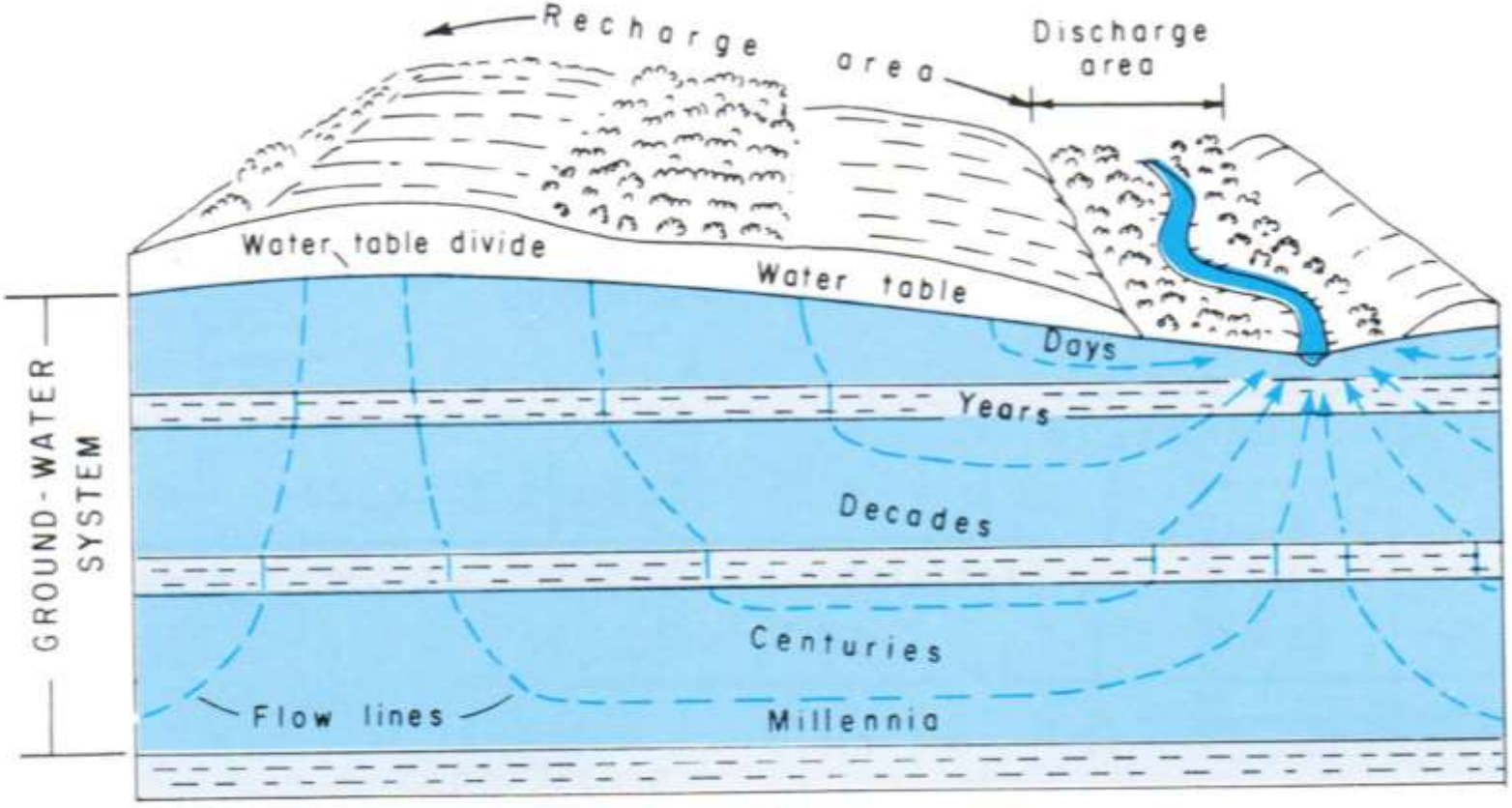

Ephemeral Flow - Seeps


Concealed Treasures

Springs – Perched systems too!



FUNCTIONS OF GROUND-WATER SYSTEMS



(1)

Gaining Reaches – lowering the water table can produce losing streams, dried up springs

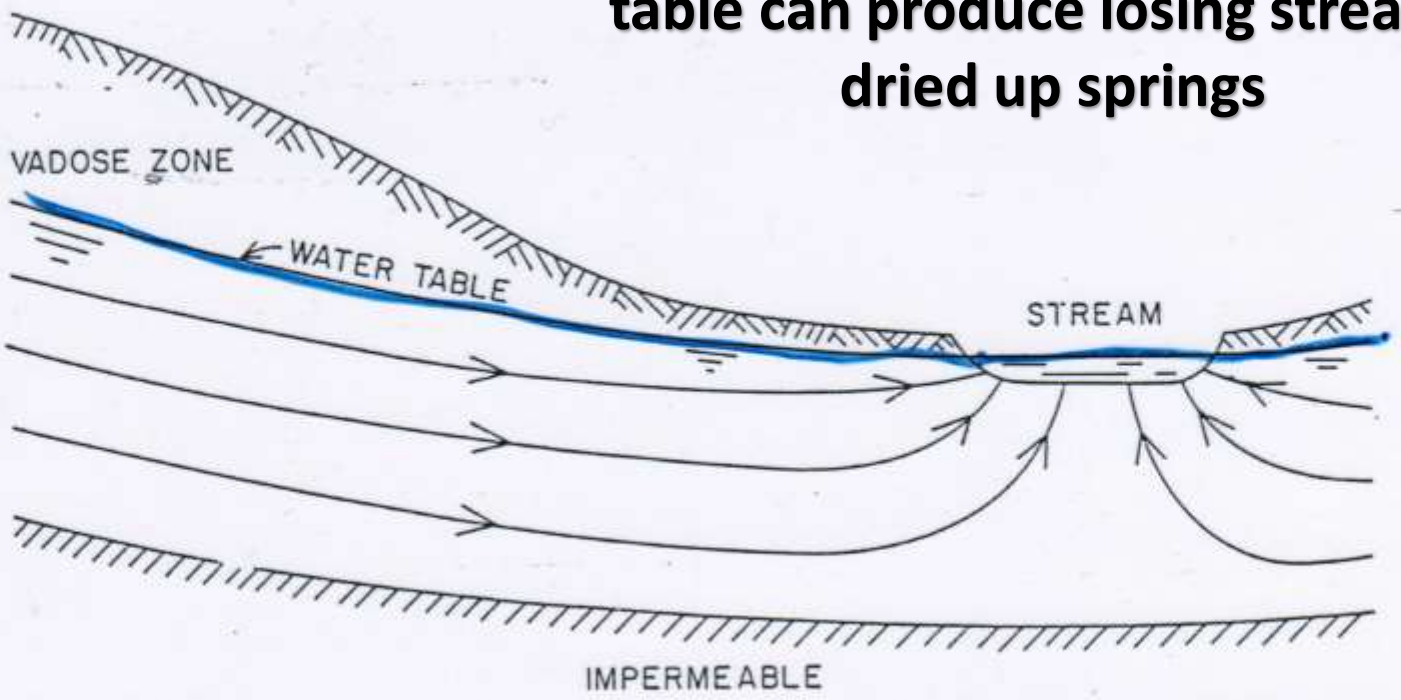
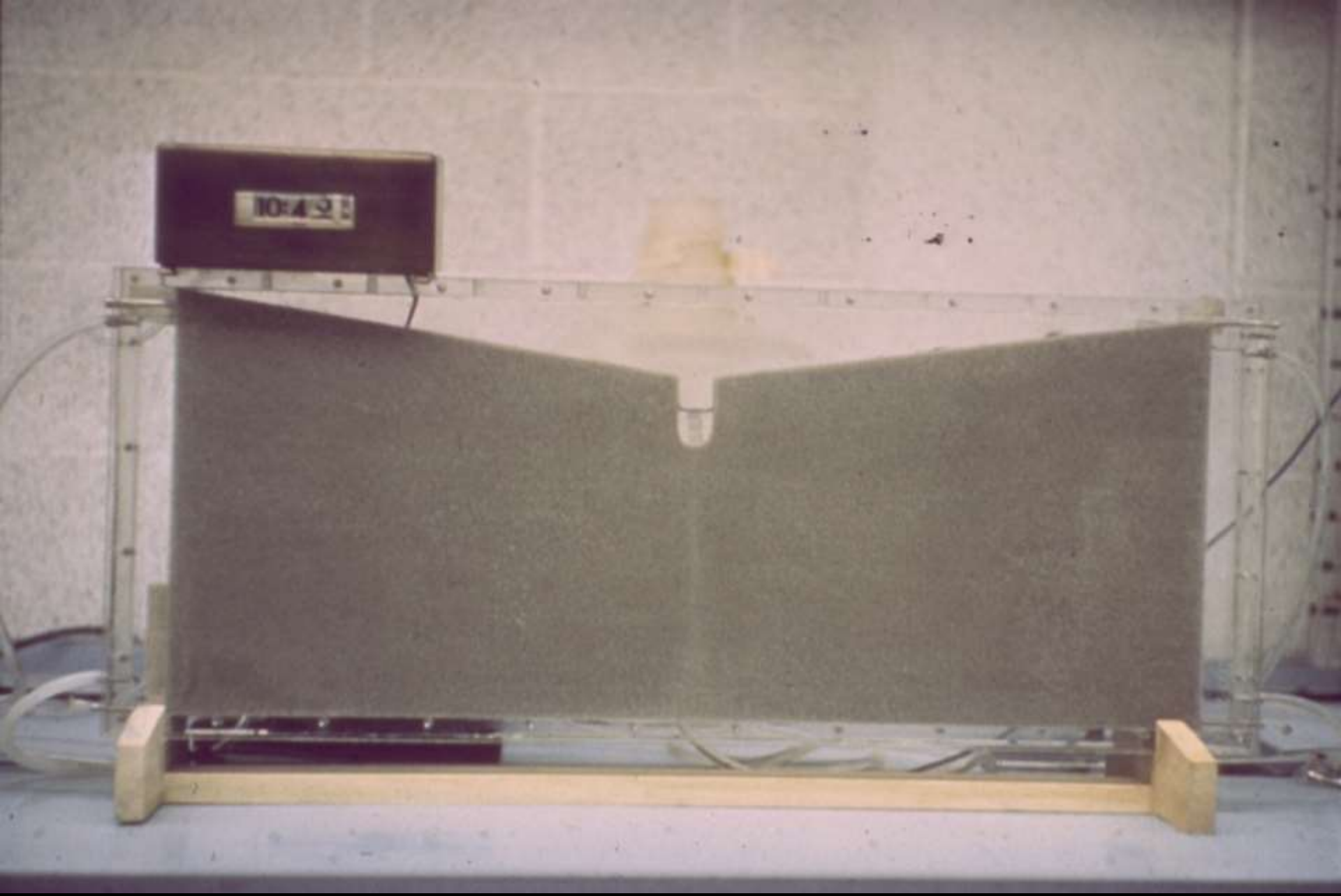


Figure 1.3 Drainage of groundwater into a stream.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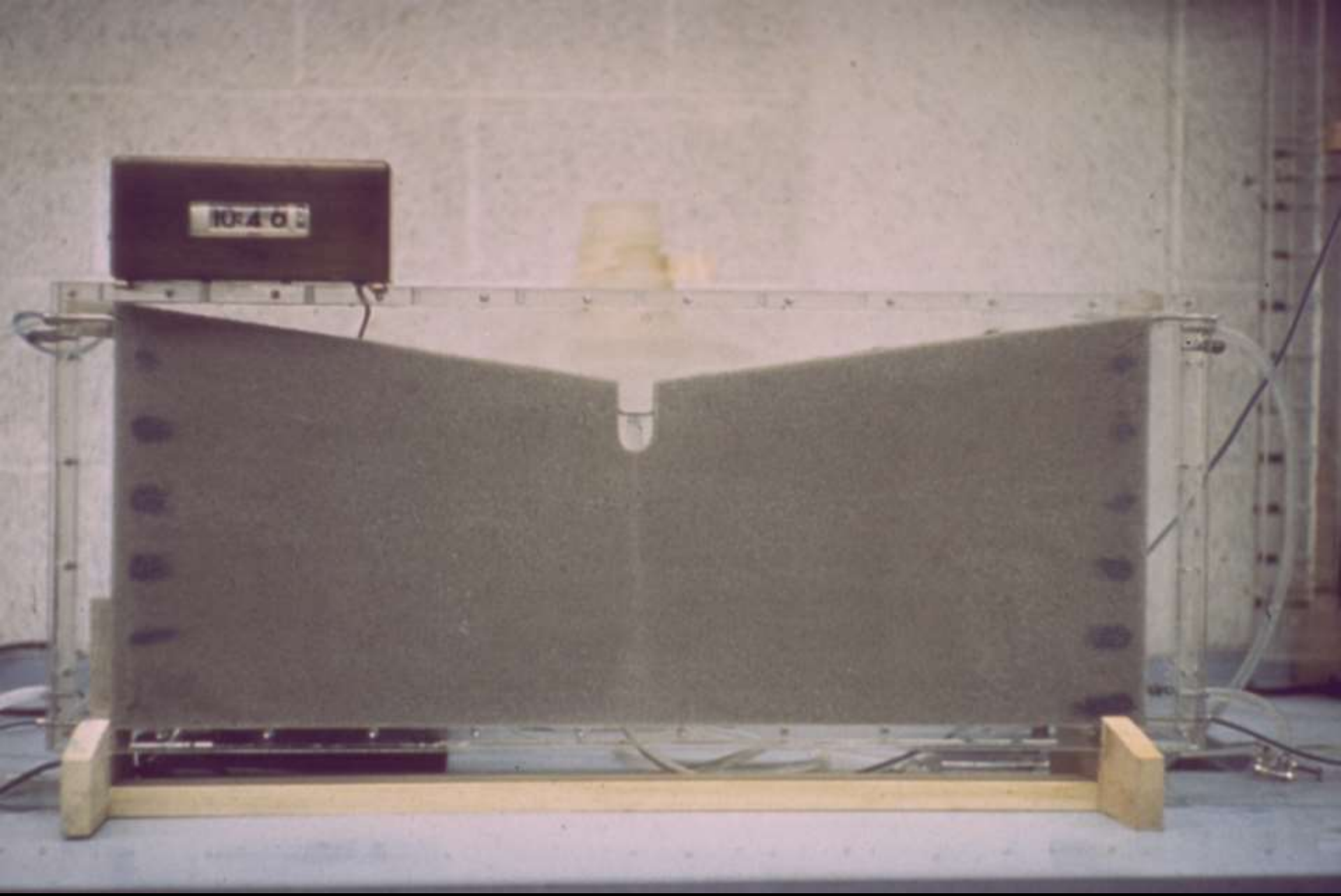

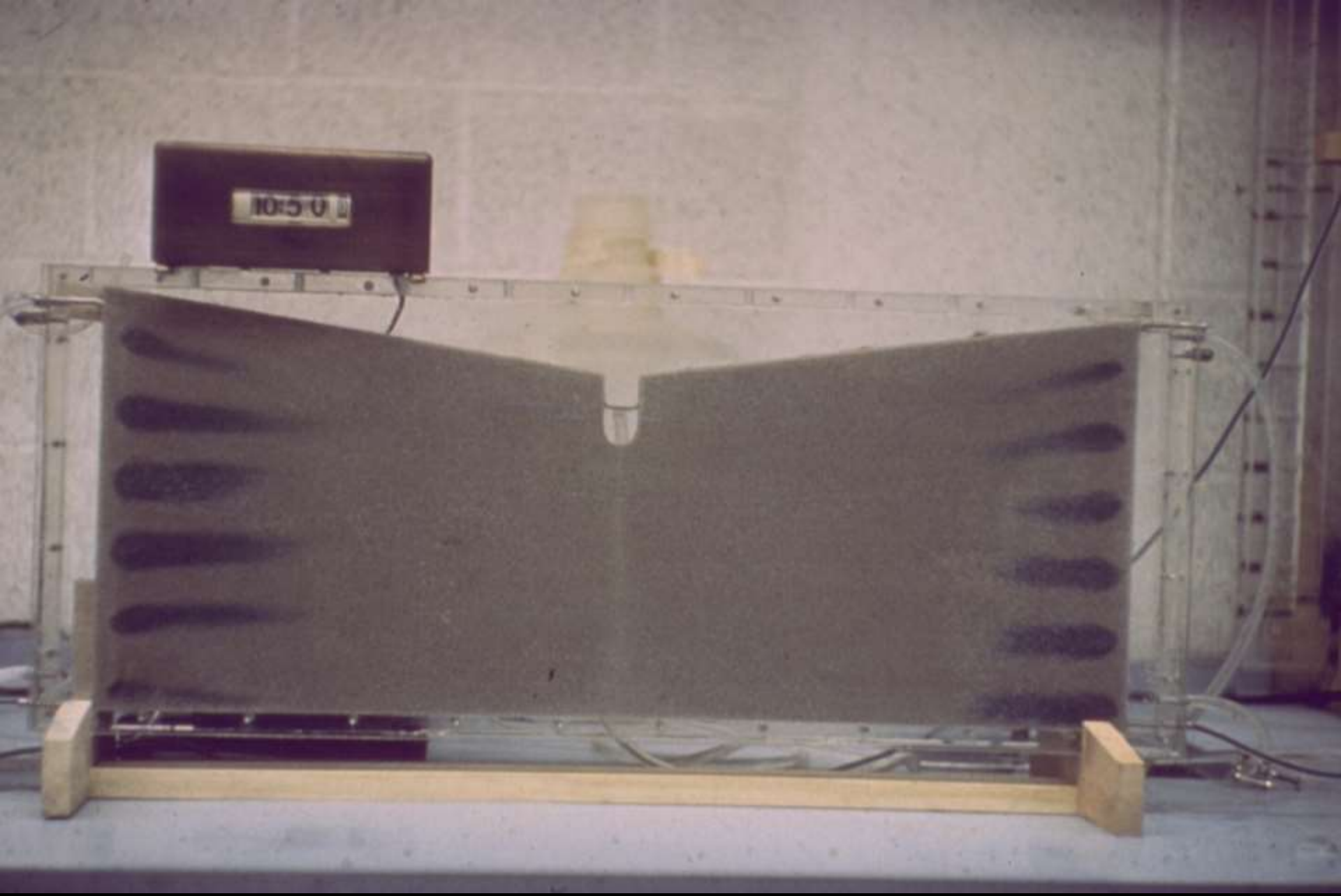

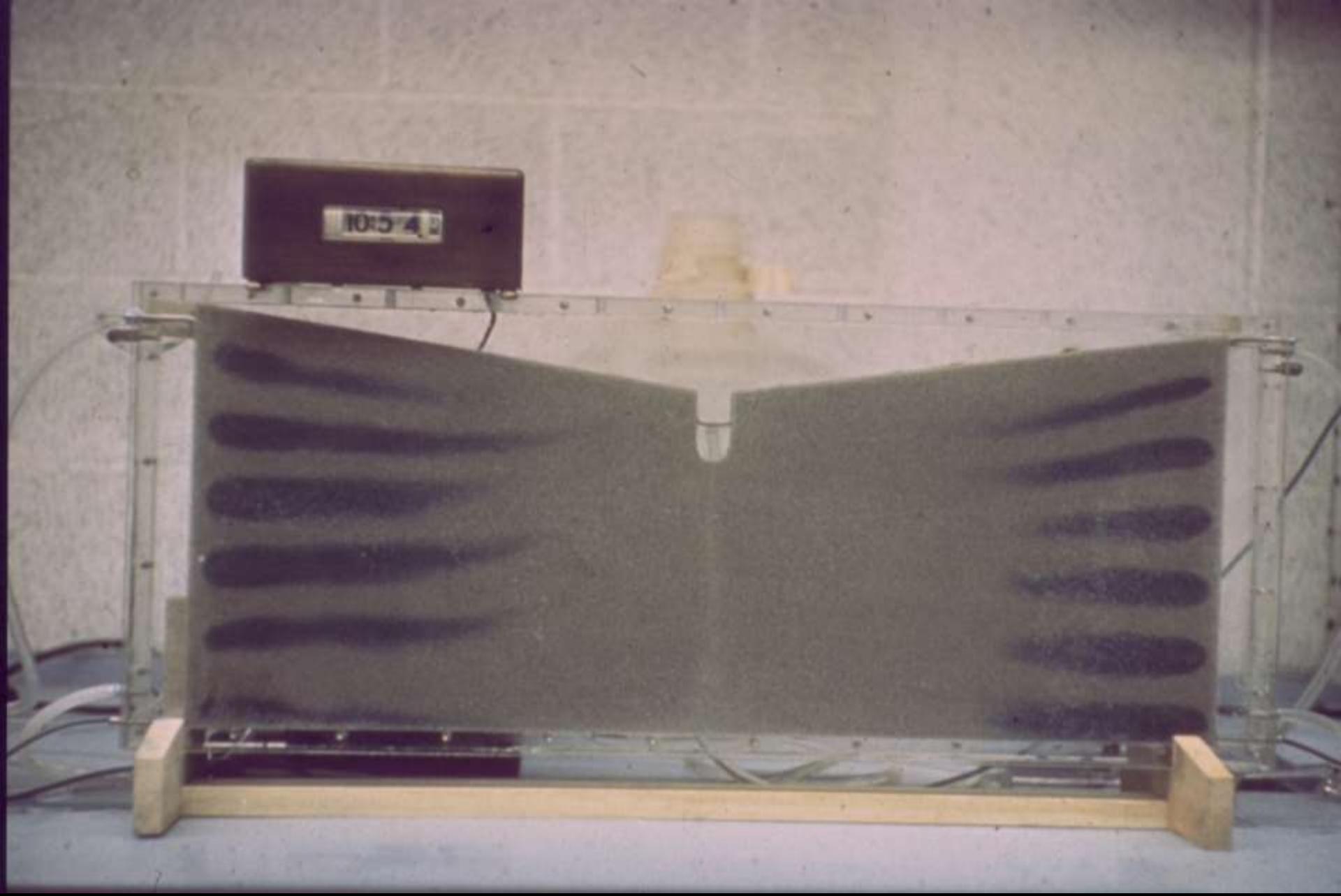
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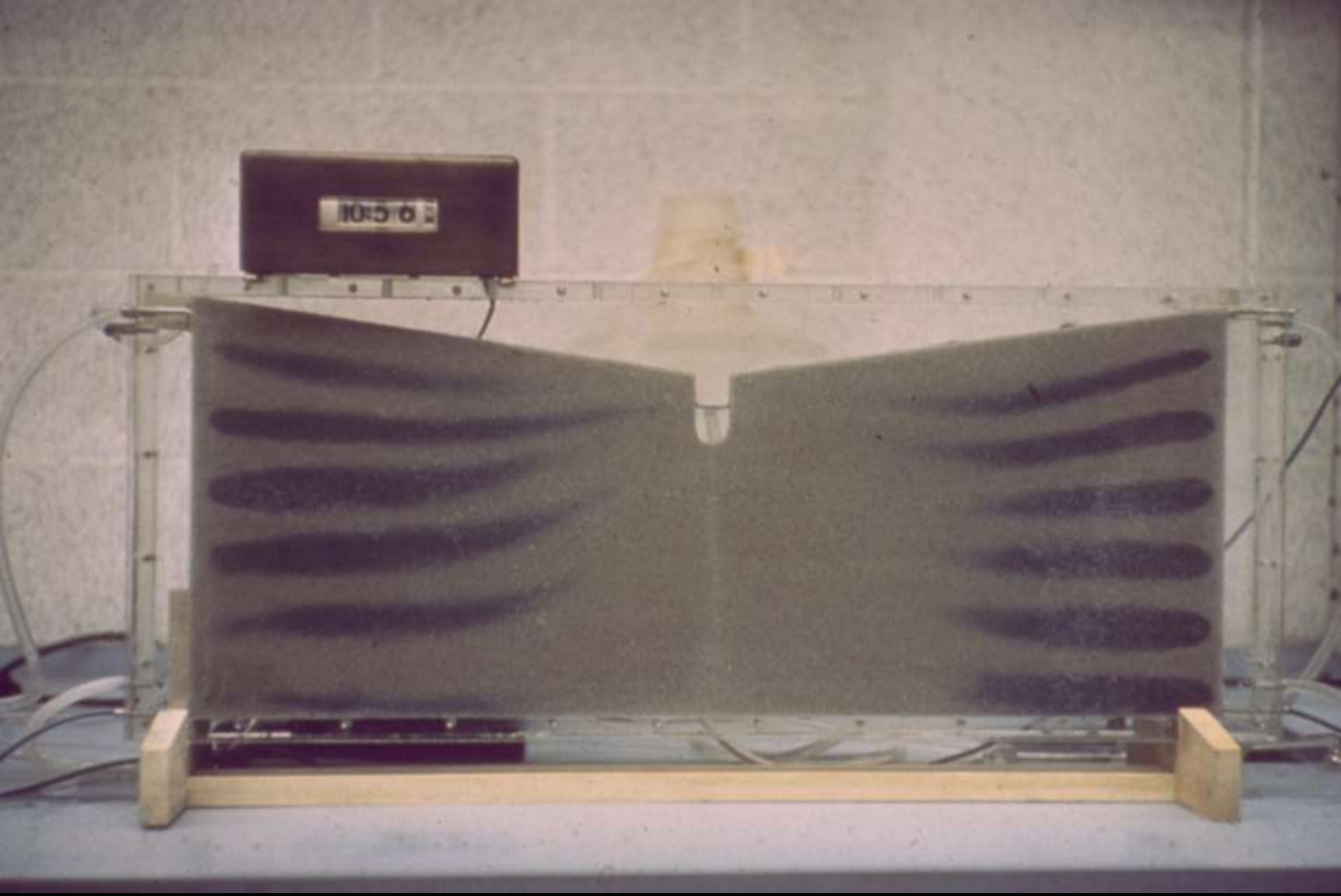
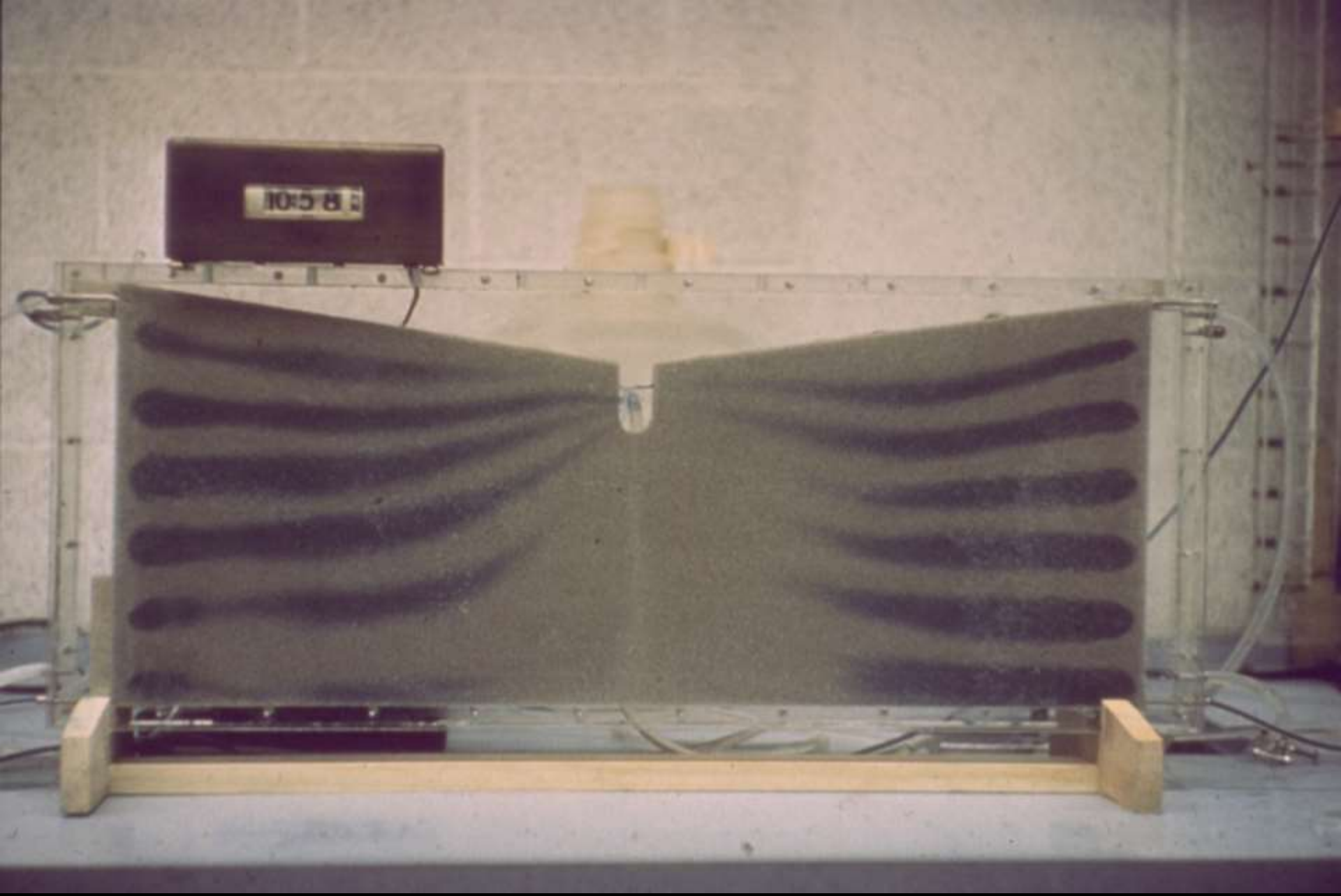
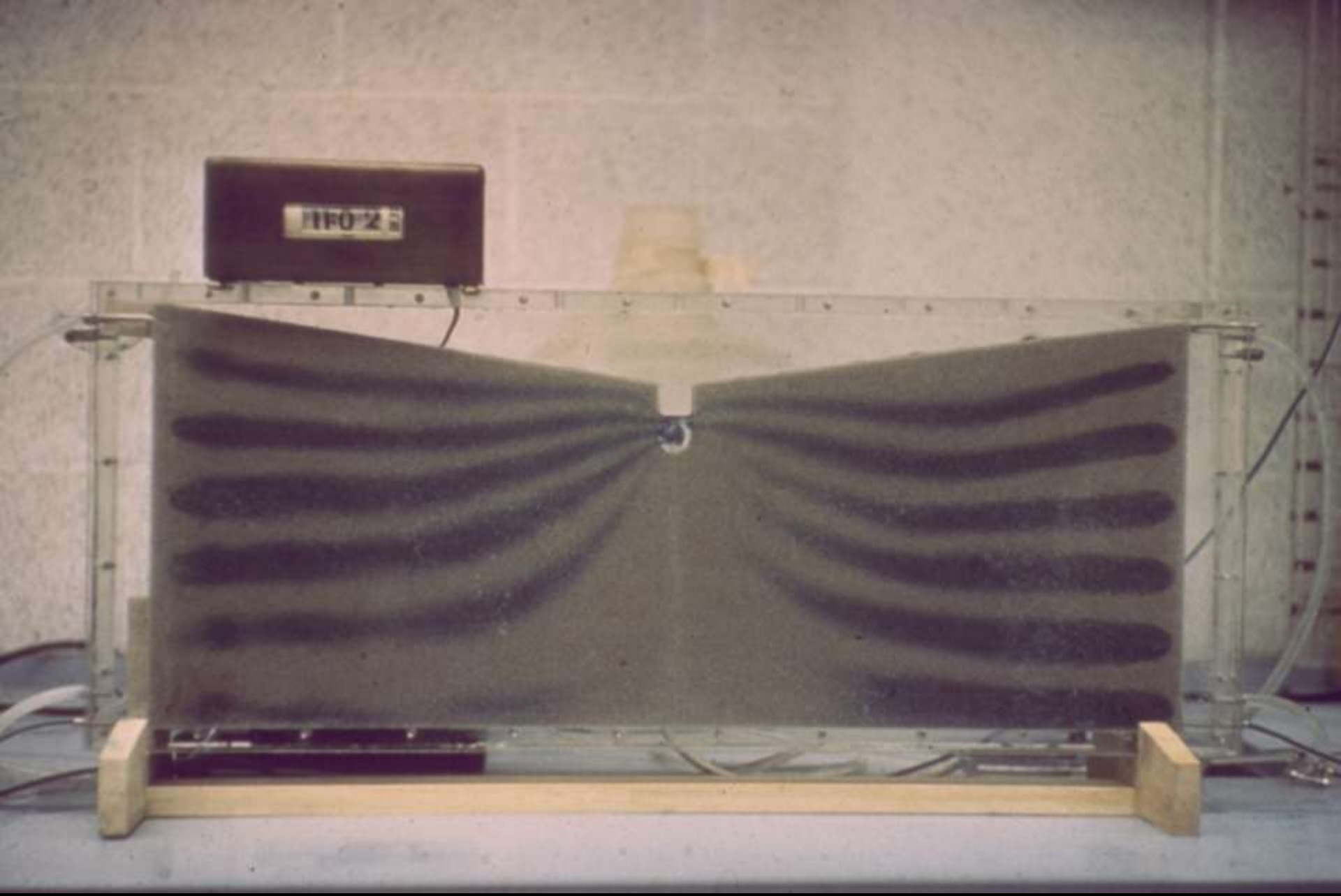
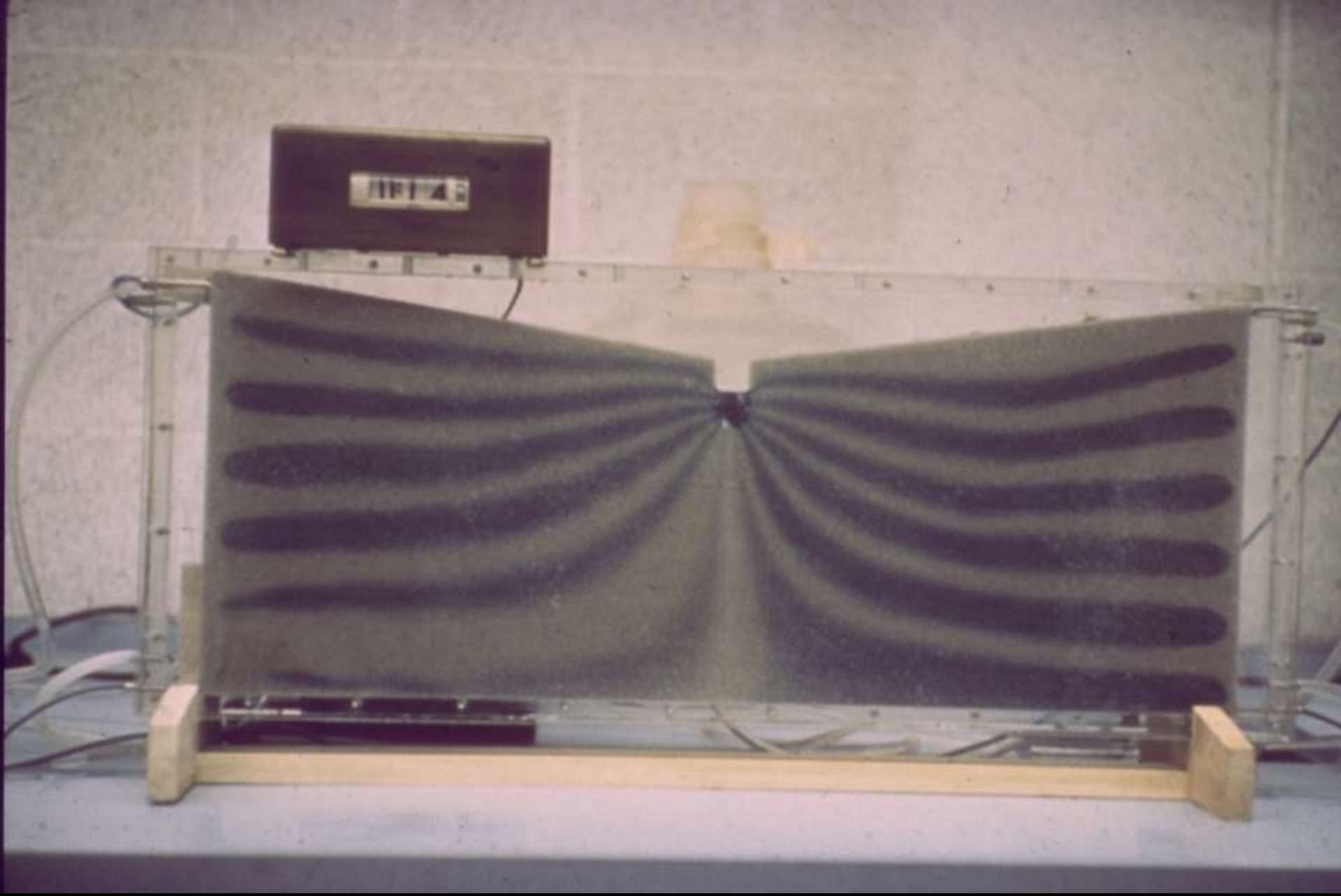
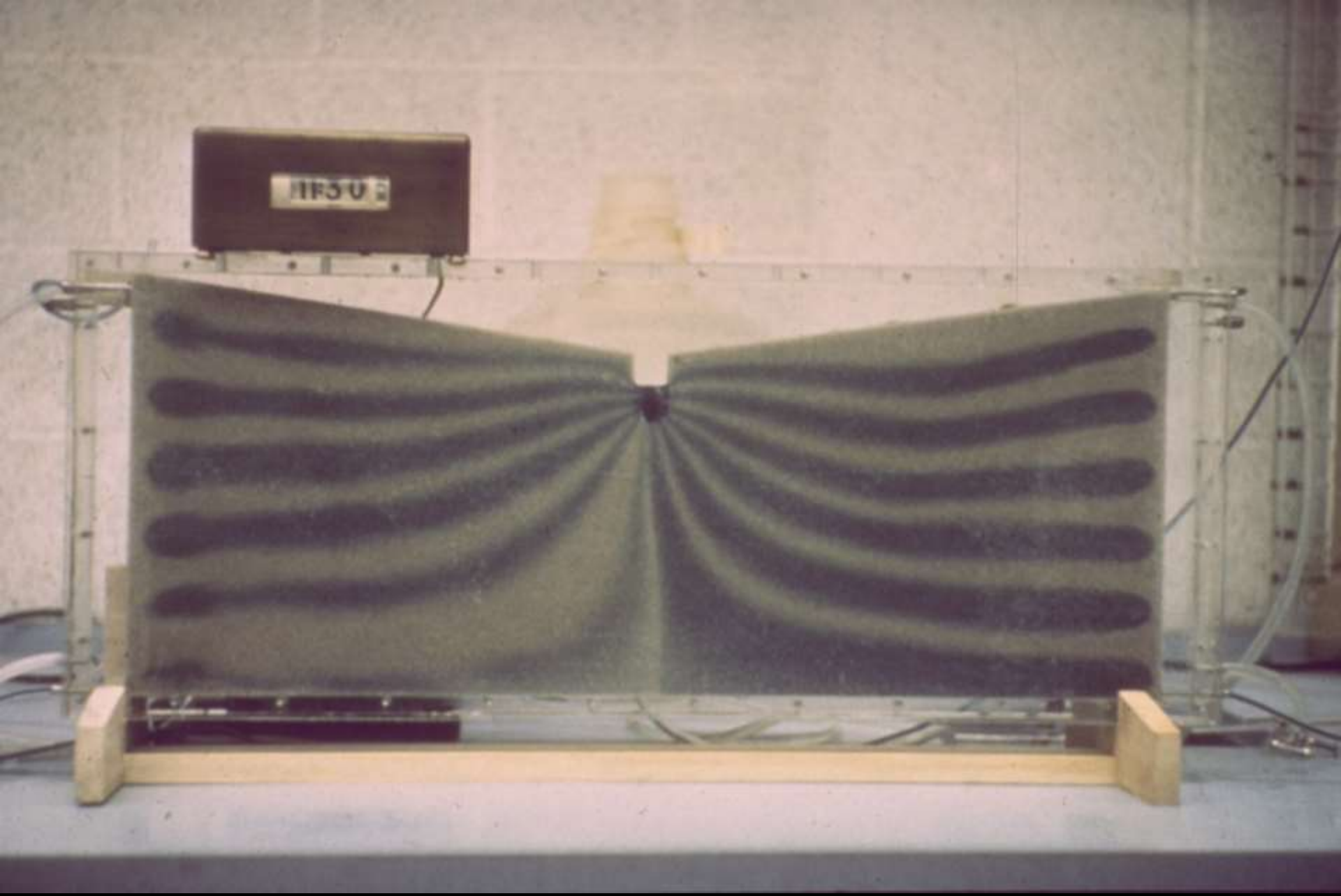
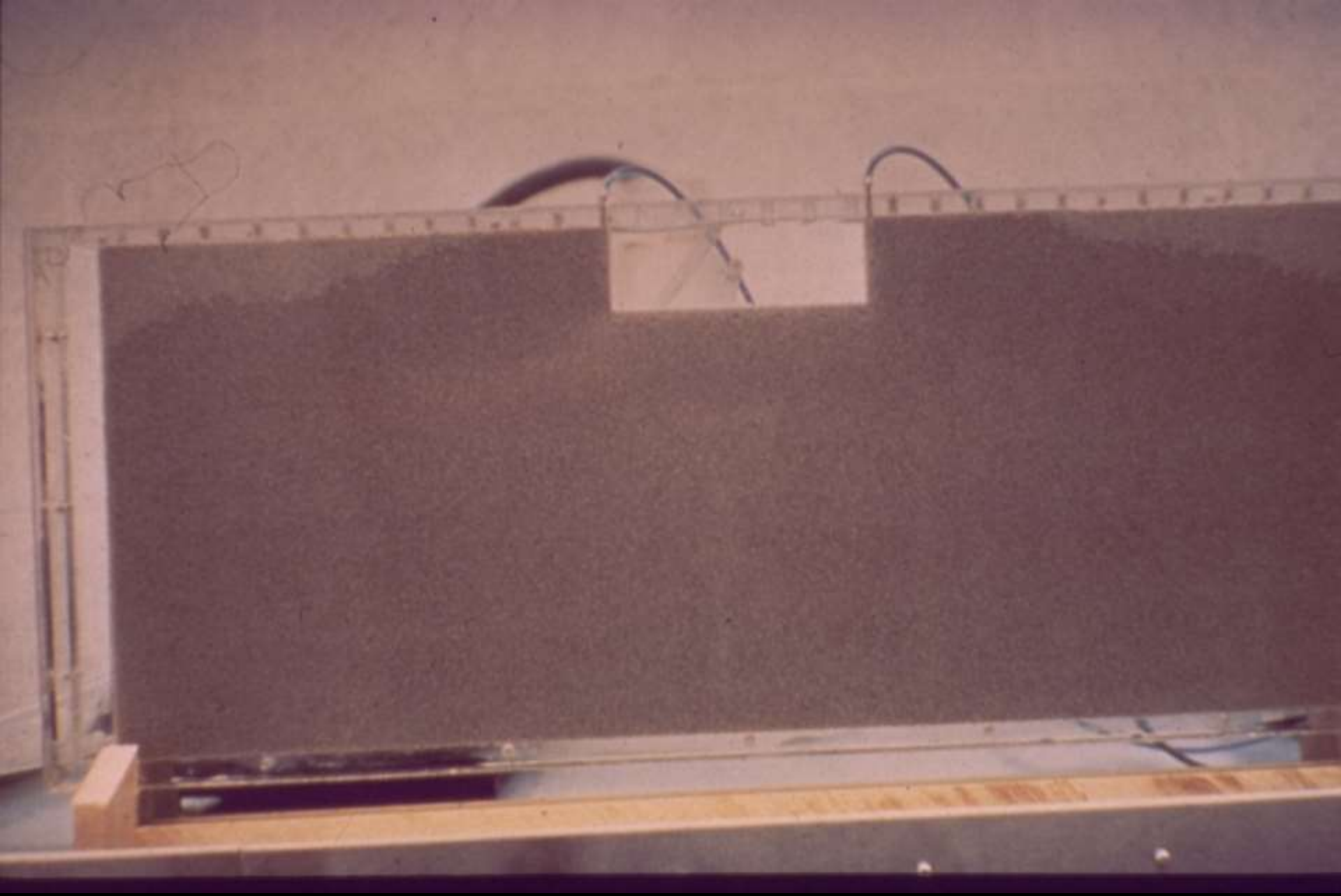


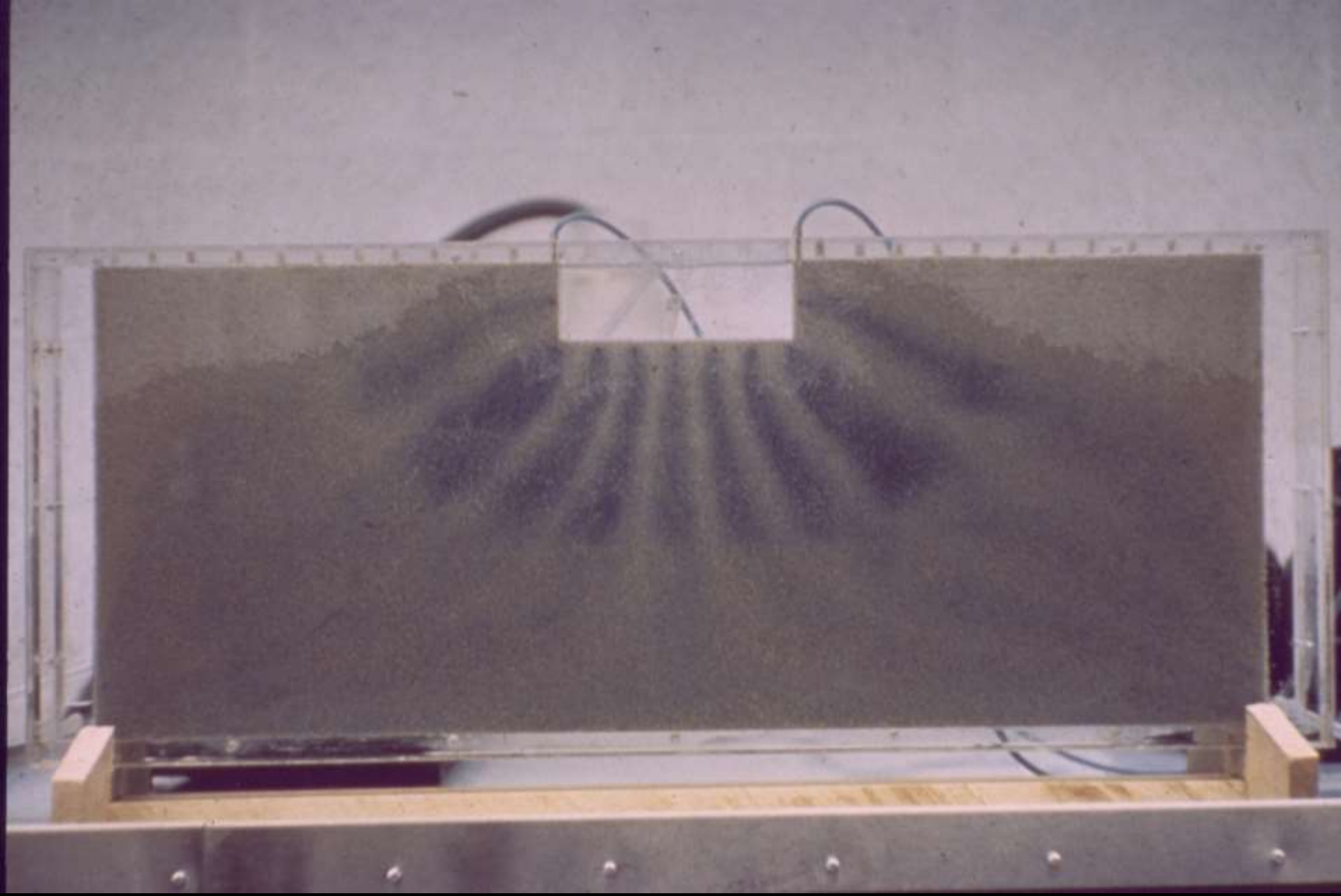


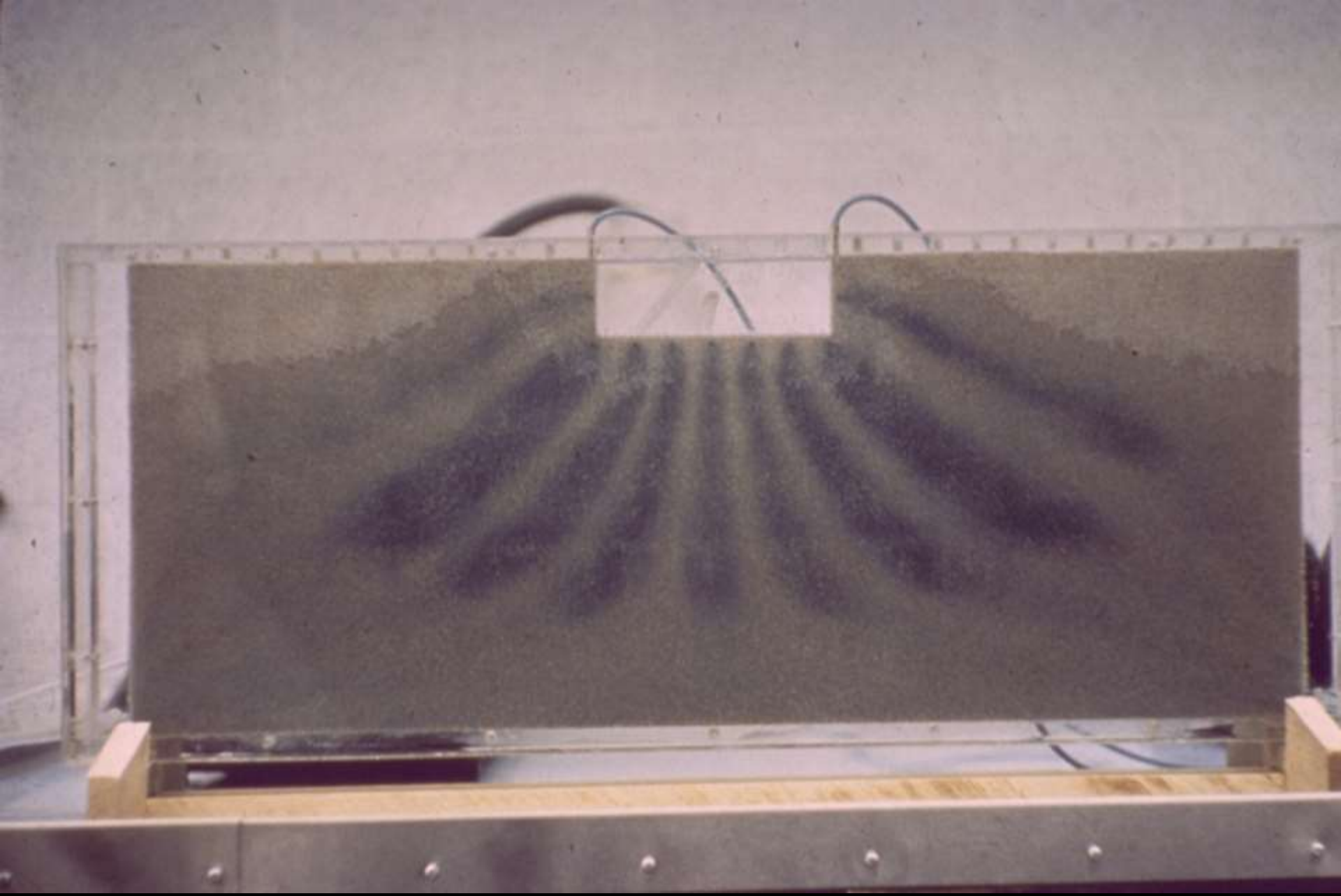

HFO 2

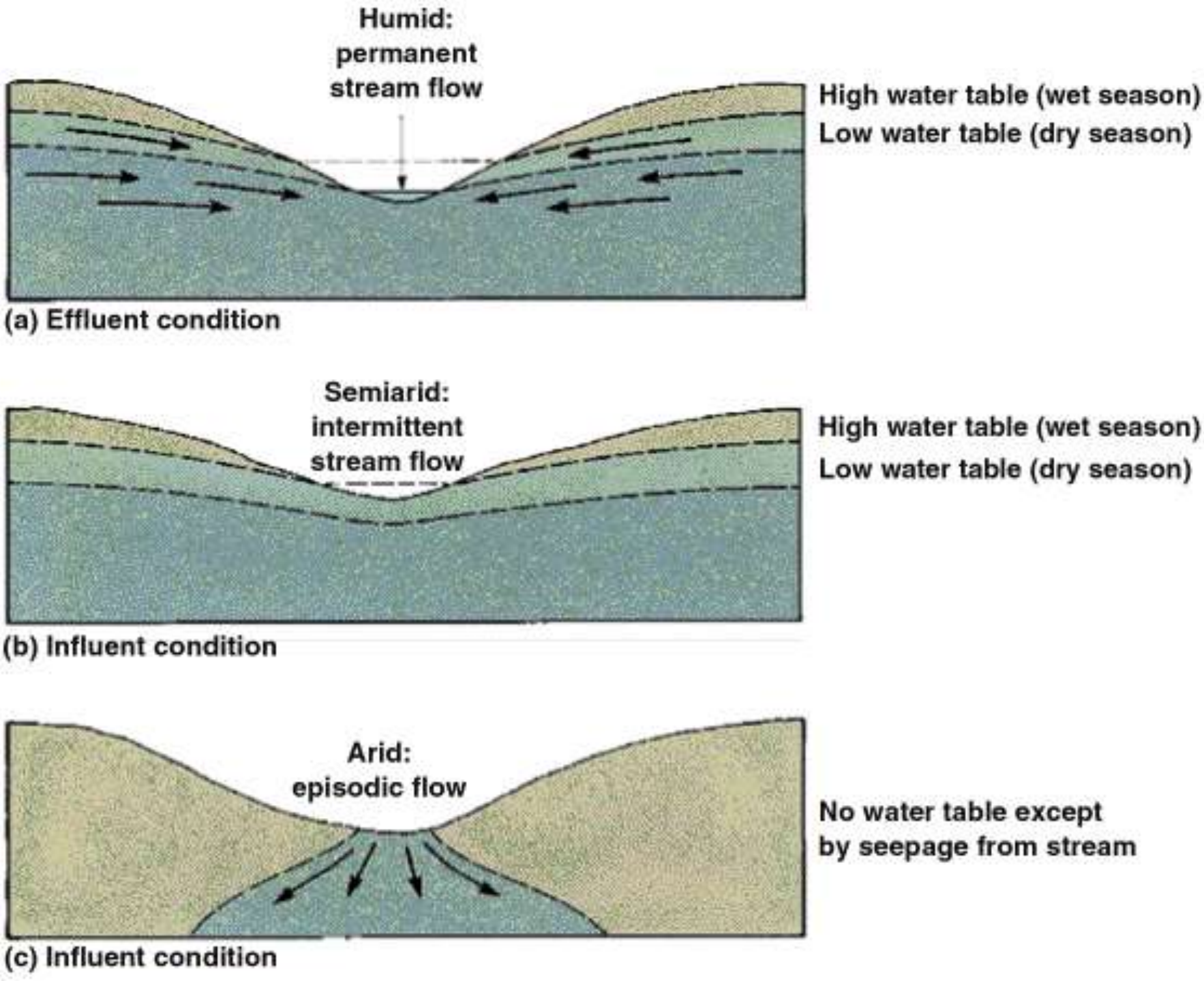


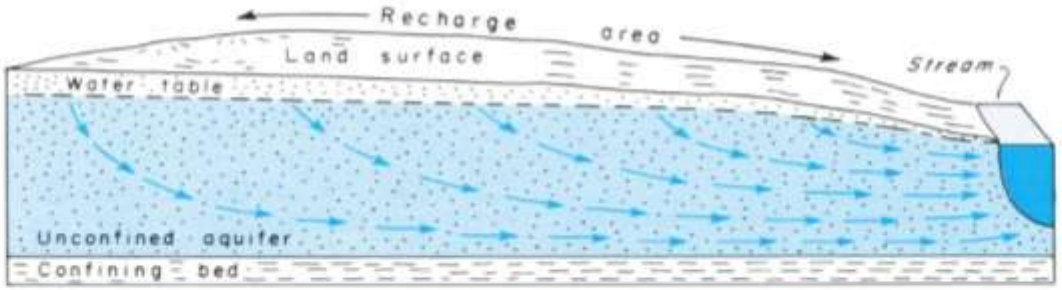






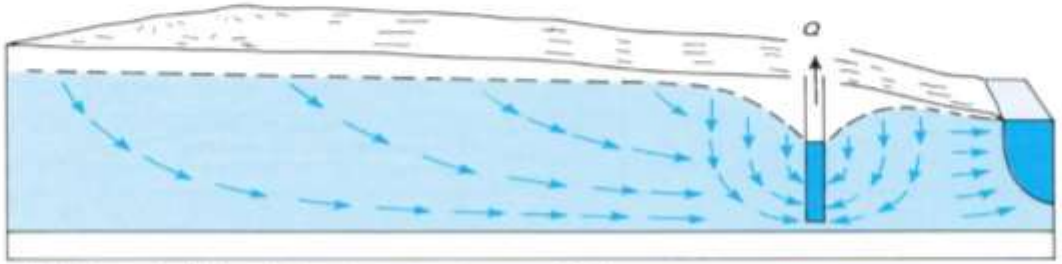



Humid:
permanent
stream flow
High water table (wet season)
Low water table (dry season)
(a) Effluent condition
Semiarid:
intermittent
stream flow
High water table (wet season)
Low water table (dry season)
(b) Influent condition
Arid:
episodic flow
No water table except
by seepage from stream
(c) Influent condition



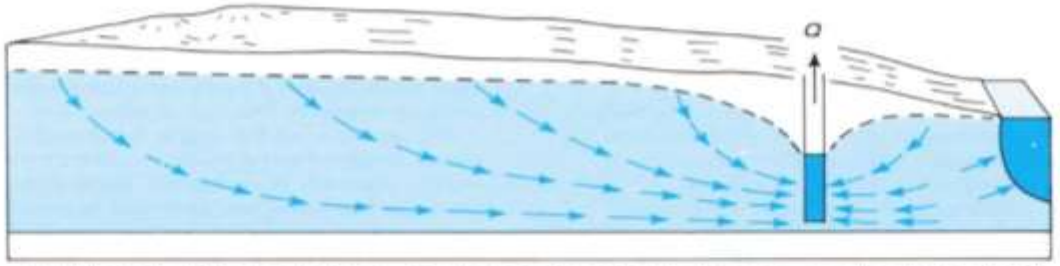
Discharge (D) = Recharge (R)

(1)



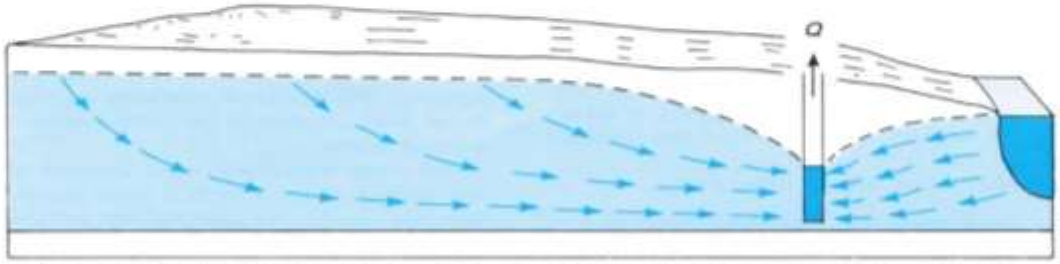
Withdrawal (Q) = Reduction in storage ($\triangle S$)

(2)



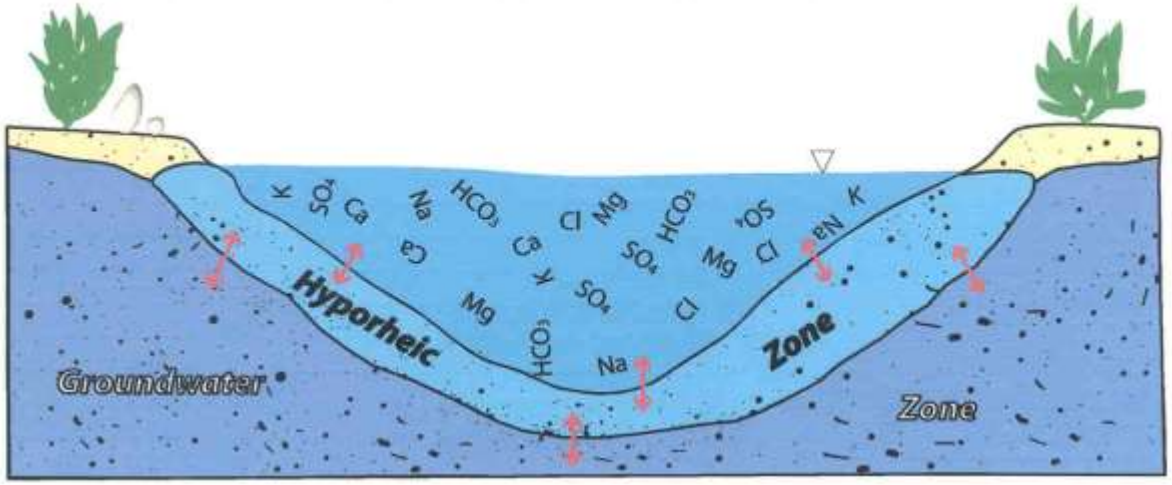
Withdrawal (Q) = Reduction in storage ($\triangle S$) + Reduction in discharge ($\triangle D$)

(3)

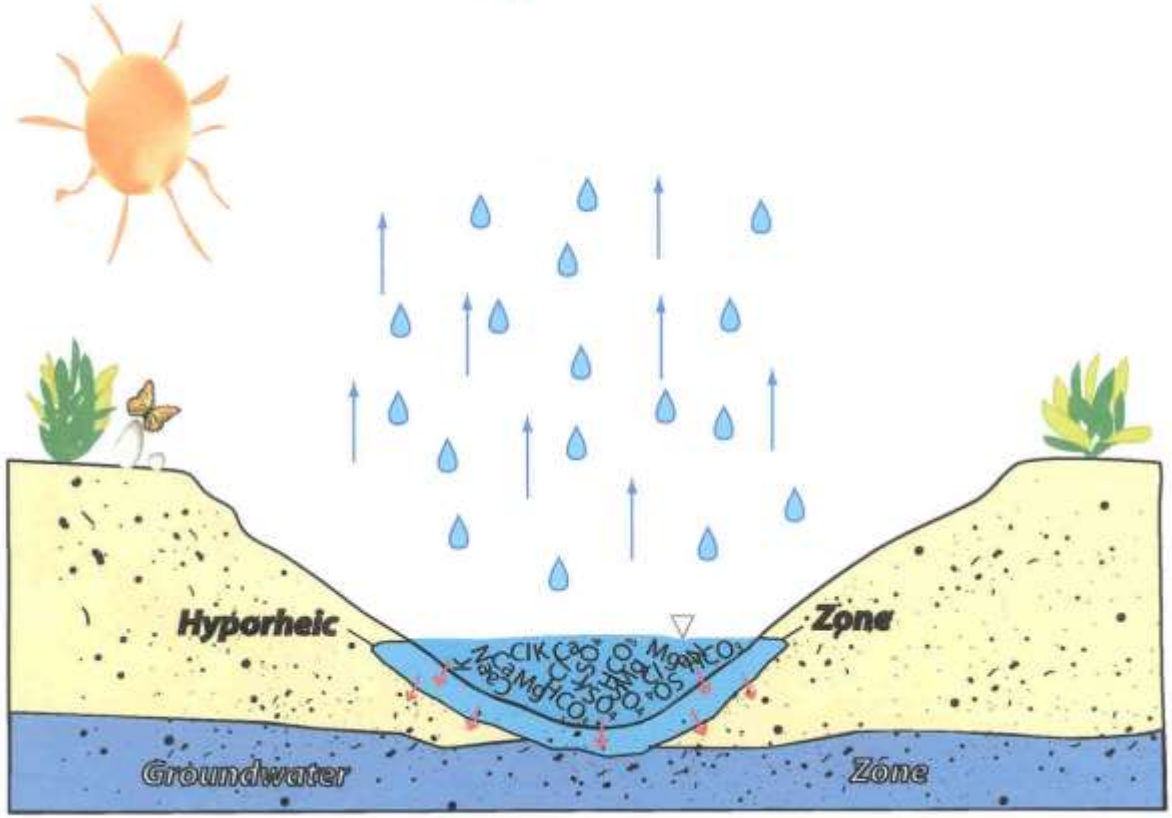


Withdrawal (Q) = Reduction in discharge ($\triangle D$) + Increase in recharge ($\triangle R$)

(4)

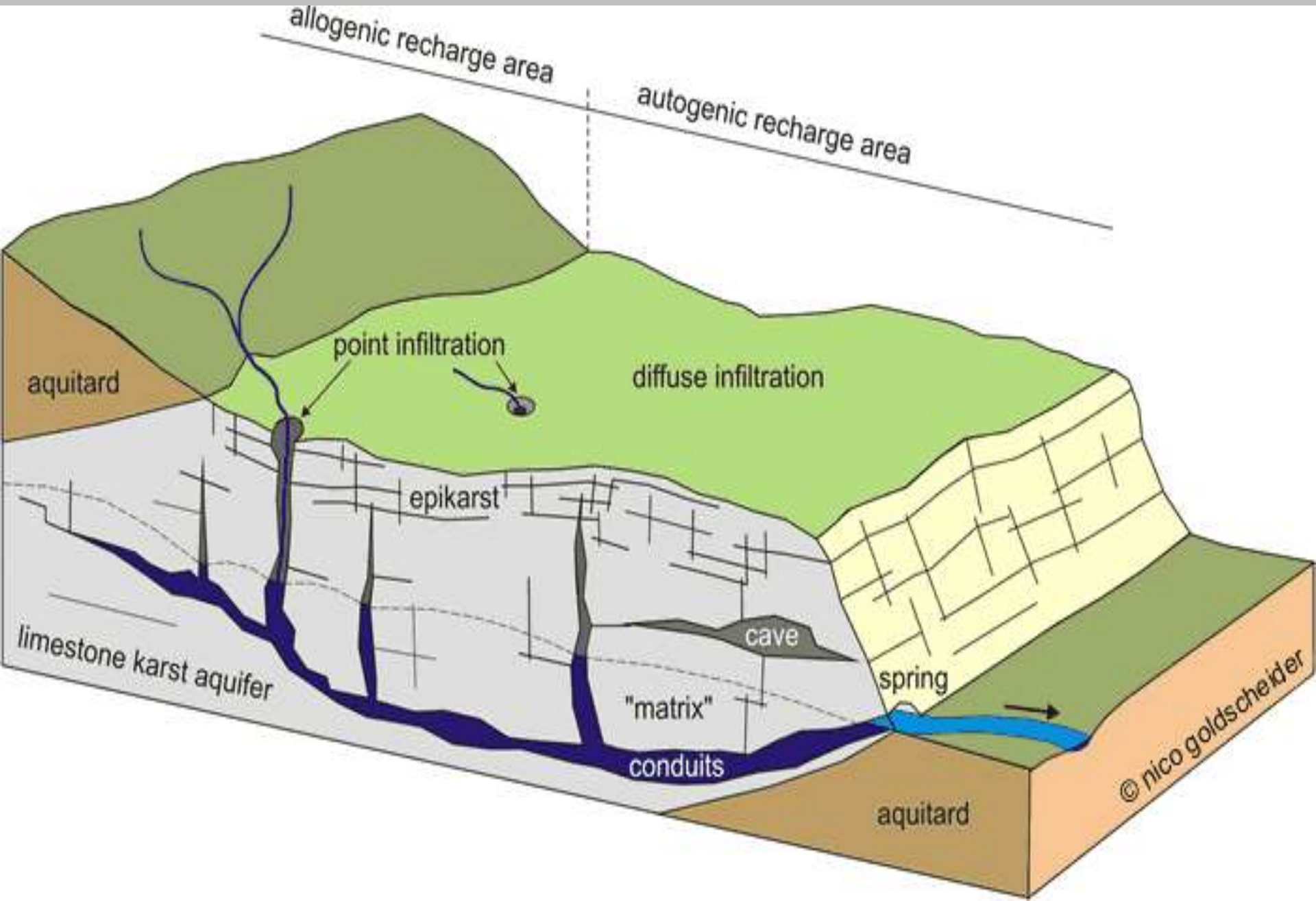


(A) Winter/Fall



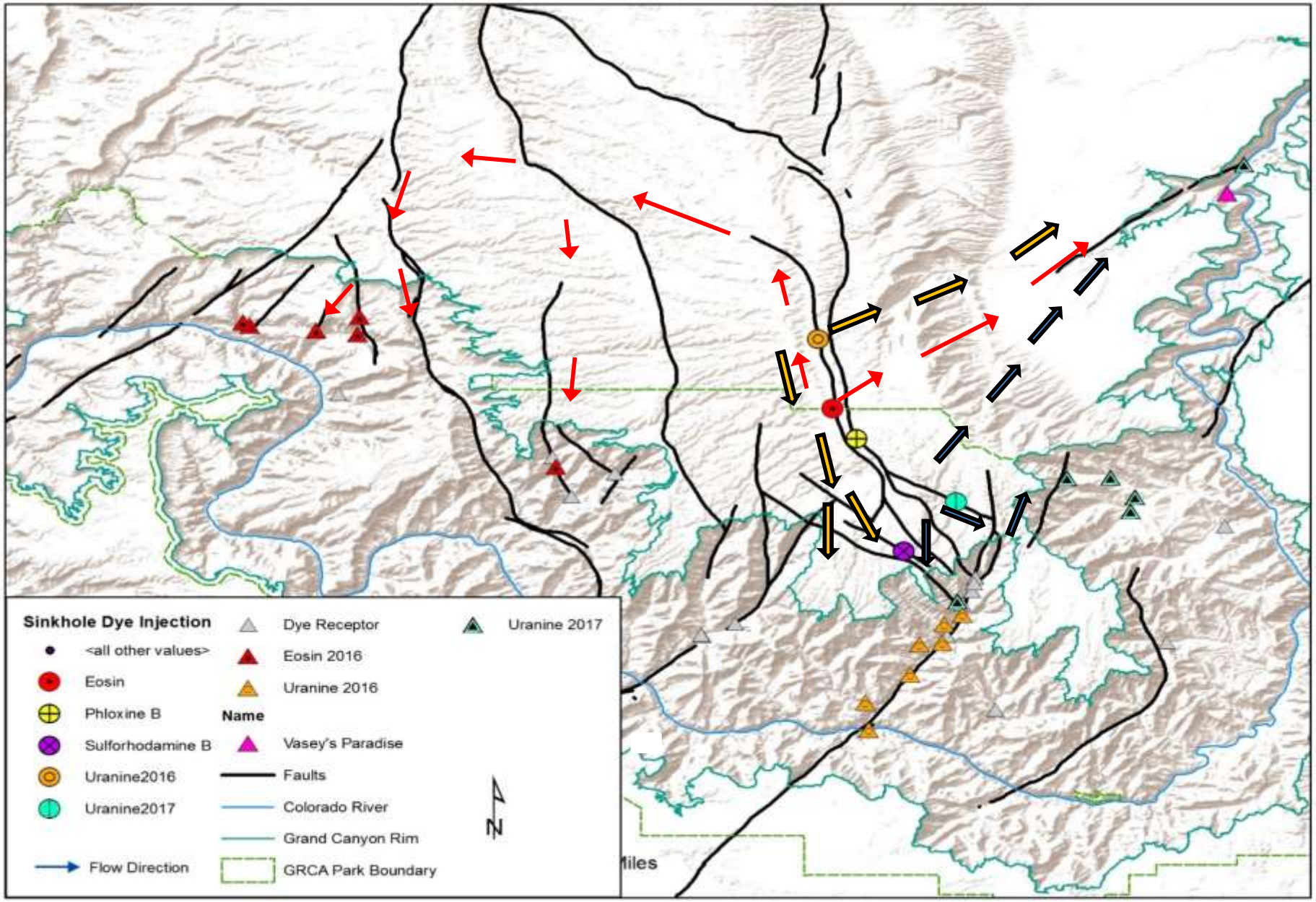
(B) Summer/Spring

Karst Environments



Weird Directions of Groundwater flow - Dye Injections (from Tobin)

2016 - 2017 Dye Detections from Tobin



Weird Recharge - North Coyote Buttes

David Loope


Weird Recharge – Grand Canyon

Example of Invisibility

- 4164 Sampling Events Analyzed Grand Canyon Springs

- Over 75% Springs
- About 21-23% surface water
- Approximately 1-2 % well water or other

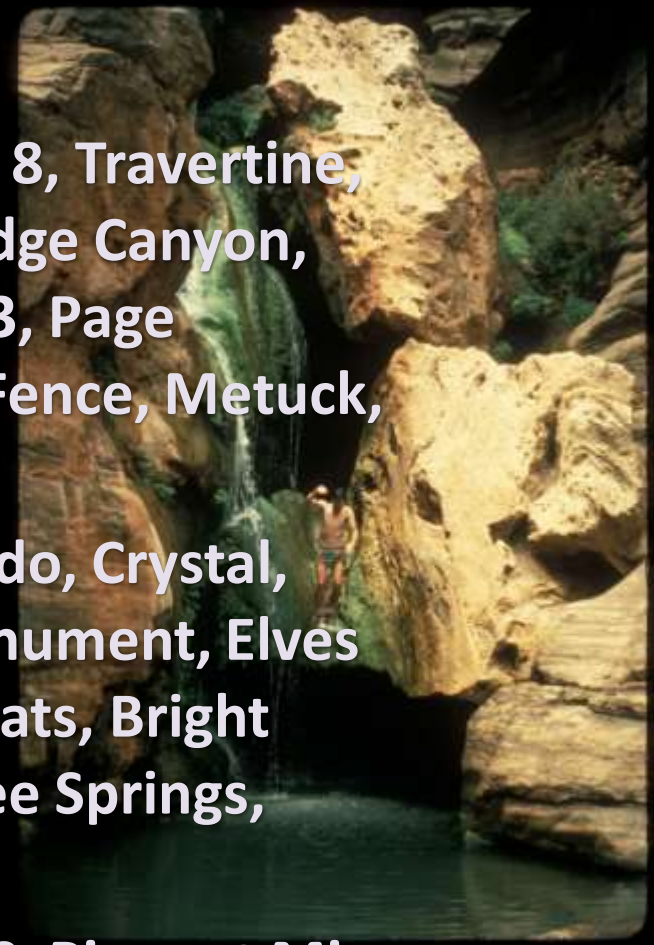
- Evaluated U.S. Environmental Protection Agency's Maximum Contaminant Levels (MCLs)

- Most Sampling events before year 2000

Arsenic (As)

- 87 % of time not analyzed
- Non detect (11.6% of total analyzed)
- Some detection of As (88.4% of total analyzed)
- 53.8 % above MCL when analyzed
- 78 Springs above MCL of 0.01 mg/L

Arsenic above MCL 0.01mg/L



- Springs include: Pumpkin, Marble Canyon 8, Travertine, South Canyon, Mesquite, Hance rapid, Bridge Canyon, Vasey's, Santa Maria, Tilted, River mile 213, Page (Miner's), Marble Canyon 2, Red Canyon, Fence, Metuck, JT, Warm, Lower Milkweed
- Creeks include: Kanab, Paria, Little Colorado, Crystal, Nankoweep, Travertine, Matakamiba, Monument, Elves Chasm, Stone, Havasu, Clear, Hermit, Tapeats, Bright Angel, Indian Garden, Shinumo, Deer, Three Springs, Diamond
- Wells include: 23077, 23032, 43536, 23029, Pinenut Mine Monitoring well, Red Spring well, Hermit Mine Monitoring well, 222 s13 E71 28 Ccc1, Diamond Creek near mouth
- Others: Hermit Mine Sump, GCCA505R Sump, GCCA506R sump, GCDE501R

Historical Perspectives on Changing Environmental Priorities from the top









Changing Priorities – Common Values of the 1960s-70s
Ah, those were the days!

- The Water Resources Research Act of 1964, Lyndon Johnson - regular funding to universities to conduct water related research.

- Richard Nixon January 22,1970 State of the Union – "*Restoring nature to its natural state is a cause beyond party and beyond factions. It has become a common cause of all the people of this country. It is a cause of particular concern to young Americans, because they more than we will reap the grim consequences of our failure to act on programs which are needed now if we are to prevent disaster later. Clean air, clean water, open spaces-these should once again be the birthright of every American. If we act now, they can be.*"

- Nixon - formation of the U.S. Environmental Protection Agency (USEPA), numerous environmental legislative initiatives, many of them affecting groundwater, spring wetlands and water quality

- Nixon - I am not a crook

1976 – 1992 Swinging Pendulum

- Carter - continued to support and strengthen environmental policies more aggressively.
- More funding for the USEPA, supported environment laws and regulation
- As a former farmer, had an understanding of the land and sympathy for environmental issues.
- Ronald Reagan 1980s veered dramatically away from Carter's environmental agenda, overriding many of the previous initiatives
- George H.W. Bush - more protective of the environment than Reagan - "*America will lose no wetlands on my watch*"

1992-2008 Seesaw – hold on to your springs!

- Clinton - a clean environment and economic growth were not in opposition
- Committed over $1.5 billion to facilitate restoration of the Florida Everglades
- Fought a wetlands “reform” bill that would have obstructed state wetland conservation efforts, cut the amount of land under federal protection by 75%, and allowed exemptions for special interests and activities
- George W. Bush swung the pendulum back, renouncing a campaign promise to restrict carbon dioxide emissions
- Suspended some remediation requirements for polluting mining operations and opposed stringent limits on arsenic in water
- Ended participation in the Kyoto climate change accords and treaty.

Obama Era - Some hydrologists and ecologists may have been cozy and adequately funded as the tympanic sound of storm, wind and weather played on the outside of their environmental tent –

Okay, Okay It's Purple Prose

- Obama - a comprehensive, national, clean water framework to improve water quality, water rivers, and watersheds
- Added conservation programs - the American West
- Considerations for response to climate change
- Funding for ecohydrology projects, favorable - 92 grants for water conservation


Comes the Deluge

Could it get any weirder? Part One

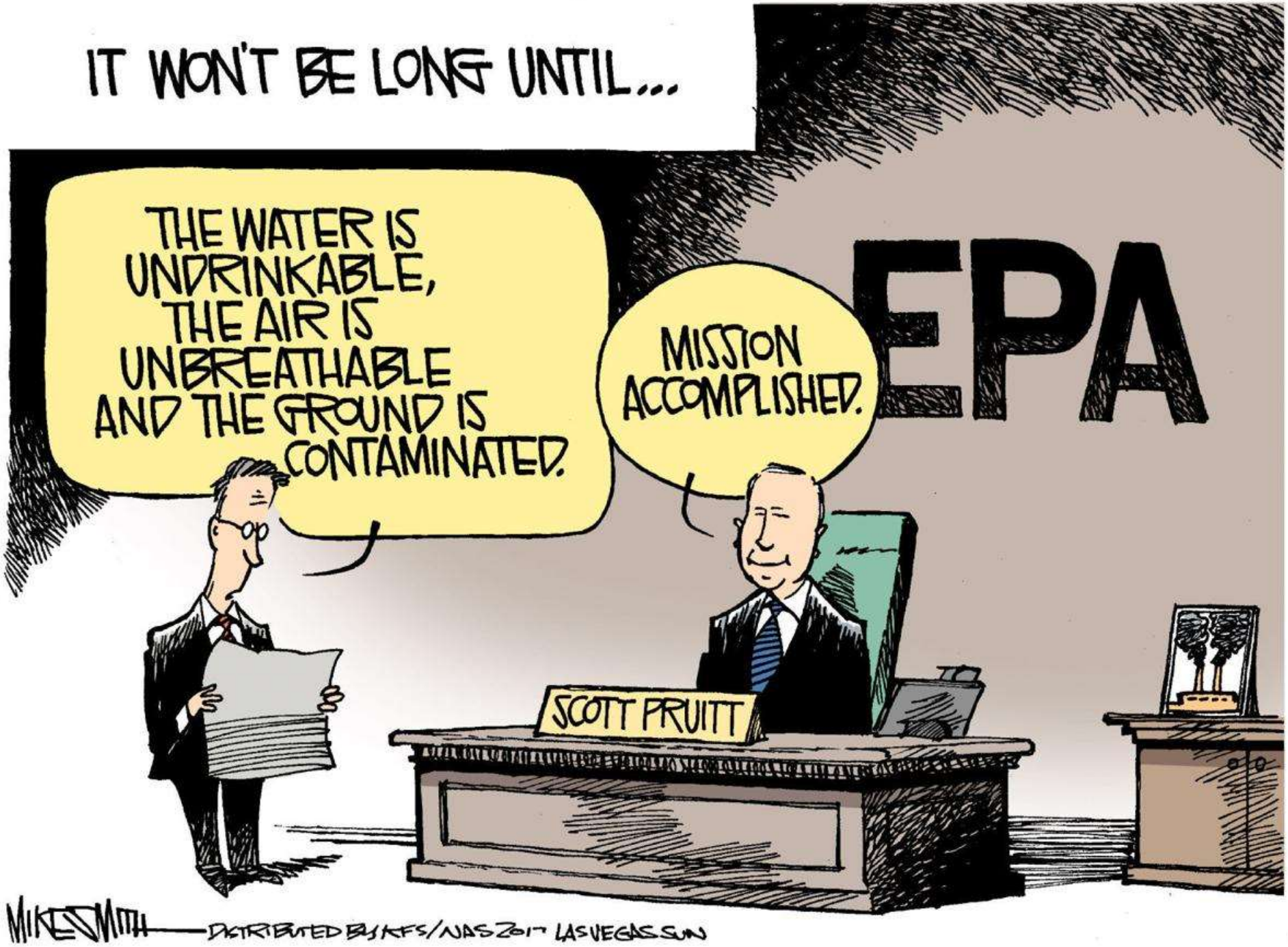
- Trump - dislike for environmental regulations calling the USEPA a "disgrace"
- USEPA program, Science to Achieve Results (STAR) - accolades from the National Academies, Pruitt called for the Program's elimination in its 2019 budget
- Trump administration sought to overturn more than 60 environmental rules
- 33 environmental rules rescinded including:
  - endangered species listings
  - environmental mitigation for federal projects
  - ban on lead ammunition
  - freezes on new coal leases on public lands
  - bans on a potentially harmful pesticide
  - anti dumping rules for coal companies
  - migratory bird protections

Could it get any weirder? Part 2

- Rollbacks of Obama era regulations are in progress
  - Status of national monuments,
  - Sage grouse habitat protections
  - Coal ash discharge regulations
  - Forest restoration projects,
  - Potential reversals are possible for hazardous chemical facility regulations, groundwater protections for uranium mines, and wetland and tributary protections

- Patagonia seeking a judicial order blocking the administration's actions on public lands by suing in Washington federal court, joins environmental groups and Native Americans

- Public lands, economic consequences – the outdoor recreation industry 887 billion dollars in consumer spending in the U.S. annually, creating 7.6 million American jobs, $65 billion in federal tax revenue, and $59 billion in state tax revenue

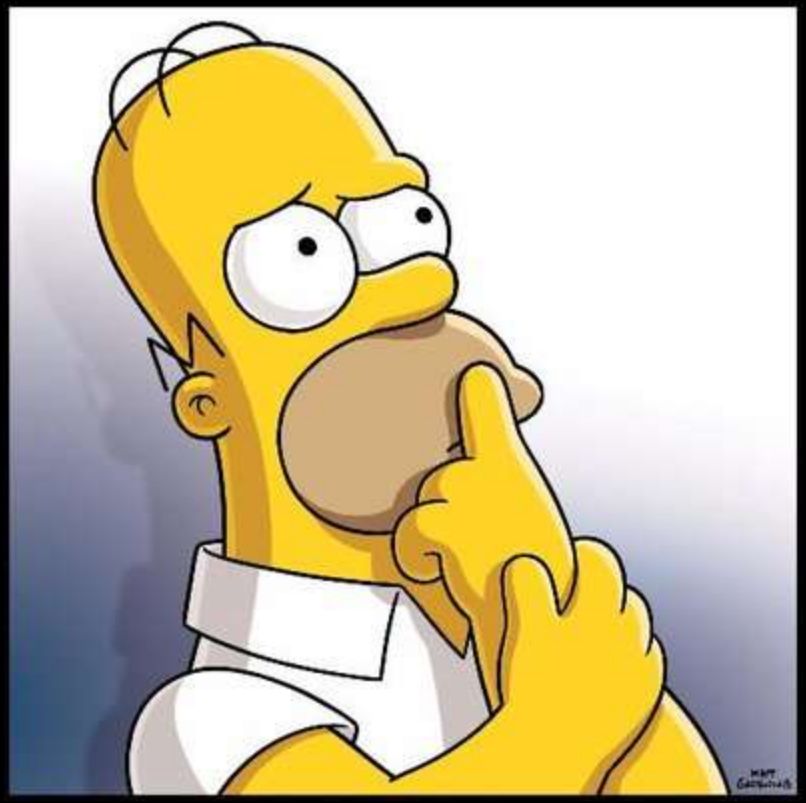

IT WON'T BE LONG UNTIL...
THE WATER IS UNDRINKABLE, THE AIR IS UNBREATHABLE AND THE GROUND IS CONTAMINATED.
MISSION ACCOMPLISHED.
EPA
SCOTT PRUITT
MIKE SMITH
DISTRIBUTED BY KFS/NAS 2017 LAS VEGAS SUN

Solutions

- Immigrate to Canada
- Just Kidding
- Public Involvement – supported by evidence based science
- Citizen Science
- Scientists get more involved in political action

So, In the words of a great philosopher

Homer Simpson



“If a tree falls in a forest…..

Will you make a sound?”