SUBSURFACE DRIP DISPERSAL OF EFFLUENT for LARGE SYSTEMS

Presented by:
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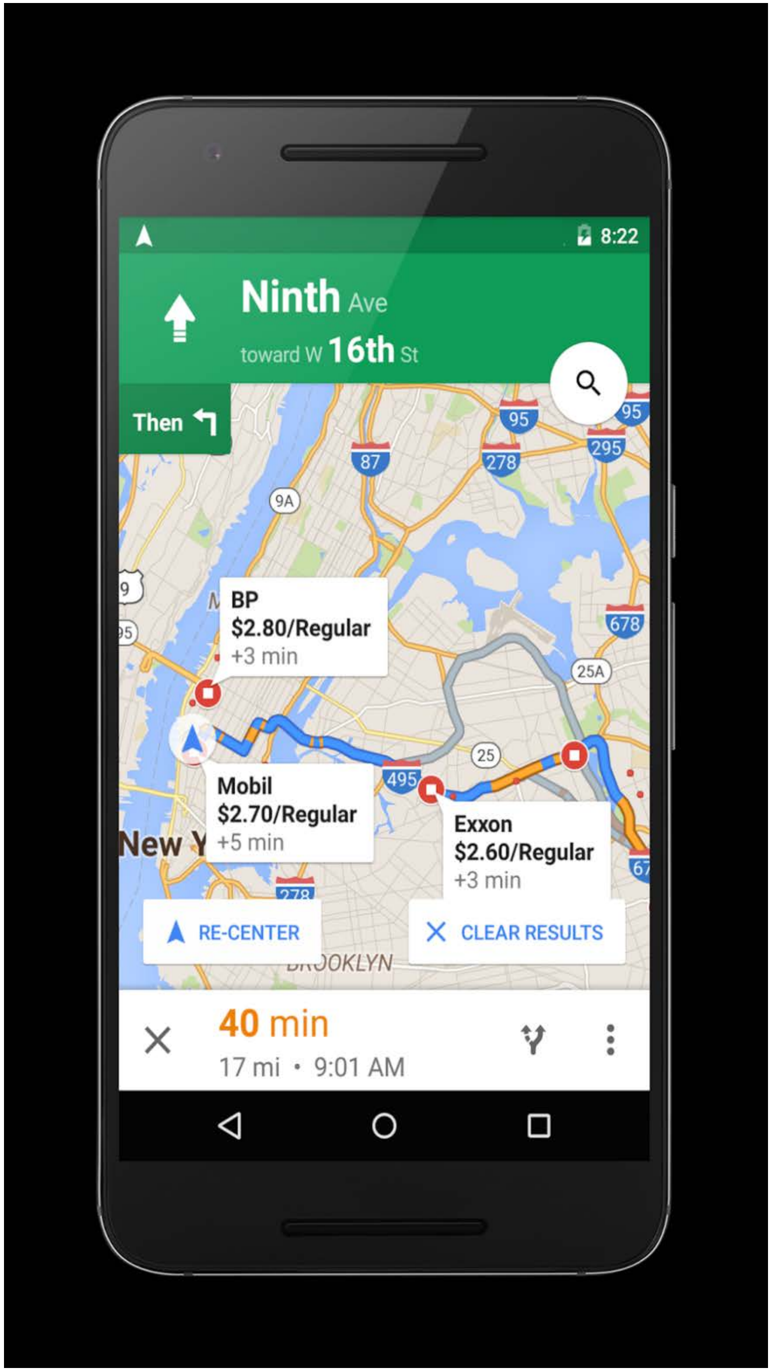
Program

Mapping



Program
Soils

Program

Site Topography

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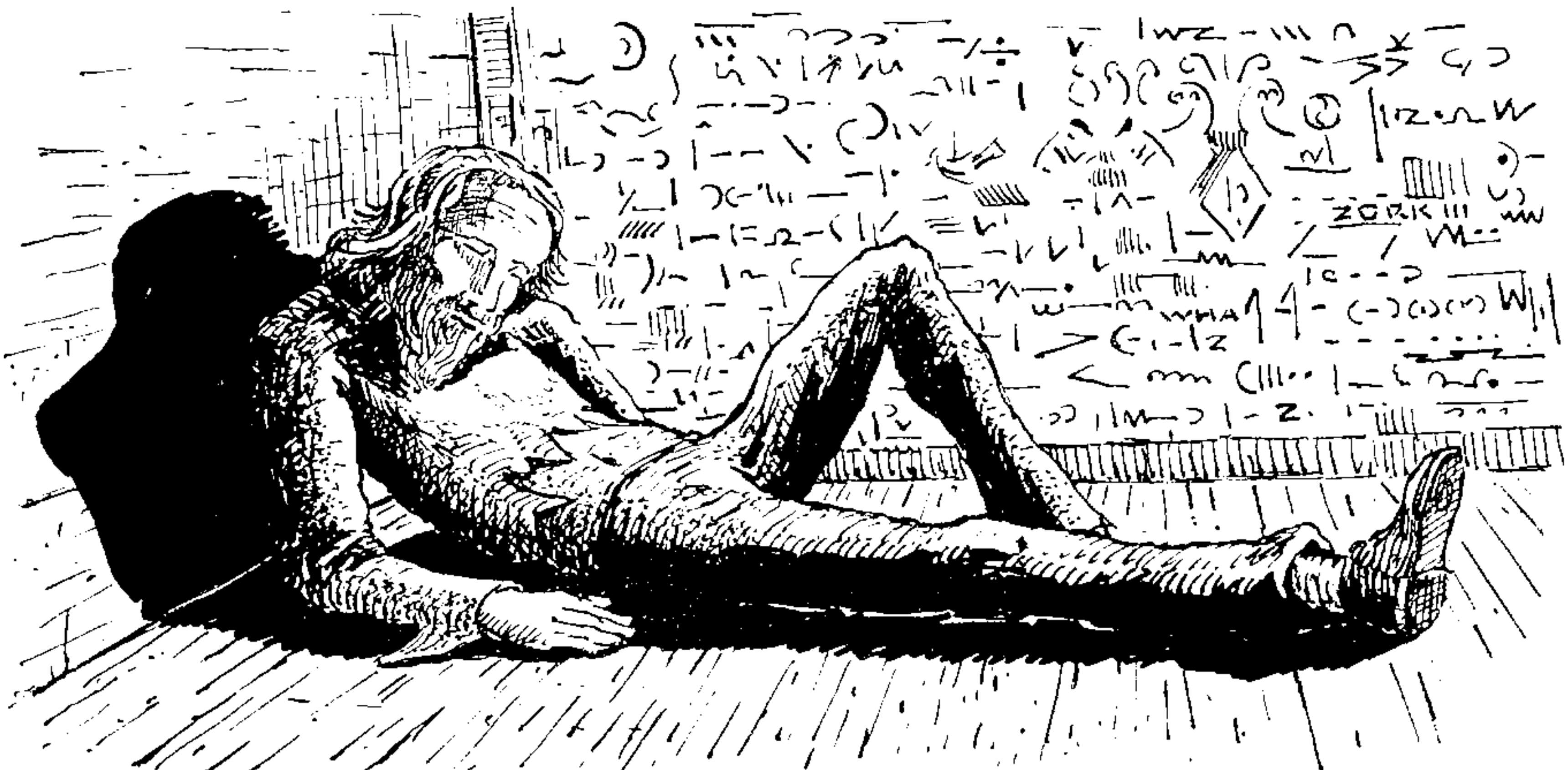
Design Process

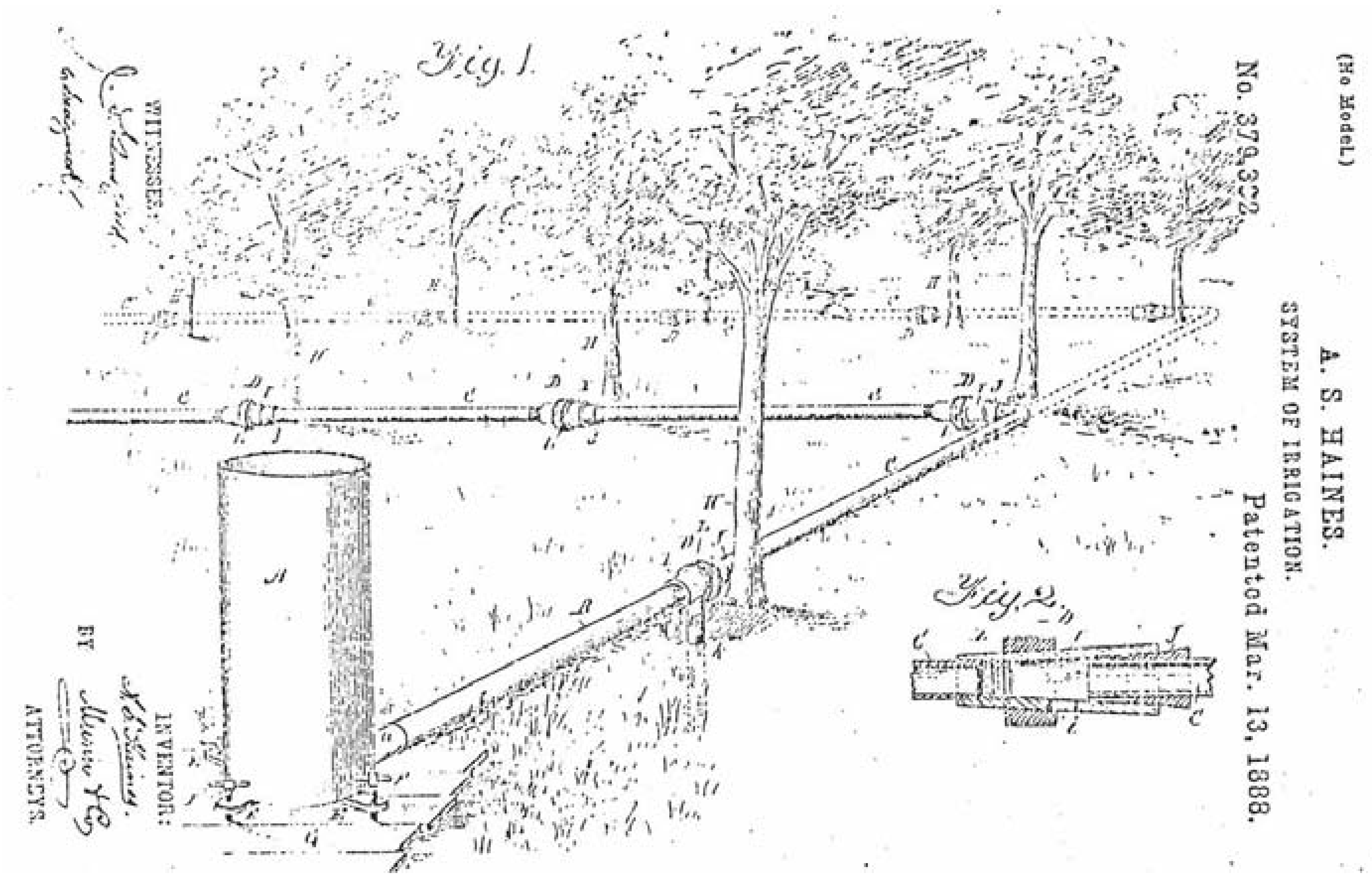
Treatment Systems, Dispersal Systems, System Efficiency and Storage

Component Selection
Antalya circa 100 B.C.

Designing

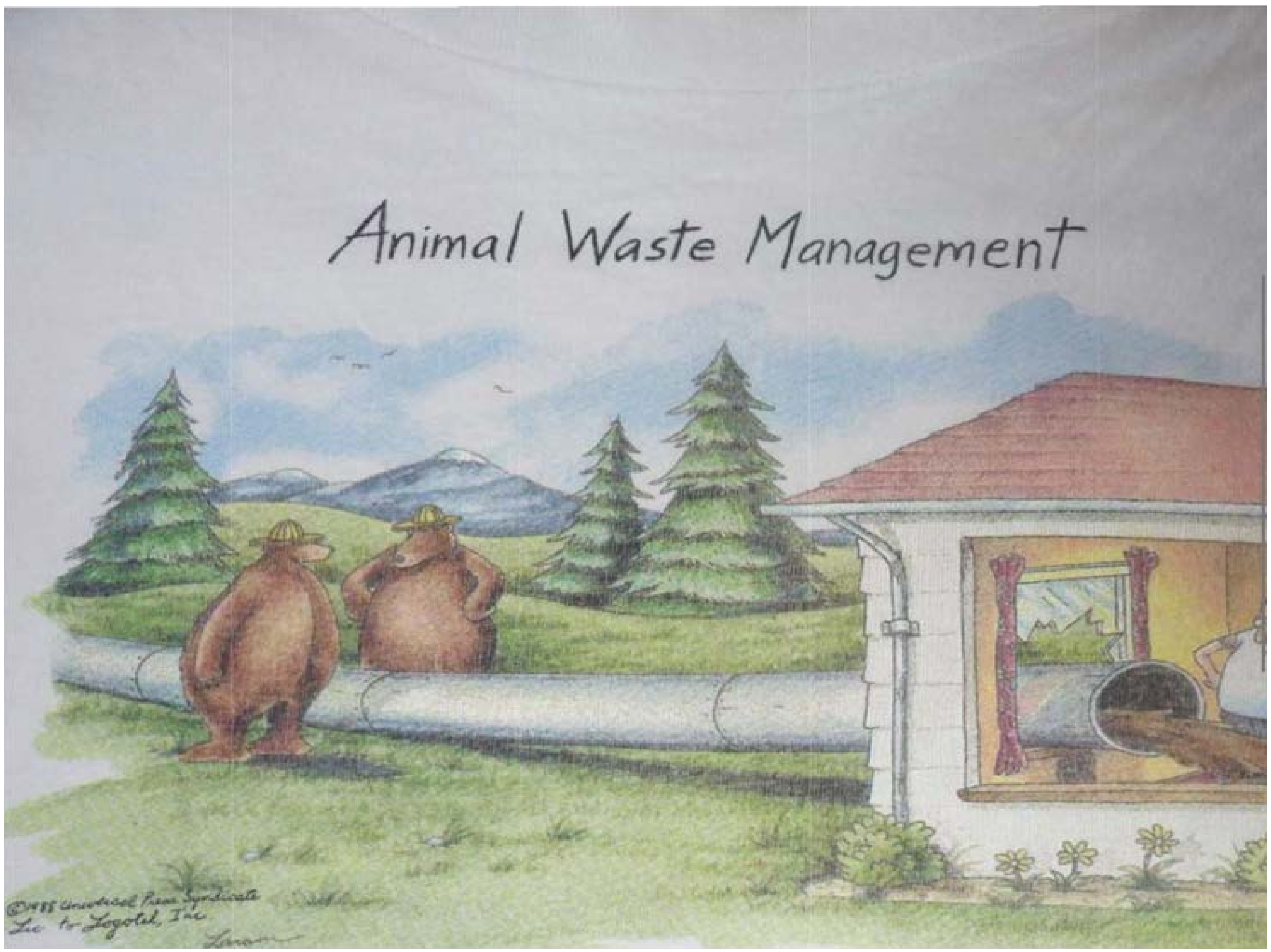


Reuse for Irrigation
1888 U.S. Patent

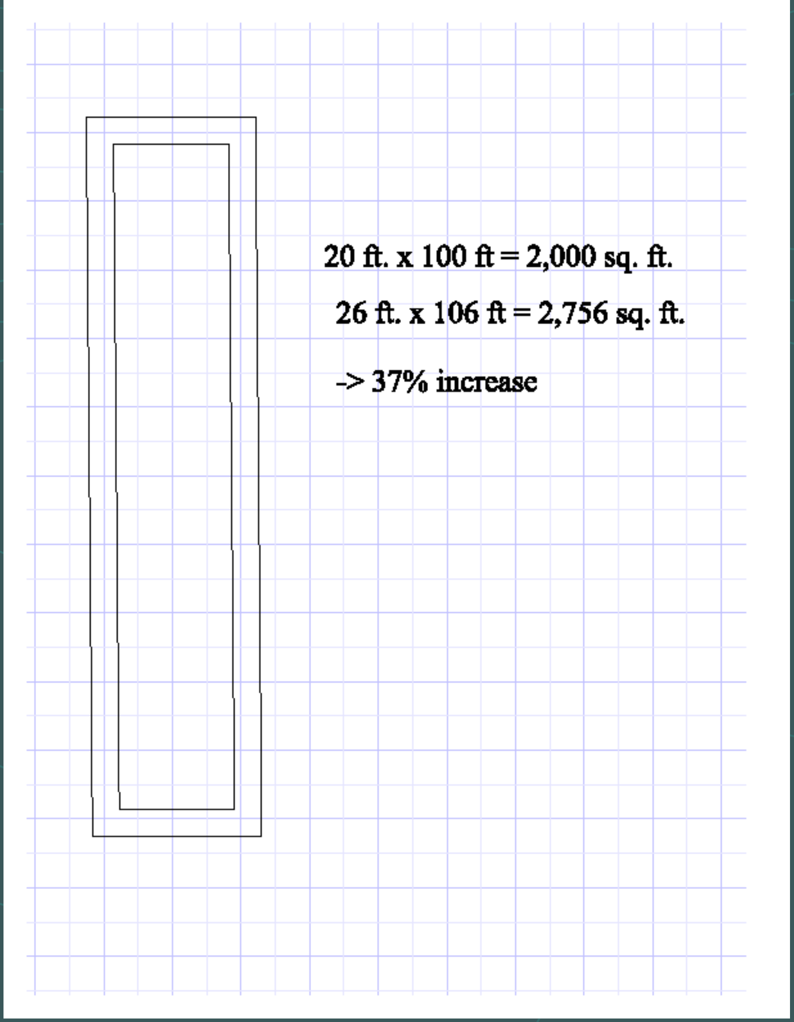


Design factors for Maintenance

Subsurface drip systems for wastewater dispersal and re-use – the basic principle of how it works.



Edge effect – small systems



Regulations

"Sure, it's a great invention, but does it comply with all government guidelines?"

Excell Spreadsheets

- Useful for designing each zone – one by one.
- Present commercial products cannot be used to design a large system.

The Site

- Determine suitability of the site
  - All sites are not suitable
- Area required for disposal field
  - Usable area versus total area
- Location of drip field
- If required, expansion and/or replacement area
- Requires an Onsite Visit by the Evaluator

Factors To Be Determined

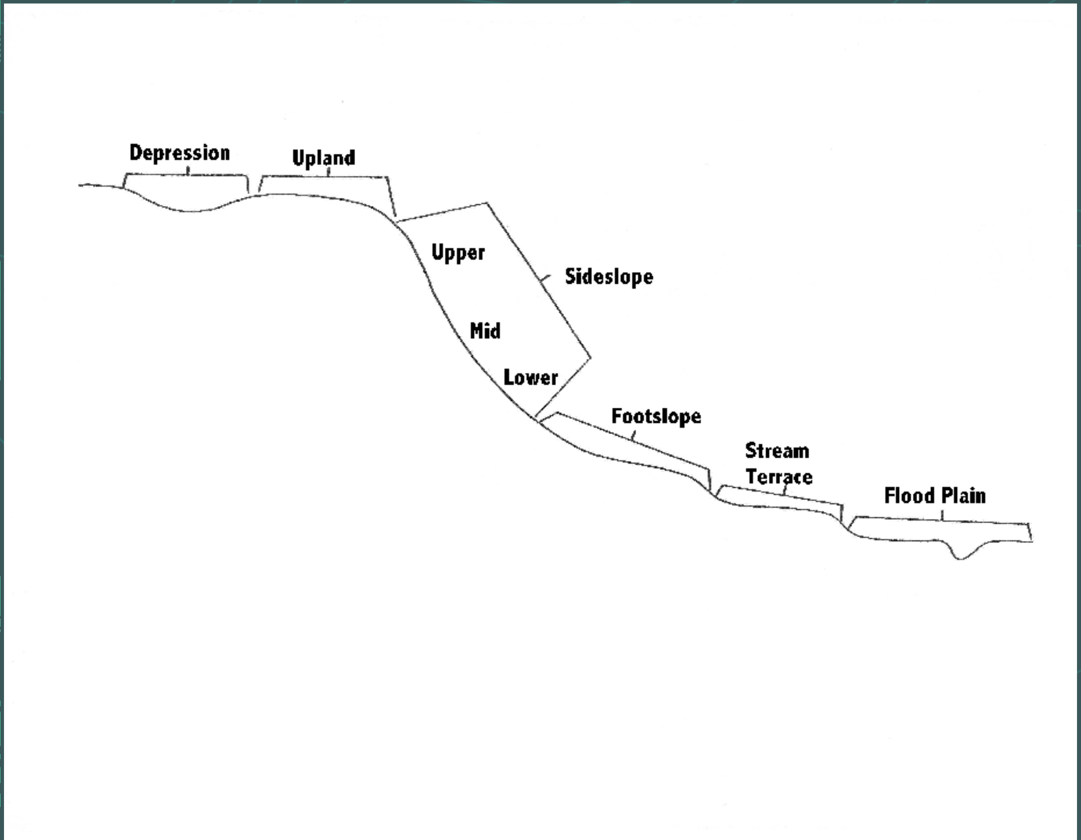
- Absence of or protection from flooding
- Landscape position
- Slope
- Soil color
  - Includes mottles
- Depth to high seasonal water table
- Soil texture
- Depth to restrictive horizon
- Soil structure
- Available area

Flooding

- The temporary covering of the soil surface by flowing water from any source or combination of sources.
  - None – No reasonable possibility of flooding (near 0% chance of flooding in any year).
  - Rare – Flooding unlikely but possible under unusual weather conditions (from 0 to 5% chance of flooding in any year).
  - Occasional – Flooding is expected infrequently under usual weather conditions (5 to 50% chance of flooding in any year).
  - Frequent – Flooding is likely to occur often under usual weather conditions (more than a 50% chance of flooding in any year).

- Shallow water standing or flowing during or shortly after rain is excluded from the definition of flooding.

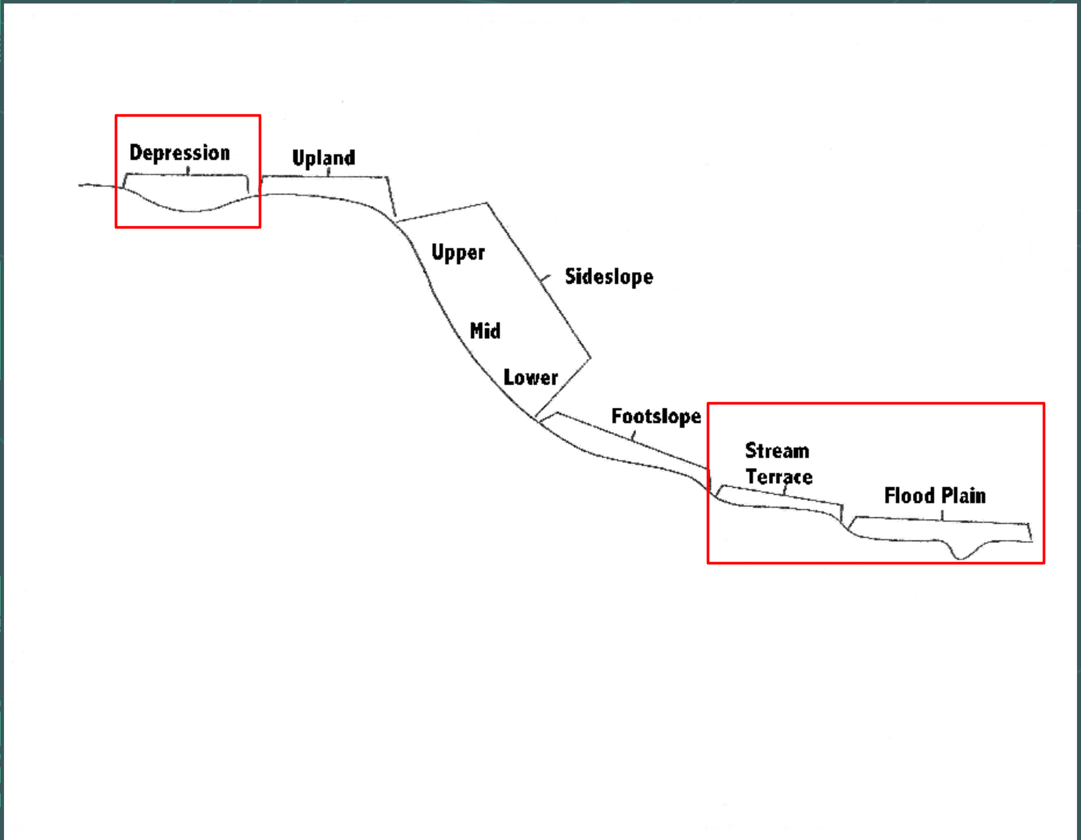
Landscape Position



Second only to parent material as a source of variation among soils.

- Flood Plains
- Stream Terrace
- Foot Slope
- Side Slope
- Upland
- Drain ways

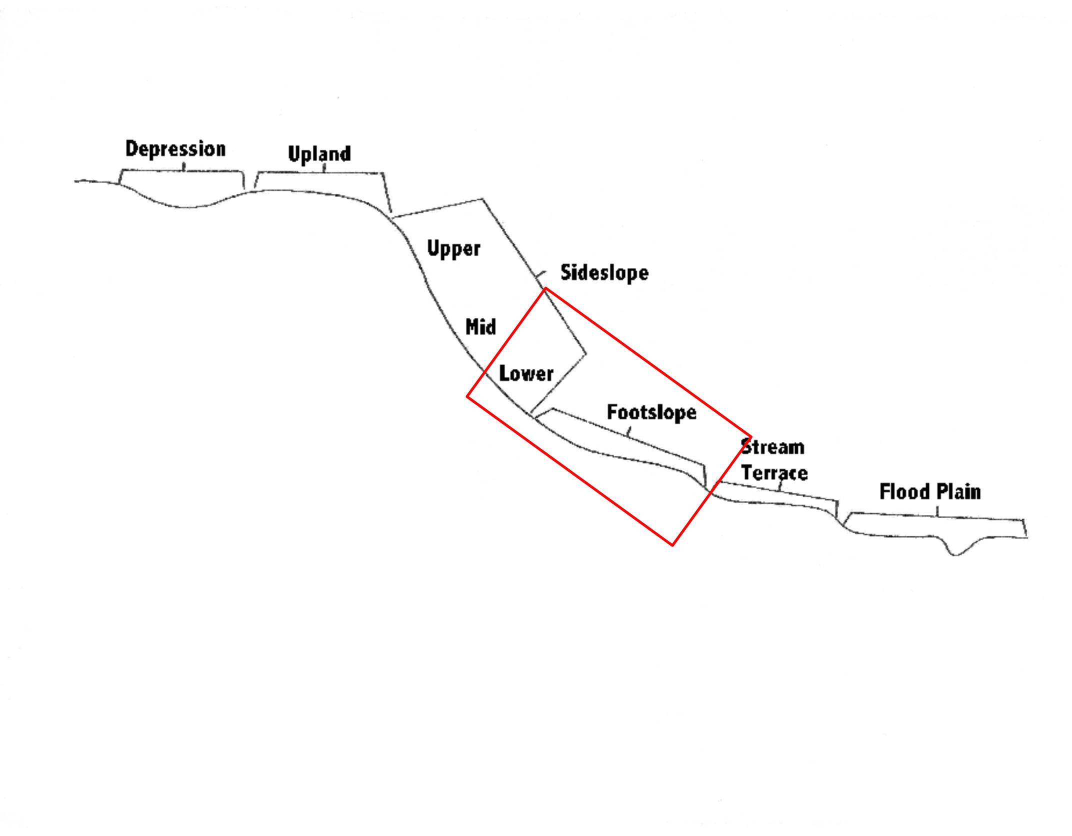
Landscape Position – continued



Flood Plains, Depressions, and Stream Terraces often have soils with high water tables, thus unsuitable for subsurface disposal.

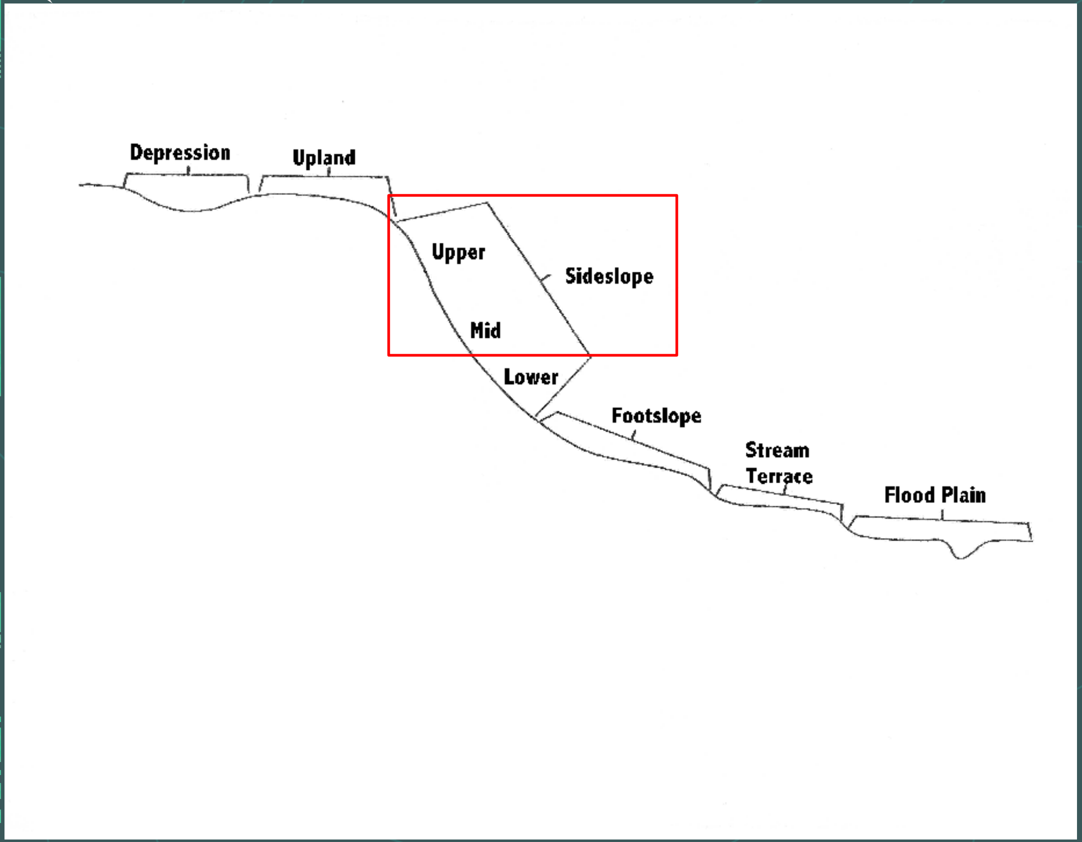
- Drain ways are areas where runoff concentrates during the process of removal of storm precipitation and are not suited for subsurface disposal.

Landscape Position – continued



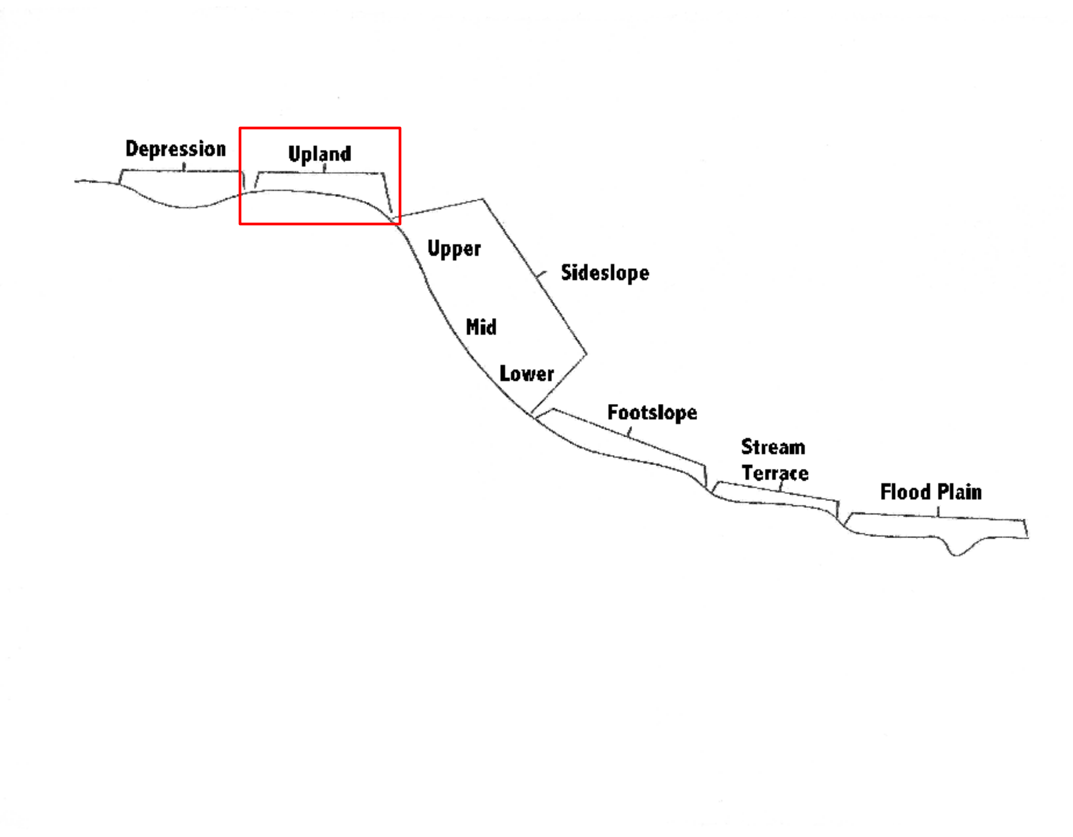
Lower Side Slopes and Foot Slopes often have seep lines where lateral water moves to the surface, if present these areas must be avoided.

Landscape Position – continued



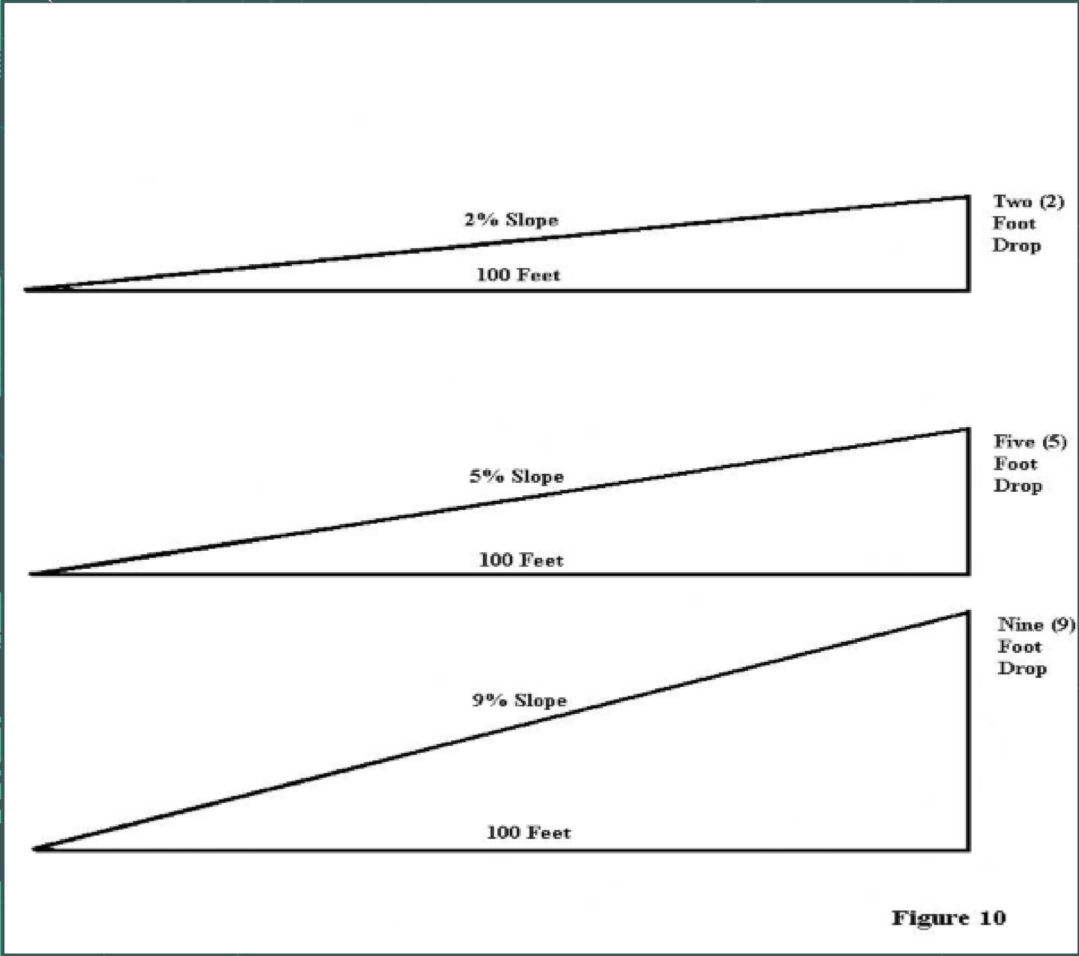
Upper and Mid Side Slope positions are often well suited to subsurface disposal.

Landscape Position – continued



Upland positions often contain soils with shallow restrictions causing perched or seasonal water tables.

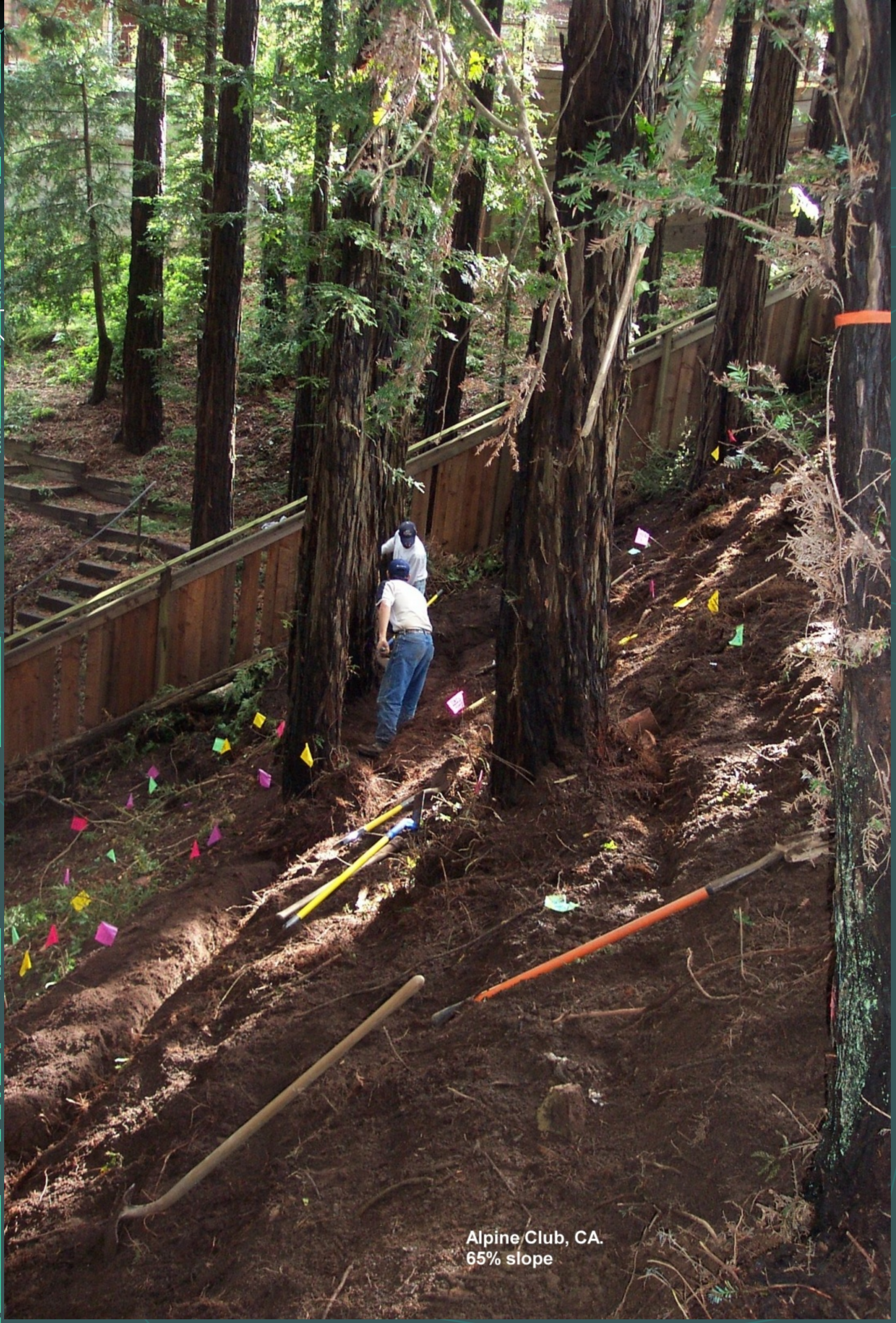
Slope



Change in elevation in 100 horizontal feet

- 30 to 35% equipment stability problems
- Over 30% may require design modification
- 0 to 4%, water tends to stack higher in the profile
- 6 to 12%, in our opinion is ideal

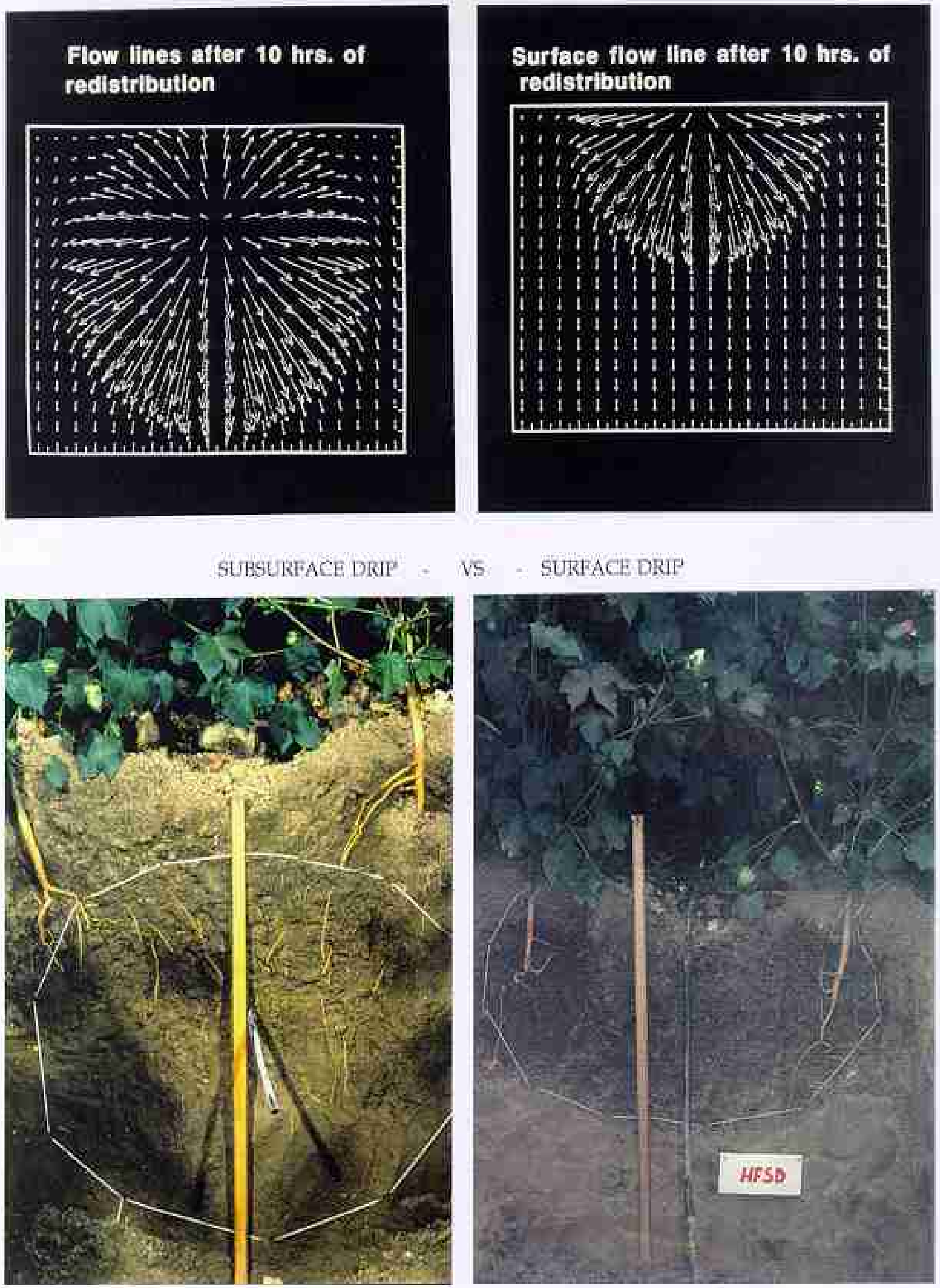
How Much Slope Can You Work?



65% slope, It Can Be Done!!!

The Mountain Club

Mt. Tam, California

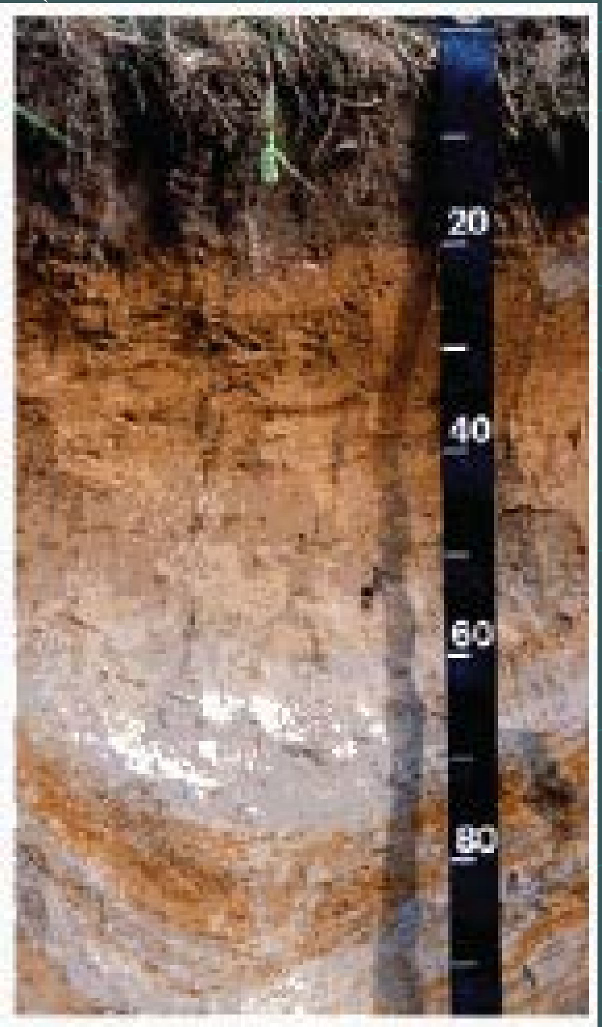


- USDA
- Dr. Claude Phene
- Approx. 1980

Soil Color

- Many soils contain only one Uniform color, while others have 2 or more and are referred to as Mottled
  - Most obvious property
  - Easily determined and recorded
  - Most useful for soil identification and appraisal
- Color is only one of many properties that must be considered

Soil Color



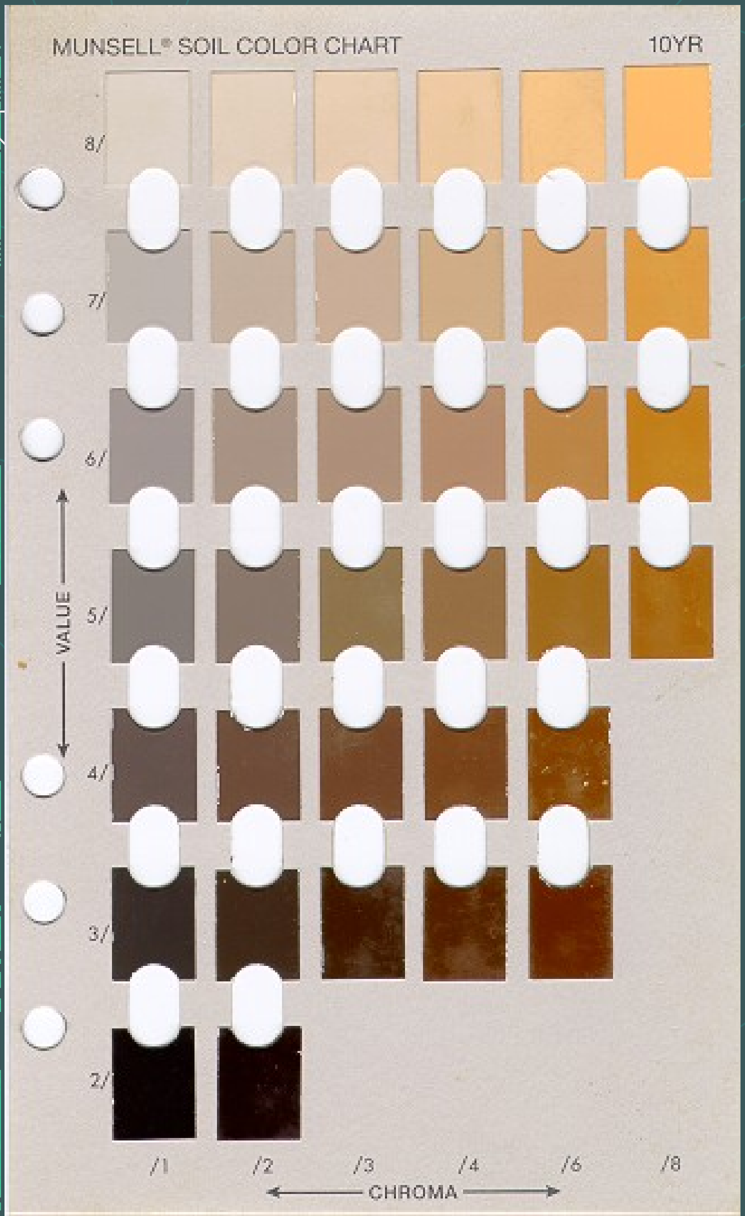
- Easily identified property
- Used to relate chemical and physical properties
  - Watertable depth
  - Drainage
  - Chemical constituents
  - Formation

Coloring Agents in Soil

- Organic matter
  - Very strong coloring agent
    - Makes soil dark or black colored

- Compounds and elements
  - Iron, sulfur, manganese, etc
    - Iron
      - Dominate element in soils
      - Aerated iron-oxides (rust) coat particles giving soil a yellowish-brown to reddish color
    - Manganese
      - Oxides are purplish-black in color

Describing Soil Color

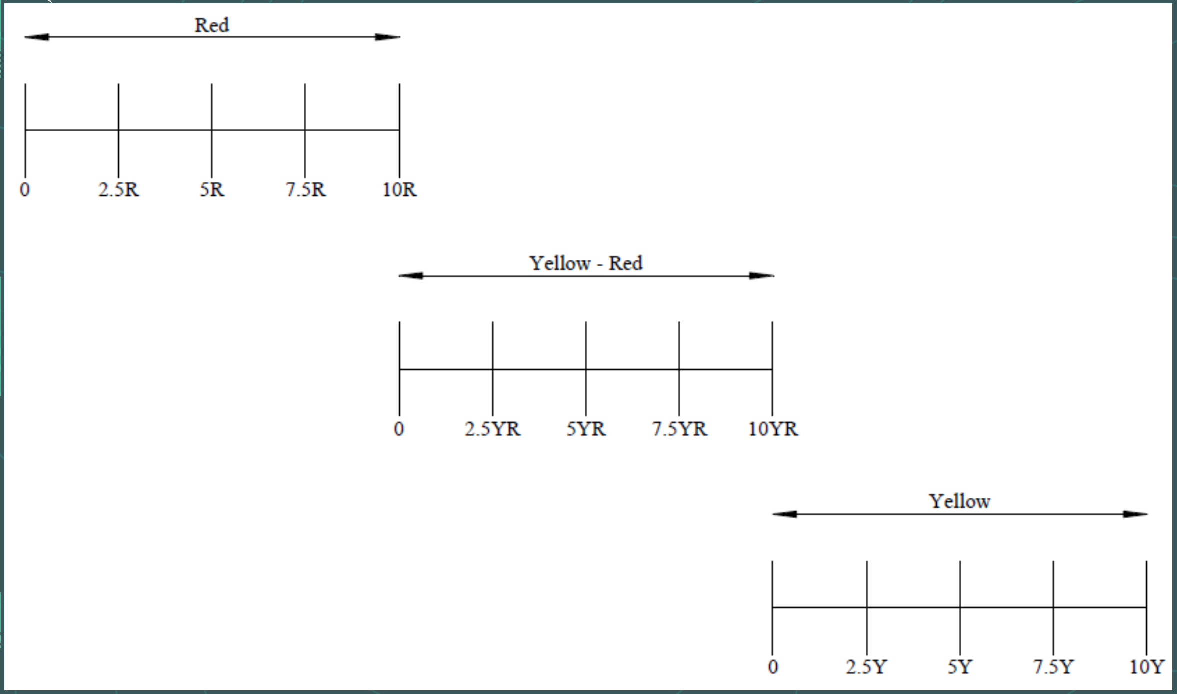


The Munsell color book is used to document color by means of a standard notation.

- Hue
  - Dominant spectral color
- Value
  - The degree of light or darkness of a color in relation to a neutral gray.
- Chroma
  - Strength of hue

Soil Color

Hue - Dominant spectral wavelength



Red

- 0, 2.5R, 5R, 7.5R, 10R

Yellow – Red

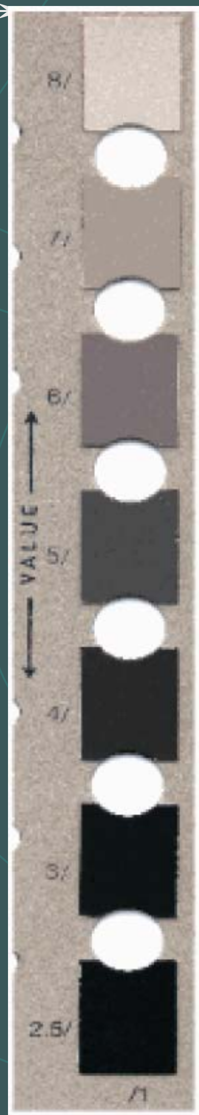
- 0, 2.5YR, 5YR, 7.5YR, 10YR

Yellow

- 0, 2.5Y, 5Y, 7.5Y, 10Y

Soil Color

Value



0/10 – Pure White

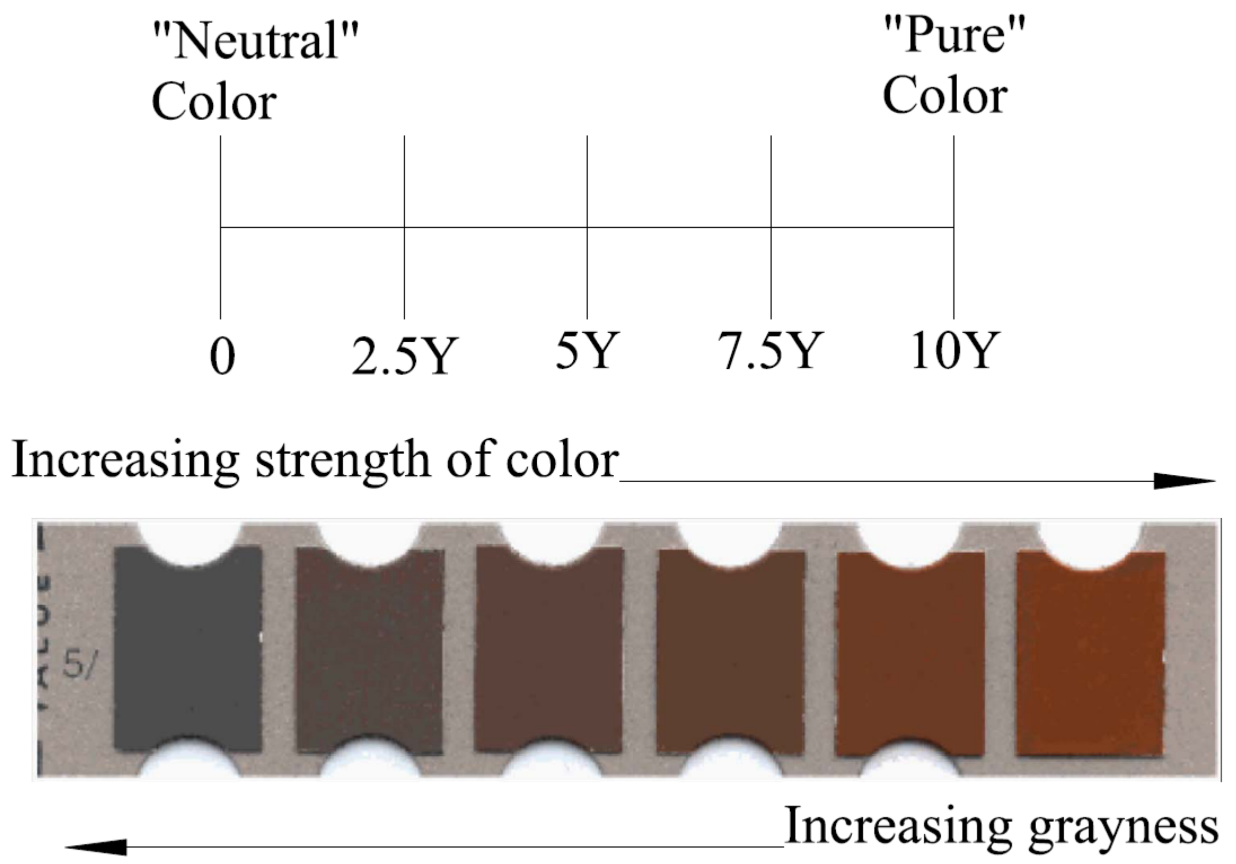
5/0 – "Gray"

0/0 – Pure Black

The lightness or
Darkness of Color

Soil Color

Chroma



Uniform Soil Colors

- Red or Brown
  - Passing rainfall without problems
    - May not take additional water due to slow rate, i.e. clay
- Yellow or Olive
  - Having some difficult with rainfall
    - Does not indicate seasonal water table
- Gray
  - Seasonal water table
    - Indicates saturation for periods of over 1 month
- Black
  - Organic matter due to wet conditions and lack of oxygen
    - Organic matter mask the gray color

Mottling of Colors

- Red and yellow mottling indicates slow absorption rates
- Gray mottling with red or brown indicates high seasonal water table
- Black mottling may indicate precipitation of iron or manganese and wet conditions
- Pale brown mottling with yellow brown indicates short periods of saturation

High Water Table

- Perched or seasonal
  - Not free water
- Redox features in soil

Soil Texture

Texture is the single greatest factor influencing water movement in soil

- Water movement in soil:
  - Quite simple and easy to understand in some ways
  - Yet complex and difficult to grasp in others
  - Nearly always moving in soil as liquid or vapor

- Water tends to move from areas of higher potential energy to areas of lower potential energy

- Soil permeability, aeration and drainage are closely related to texture because of it’s influence on pore size and continuity

Soil Texture

Definition: relative proportions of various sizes of individual soil particles

- USDA classifications
  - Sand: 0.05 – 2.0 mm
  - Silt: 0.002 - 0.05 mm
  - Clay: <0.002 mm
- Textural triangle: USDA Textural Classes
  - Coarse vs. Fine, Light vs. Heavy
  - Affects water movement and storage

Soil Texture
Potential Energy

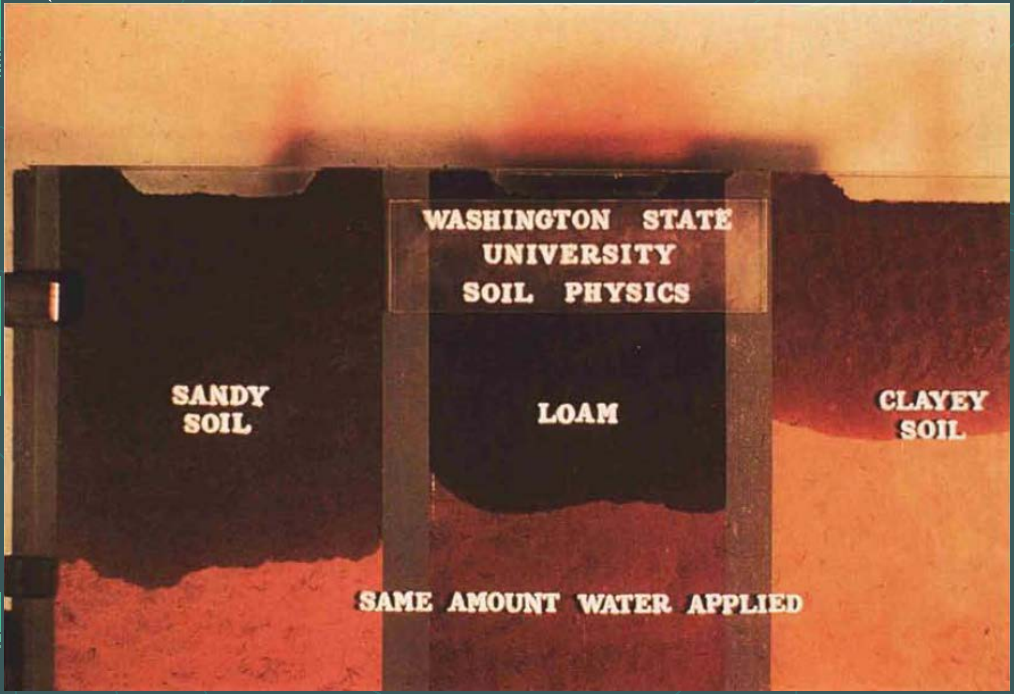
- Force of gravity
  - Just as water at a higher elevation moves to a lower elevation, water in soil tends to move downward due to gravity
- Attraction of the soil surfaces
  - If you add water to the bottom of a dry pot of soil, the water moves up into the soil
  - As the soil in the pot becomes wet, the attraction reduces
  - Once the pores are completely filled, the soil no longer attracts water
- External pressure
  - In saturated soils, external pressure may be present if the area is flooded

Soil Texture - Pore Size & Continuity

Capillary Action

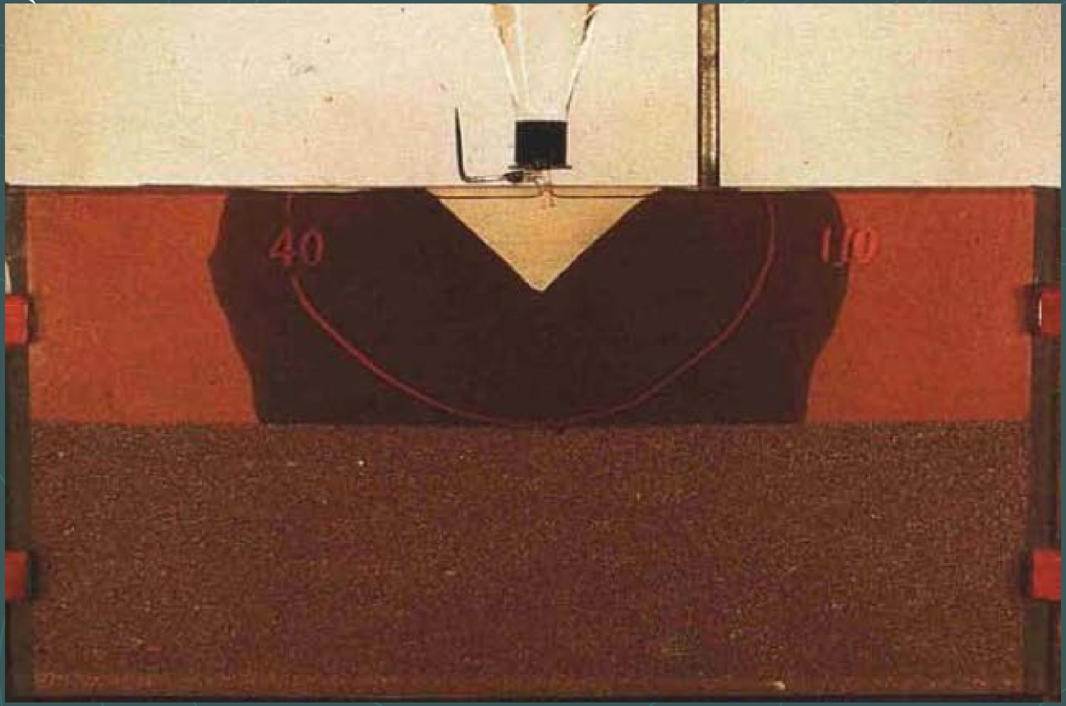
- Refers to the attraction of water into soil pores – which makes water move in soil
- Involves two types of attraction, adhesion and cohesion
  - Adhesion is the attraction of water to solid surfaces
  - Cohesion is the attraction of water to itself
- Some surfaces repel, rather than attract water
  - When cohesive force is stronger than adhesive force
- Capillary forces can move water in any direction

Soil Texture & Water Storage



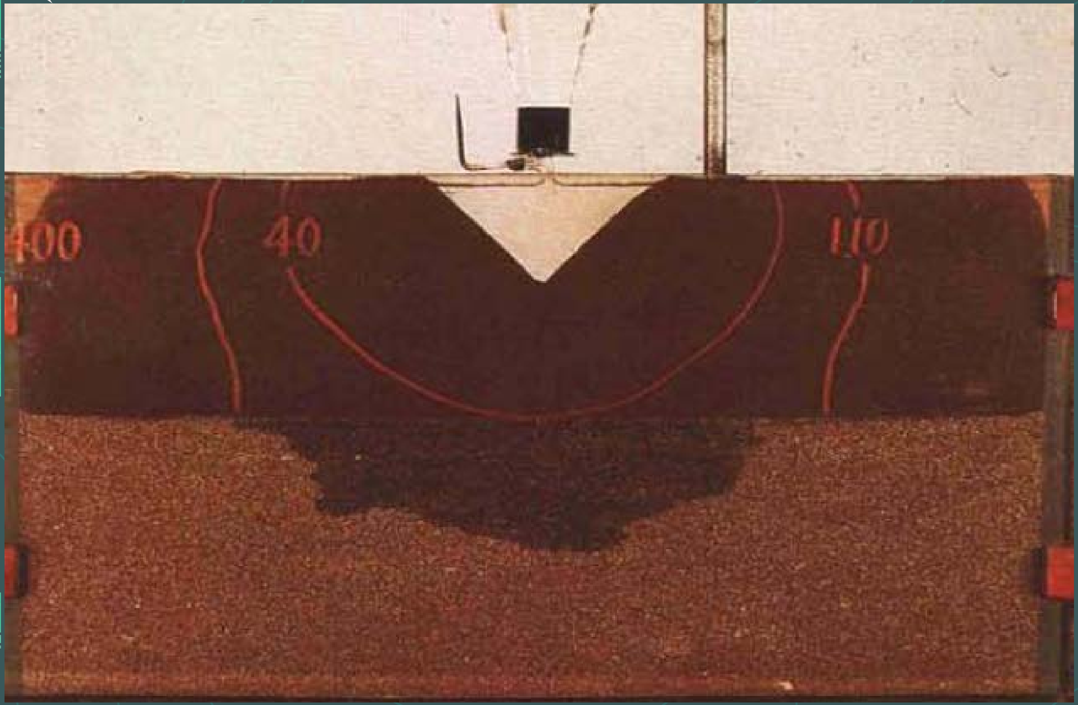
- Equal volume of water & soil
  - Sandy soils have less pore space than silt or clay soils
  - Water penetrates more rapidly and deeper in sandy soils than silt or clay soils
  - Consequently sandy soils drain quicker than silt or clay soils
  - However, water eventually rises higher and moves farther laterally in silt and clay soils than in sandy soil due to the forces of adhesion and cohesion

Soil Texture & Water Movement



- In a layered soil, water will not move by capillary action from a finer texture to a coarse texture
- The adhesive and cohesive forces in the finer texture are greater that the gravitational force and the adhesive force of the coarser texture
- This holds true until saturation of the finer texture is reached

Soil Texture & Water Movement



Lateral movement stopped at 400 seconds, saturation of the finer texture occurred

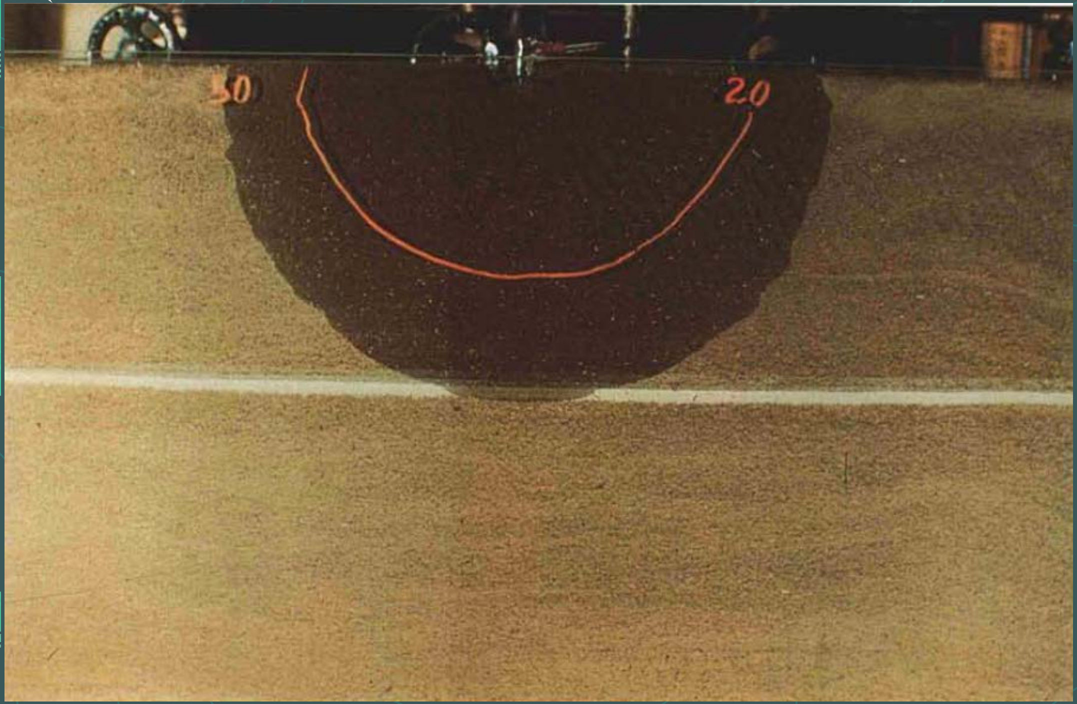
Gravitational force plus adhesive force of the coarser texture now exceeds the adhesive and cohesive force of the finer texture

If the fine texture is 10" thick and the coarse texture is 30" thick

Which layer do you use to size the system?

How deep should the drip tube be installed?

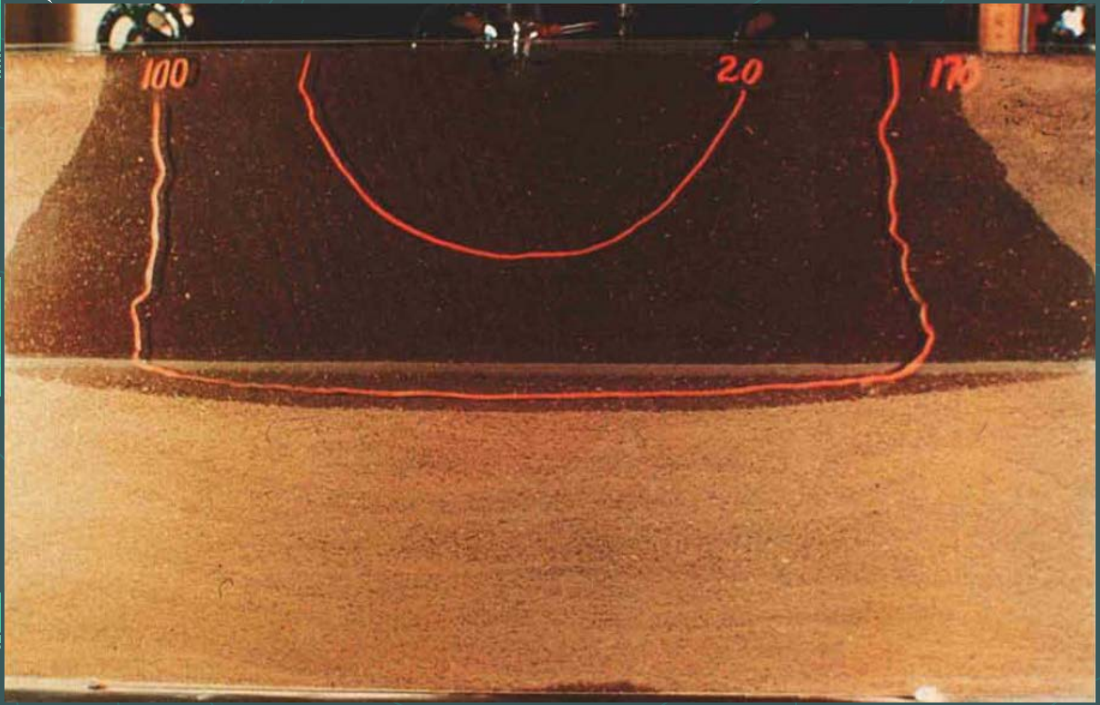
Soil Texture & Water Movement



When soil with larger pores (loam) overlies soil with smaller pore (clay), water moves uniformly by gravity and capillary action through the upper layer until it reaches the clay layers

Capillary forces in the clay layer immediately draw water downward into the clay layer

Soil Texture & Water Movement



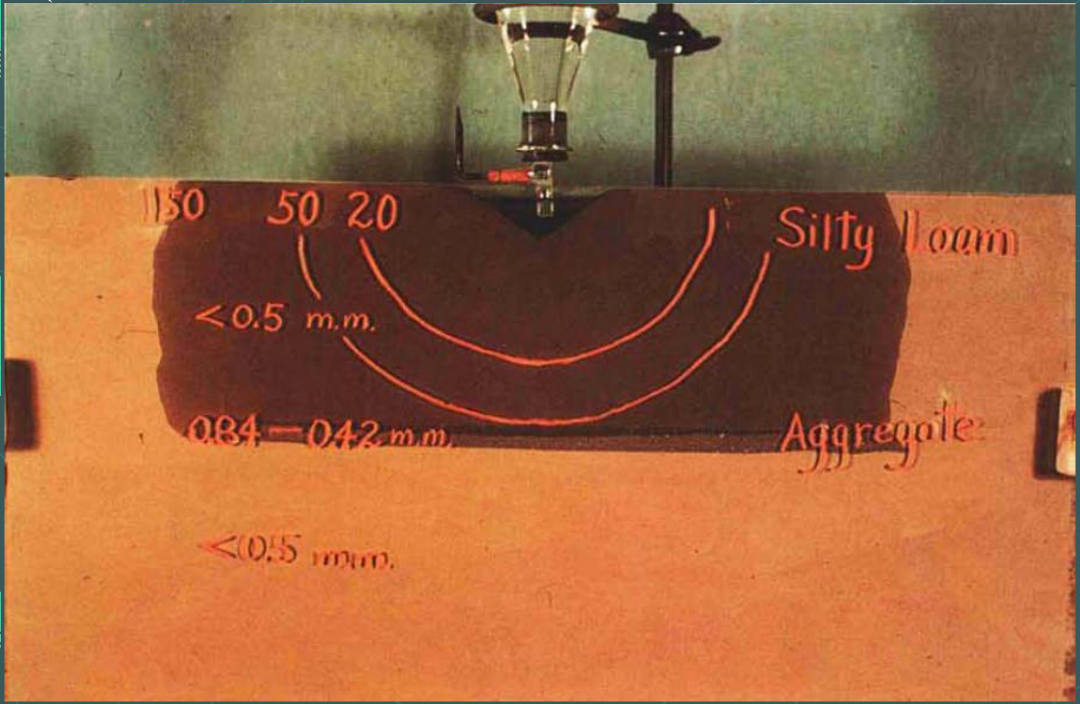
As water moves slowly through clay layers, water accumulates at the boundary

Clay has a relatively high water holding capacity and high soil tension, thus it can absorb and hold a large quantity of water

Little or no water moves to soil horizons below until the clay layer becomes saturated

Even then the clay layer restricts the downward movement

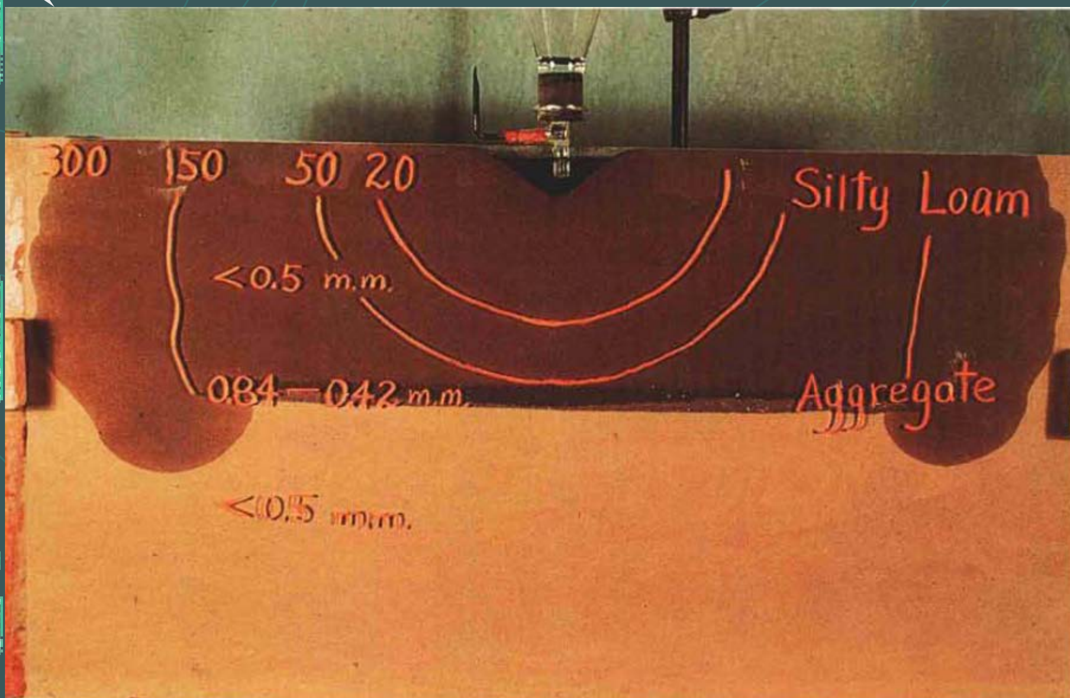
Soil Texture & Water Movement



Any change in soil porosity encountered by a wetting front affects water movement

Partial subsoil layers can redirect water flow so that some areas receive much more water than others

Soil Texture & Water Movement



The relatively small number of contacts between the buried aggregate and the soil above limits the amount of water that can move through it

Water will not move through the aggregate until the soil above is saturated

Saturation was not reached – note that more water is moving around the right side as opposed to the left

Restrictive Horizons

- Any horizon occurring within 5 feet of the surface that restricts downward movement is considered detrimental.
  - Clay
  - Rock
    - Iron stone
    - Sand stone
    - Silt stone
  - Geological contact zones
    - Different soil formations, one over the other

- Can a sand or gravel layer be a restrictive horizon?

Soil Structure

- Refers to the natural organization of soil particles into units
- These units are separated by surfaces of weakness
- The surfaces persist through more than one cycle of wetting and drying
- An individual unit is called a ped

Pore spaces around the peds transport water and air, soil with small peds have a greater capacity to transport water

Soil Structure

- Soil structure is describe based on shape, size and grade
  - Shape
    - Platy – flat and plate like, generally oriented horizontally
    - Prismatic – units are bounded by flat to round vertical faces, distinctly longer vertically
    - Columnar – units are bounded by flat or slightly rounded vertical faces, tops are very distinct and normally rounded
    - Blocky – units are block like and bounded by flat or slightly rounded surfaces

Soil Structure

- Soil structure is described based on shape, size and grade
  - Size
    - Has five classes – very fine, fine, medium, coarse, and very coarse

	Shape of structure			
Size Classes	*Platy*[1] mm	*Prismatic and Columnar* mm	*Blocky* mm	*Granular* mm
1	<1	<10	<5	<1
2	1-2	10-20	5-10	1-2
3	2-5	20-50	10-20	2-5
4	5-10	50-100	20-50	5-10
5	>10	>100	>50	>10

[1] In describing plates, "thin" is used instead of "fine" and "thick" instead of "coarse."

Soil Structure

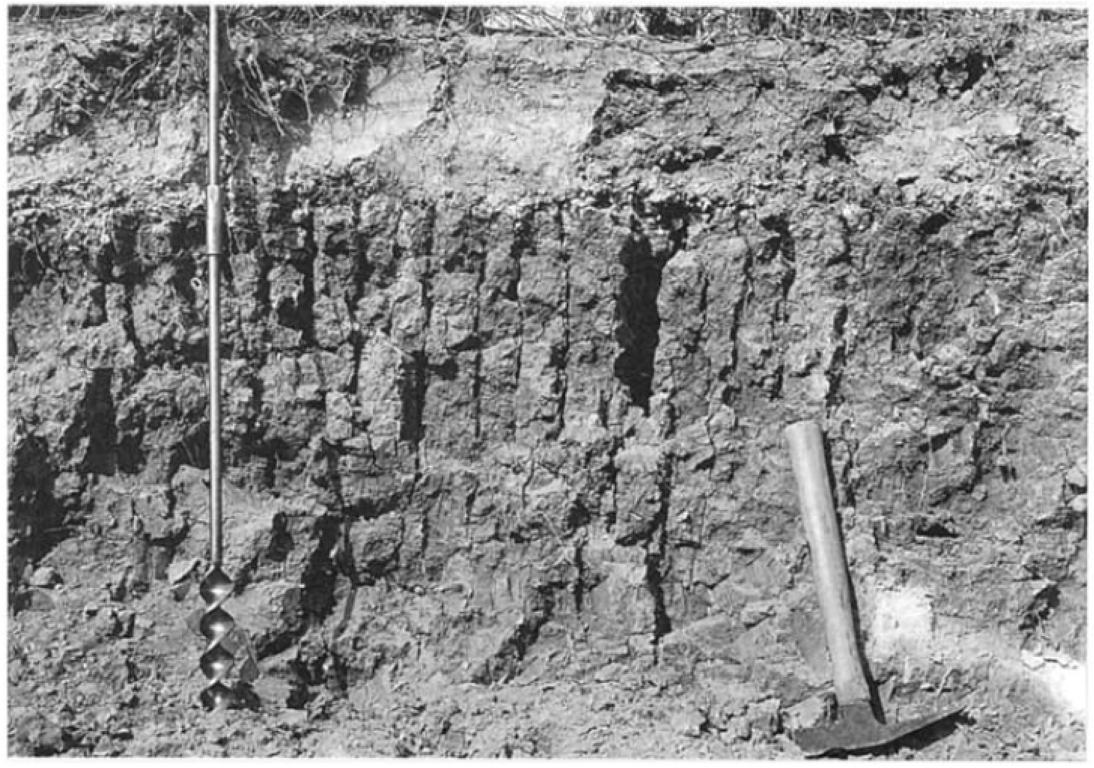
- Soil structure is described based on shape, size and grade
  - Grade
    - Weak – barely observable in place, parts into a mixture of whole and broken units when gently disturbed
    - Moderate – well formed and evident in undisturbed soil, parts into mostly whole units with some broken when disturbed
    - Strong – units are distinct in undisturbed soil, separates cleanly into mostly whole units when disturbed

Soil Structure Influence on Infiltration

Strong Thin Platy

Slow to Very Slow

Soil Structure Influence on Infiltration



Strong Medium Prismatic

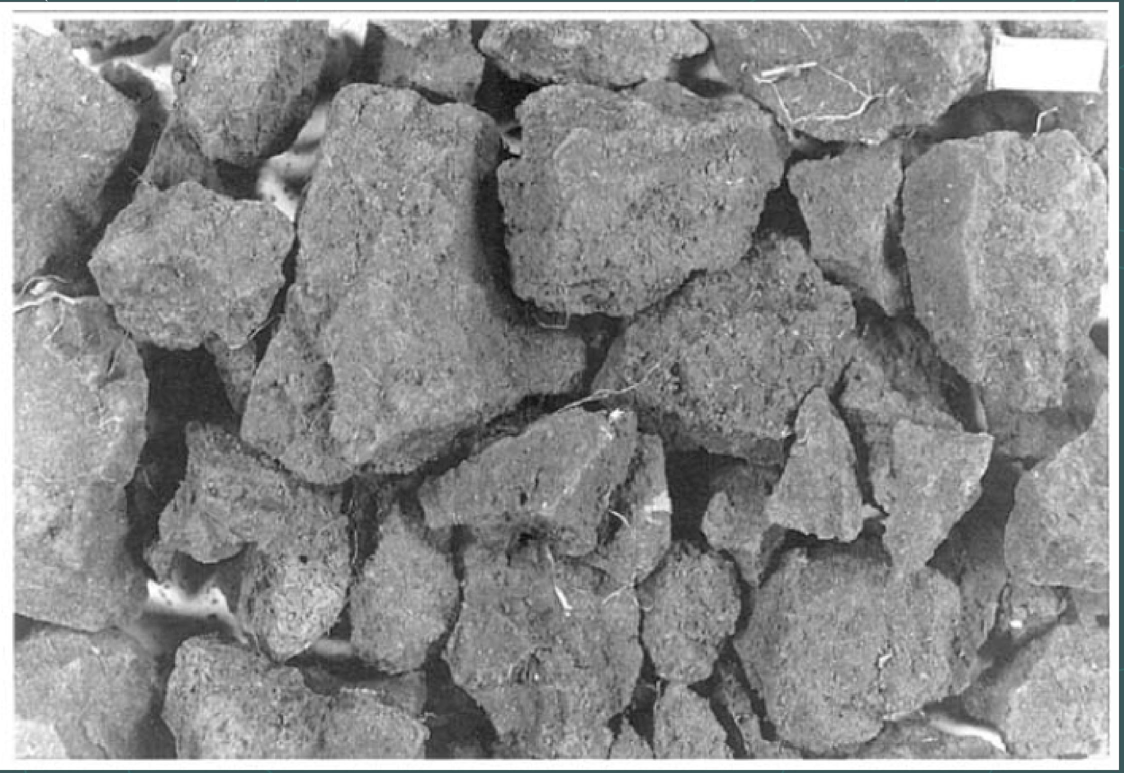
Moderate to Slow

Soil Structure Influence on Infiltration

Strong Medium Columnar

Moderate to Slow

Soil Structure Influence on Infiltration



Strong Medium & Coarse Blocky

Moderate

Soil Structure Influence on Infiltration

Strong Fine & Medium Granular

Rapid

Available Space

- Unacceptable
  - Drain ways
  - Flood prone
  - Slope
  - High water table
  - Shallow restrictions
- Setbacks
  - Property line
  - Drinking water wells
  - House, driveways, walkways
  - Out buildings

Summary Point 1

Pore size is one of the most fundamental soil properties affecting water movement.

The rate at which water moves through soil is primarily a function of soil texture and structure.

Larger soil pores, such as in sand conduct water more rapidly than smaller pores, such as in clay.

Sandy soils contain larger pores than clay, but have less total pore space.

Summary Point 2

The two primary forces that make water move through soil are gravitational and capillary.

Capillary forces are greater in small pores and involves two types of attraction – adhesion and cohesion.

Adhesion is the attraction of water to solid surfaces. Cohesion is the attraction of water molecules to each other.

Gravity pulls water downward when the water is not held by capillary action.

Summary Point 3

Factors that affect water movement through soil include soil texture, structure, organic matter and bulk density.

Any condition that affects soil pore size and shape will influence water movement.

Examples include tillage, compaction, residue, decayed root channels and worm holes.

Summary Point 4

The rate and direction of water moving through soils is affected by soil layers of different textures and structure.

Abrupt changes in pore size from one soil layer to the next affects water movement.

Capillary forces are greater in soil layers with small pores, such as clay, than in soil with large pores, such as sand.

Therefore, when clay soil overlies sands, downward water movement will temporarily stop at the sand/clay interface until the soil above is nearly saturated.

Summary Point 5

The rate of water movement is slower in clay soil than in sand.

So when a coarse textured soil such as sand overlies clay, the downward rate of water movement slows once the wetting front contacts the clay soil.

This can result in a long term build up of a perched water table above the sand/clay interface.

REUSE FOR IRRIGATION

- A ski resort in Utah is very different from a golf course in Arizona.
- Usually there has to be an alternative method of disposal – a sewer, a reserve percolation area, or storage.

Crop take-up for some common cover crops has been evaluated by the USEPA:

Forage crops:

TABLE 4–11 NUTRIENT UPTAKE FOR SELECTED CROPS - LB/ACRE – YEAR

Forage Crops:

	Nitrogen[b]	Phosphorous	Potassium
Alfalfa[a]	201–482	20–31	156–200
Brome Grass	116–201	36–49	219
Coastal Bermuda Grass	357–602	31–40	20
Kentucky Blue Grass	178–241	40	178
Quack Grass	210–250	27–40	245
Reed Canary Grass	299–401	36–40	281
Ryegrass	178–250	54–76	241–290
Sweet Clover	156	18	89
Tall Fescue	133–290	27	268
Orchard Grass	233–312	18–45	201–281

Field crops

Barley	112	13	18
Corn	156–178	18–27	98
Cotton	67–98	13	36
Grain Sorghum	120	13	62
Potatoes	205	18	219–290
Soybeans[a]	223	9–18	27–49
Wheat	143	13	18–40

Field Crops:

- Legumes will also take nitrogen from the atmosphere

Re-use in the Landscape of an Hotel in Carmel Valley

Omaha Beach Golf Course, N.Z.

Reuse at B.Y.U. Campus, HI.

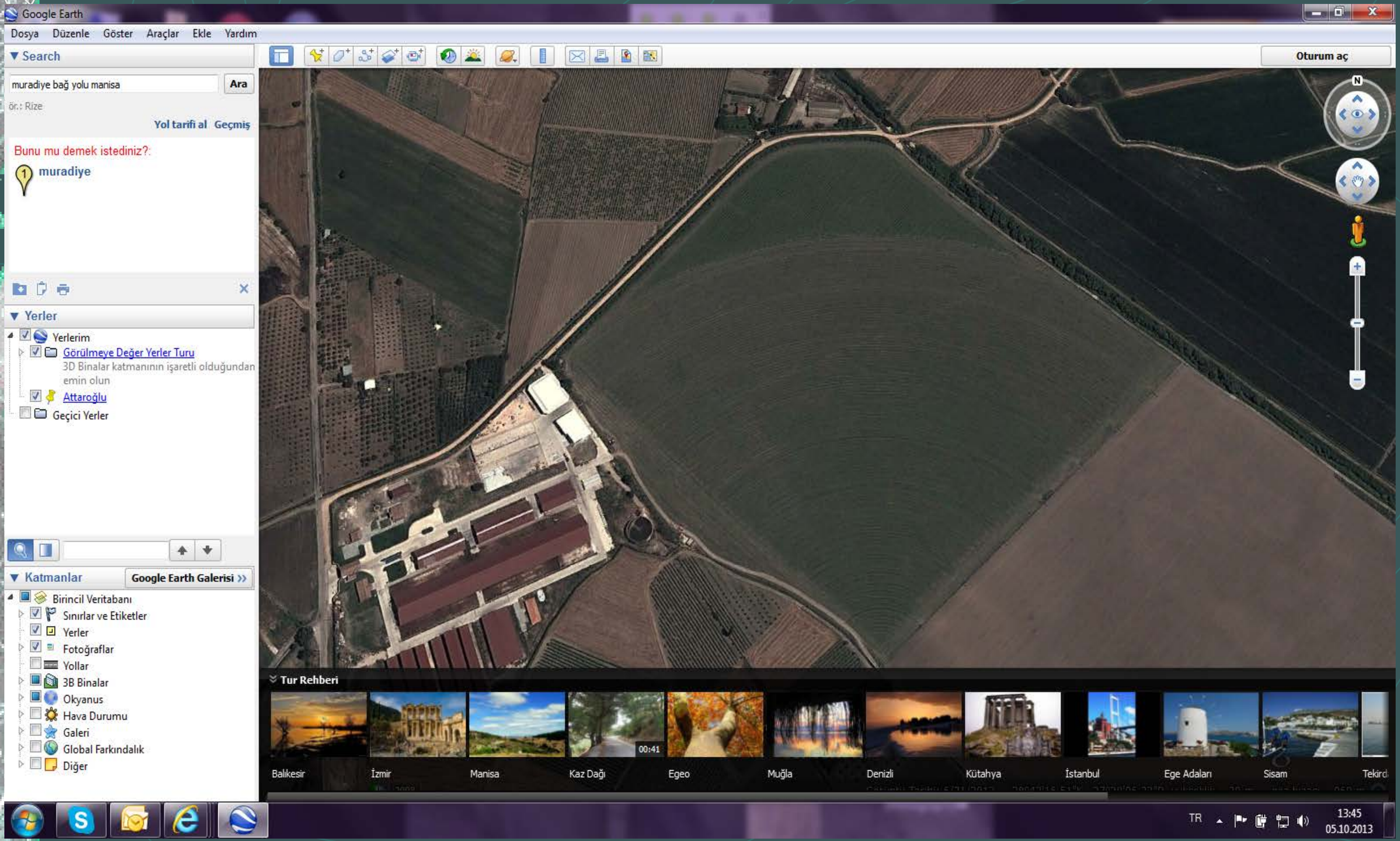
Eucalyptus in N.Z.

Pauanui, N.Z.
Approx 3,000,000 gpd

The Disposal Area
Drippers 9” x 9”

Disposal Area

Alfalfa – Reuse of dairy wastewater.



Questions or do you want to head down the road?

Easy questions

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(A link to this presentation will be on the Geoflow website – www.geoflow.com)

THANK YOU