A Brief History of Wastewater

Tom O'Connor, PE

Overview

Wastewater Characteristics

Wastewater Past

Outhouses and Toilets

Wastewater Treatment

Wastewater in India and Japan

Wastewater Future

What is Wastewater?

Wastewater *n.* **Water that has been used, as for washing, flushing, or in a manufacturing process, and so contains waste products; sewage.**

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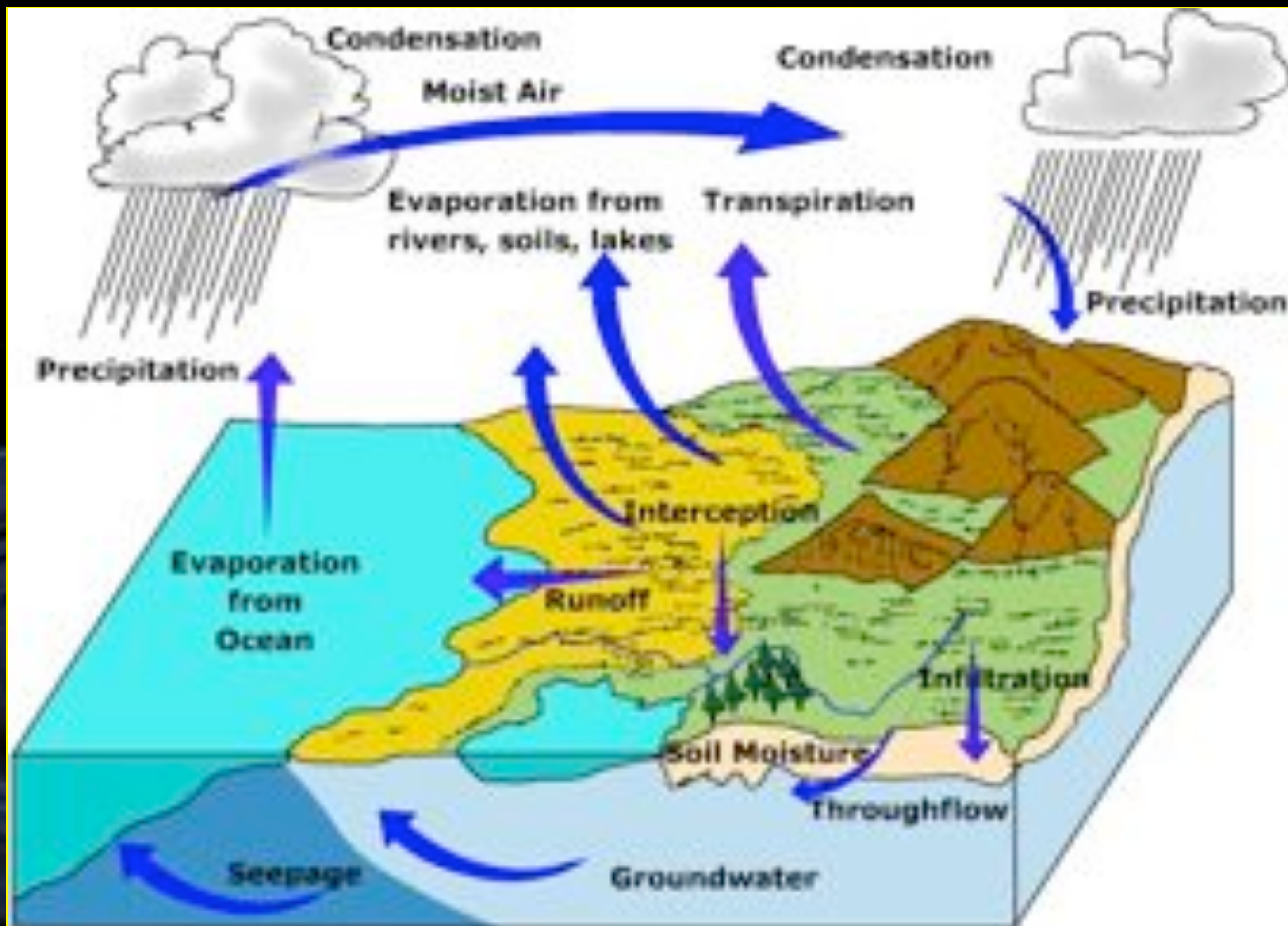
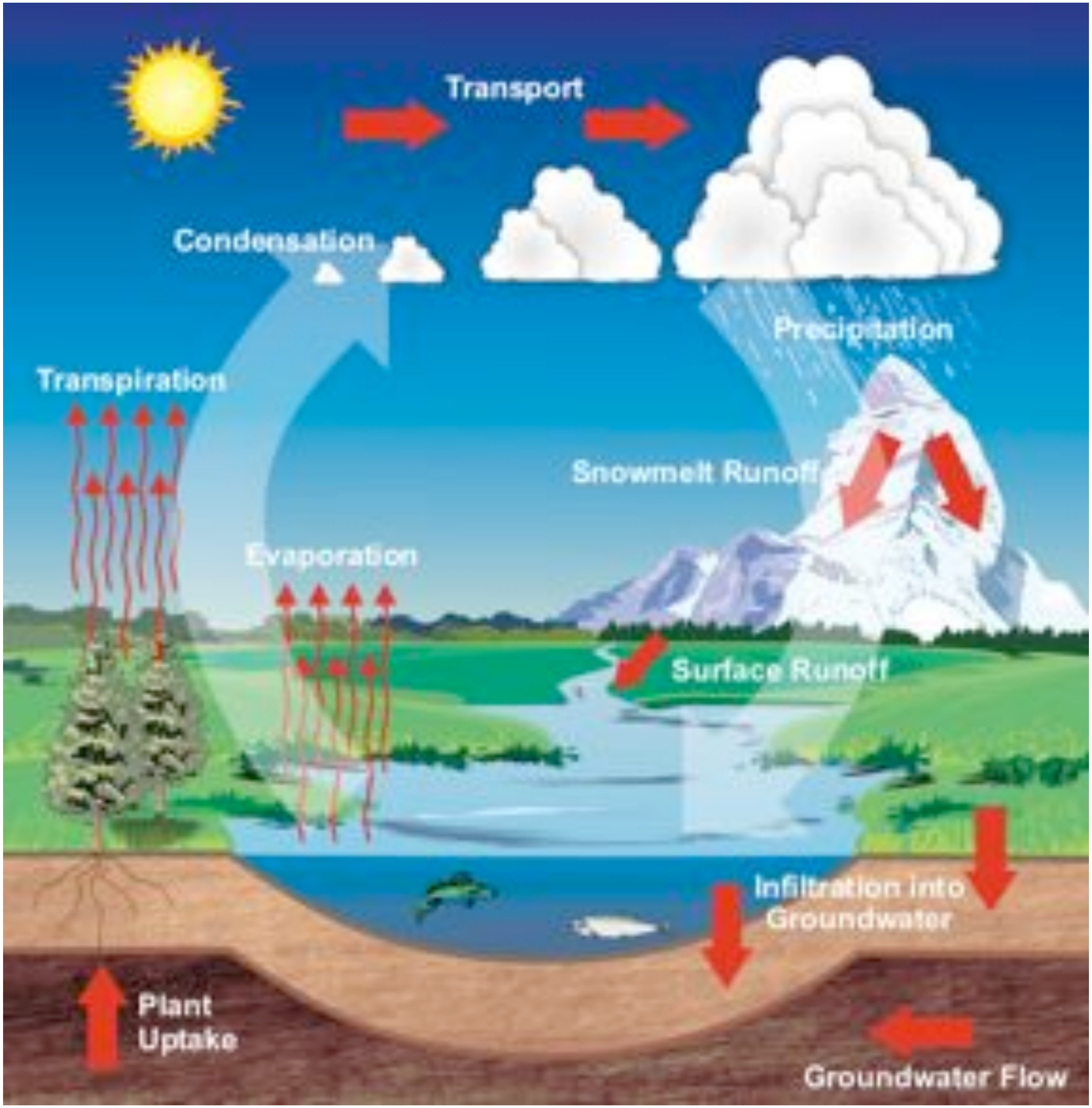
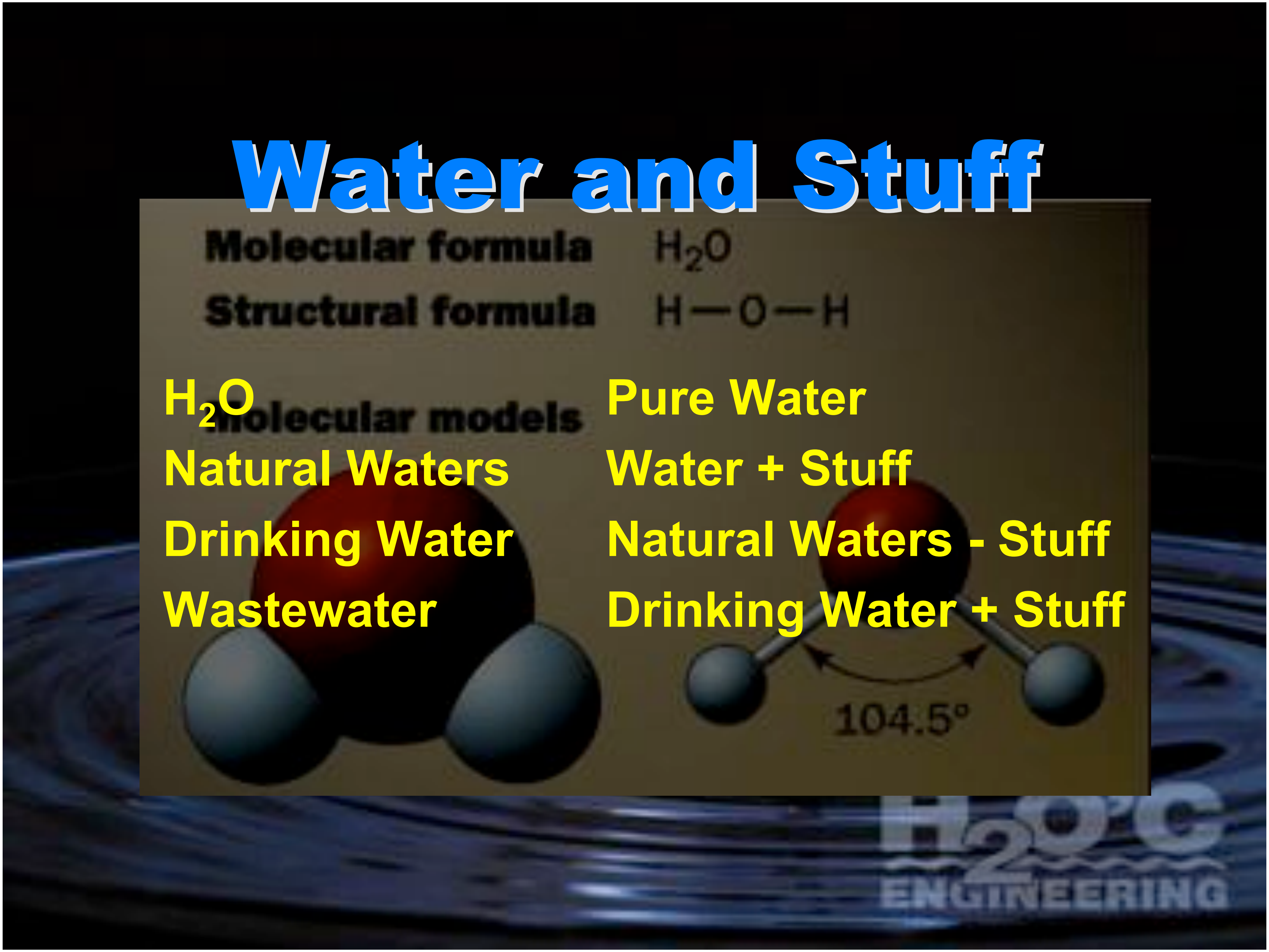
Hydrologic Cycle




Transport
Condensation
Precipitation
Transpiration
Snowmelt Runoff
Evaporation
Surface Runoff
Infiltration into
Groundwater
Plant
Uptake
Groundwater Flow


Safe Drinking Water Act - Protecting America's Public Health
Deforestation / Soil Erosion
Local, State and National Public Health Protection Programs
Protected Watershed
Municipal Wastewater Treatment Plant
Landfill
Mining
Concentrated Animal Feeding Operation
Livestock Waste Lagoon
Pesticide / Fertilizer Application
Construction / Urban Sprawl
Septic System
Crop Dusting
Fertilizer / Manure Spreading
Local Land Use Decisions
Protected Wetlands
Water Table
Saturated Zone
Class Injection Well
Industrial Releases To Air & Water
Industrial Wastewater Discharge
Spills
Shallow On-site System
Drinking Water Storage Tower
Confining Layer
Future Source Of Drinking Water
Private Drinking Water Well
Ground Water Flow
Ground Water Treatment Plant
Abandoned Well
Light Industry
Infrastructure Repair
Roads & Parking Lot Runoff
Gas Station / Underground Storage Tank
Source Water Protection Area
Fresh Water Aquifer
Vehicle Service Station
Surface Water Treatment Plant
Boat Marina Debris
Drinking Water Intake
Storm Drain
Sediment
MULTIPLE RISKS REQUIRE MULTIPLE BARRIERS
Safe Drinking Water Hotline – (800) 426-4791 Safewater Web Site – www.epa.gov/safewater
EPA



Water and Stuff
Molecular formula H2O
Structural formula H—O—H
Molecular models
104.5°
H2O
Natural Waters
Drinking Water
Wastewater
Pure Water
Water + Stuff
Natural Waters - Stuff
Drinking Water + Stuff
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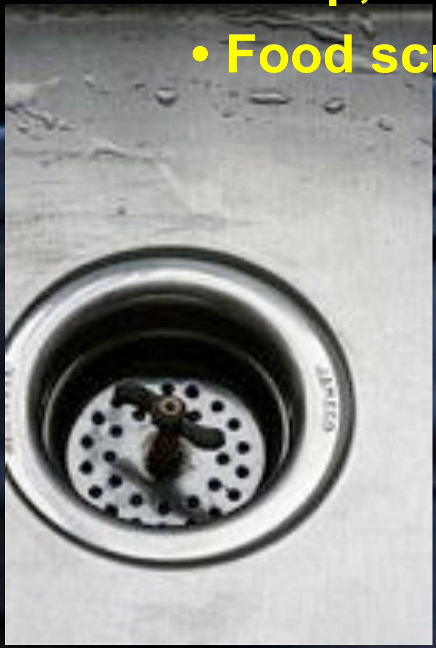
What is the Stuff in Municipal Wastewater?

Stuff we put down the toilet or drain…

- Water
- Poop, urine, toilet paper, condoms, tampons…
- Food scraps, toothpaste, soap, hair, paint, chemicals…



…and stuff that just finds its way in.

- storm water
- wee beasties

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What is the Stuff in Municipal Wastewater?

- Water (> 95%)
- Pathogens (bacteria, viruses, prions and parasitic worms)
- Non-pathogenic bacteria
- Organic particles (feces, hairs, food, vomit, paper fibers, plant material)
- Soluble organic material (urea, fruit sugars, soluble proteins, drugs)
- Inorganic particles (sand, grit, metal particles, ceramics)
- Soluble inorganic material (ammonia, salt)
- Animals (protozoa, insects, arthropods, small fish)
- Macro-solids (sanitary towels, diapers, condoms, needles, children's toys, dead pets, body parts)
- Gases (hydrogen sulfide, carbon dioxide, methane)
- Emulsions (paints, adhesives, mayonnaise, hair colorants, emulsified oils)
- Toxins (pesticides, poisons, herbicides)

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How Do We Measure Stuff in Wastewater?

- Biochemical Oxygen Demand
- Total Suspended Solids
- Nitrogen
- Phosphorous
- Chloride

How Much of this Stuff is in Wastewater?

	(mg/l)
Biochemical Oxygen Demand	200
Total Suspended Solids	200
Nitrogen (total)	40
Phosphorous	10
Chloride	50

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Evolution of Waste Management

Evolution of Waste Management: Driving Issues

#1. Smell

#2. Infectious Disease

#3. Chronic Health Risks

#4. Environmental Concerns

Waste Management: 10,000 BC

Nomadic Tribes:

MOVE

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3500 BC

City of Ur (Mesopotamian Capital in Iraq):
Swept waste into the streets

When street
level rises,
raise the doors

2500 BC

Indus Valley (Pakistan): Ahead of Their Time

- Drainage systems
- Some houses had water-flushing toilets
- Houses had rubbish chutes, and there were rubbish bins placed around the city for refuse disposal
- Great leap in waste management

2100 BC

City of Hierakopolis (Egypt)

Waste generally swept into streets, but rich & religious people put waste into rivers

1700 - 1500 BC

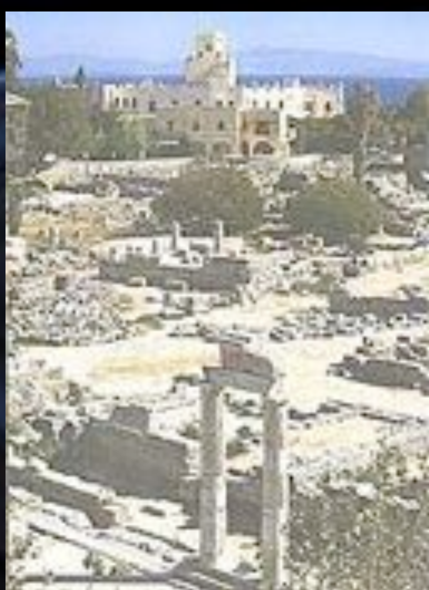
King Minos of Crete, also ahead of his time--
Running water in palace bathrooms,
Baths filled & emptied w/ clay pipes

320 BC

Athens (Greece):

First known edict banning disposal of refuse in the streets

300 BC: City collects waste, charges landowners



The early Greeks understood the relationship between water quality and general public health. This concern was passed onto the Romans.

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600 BC - 400 AD

Ancient Rome

- Aqueducts
- Cloaca Maxima (the Great Sewers)
- Waste to Rivers (Tiber, Rome)
- Public Baths
- Flush Toilets (not seen again until ~1600)

Romans Raise the Bar

- 11 public baths
- 1300 public fountains
- 856 private baths
- 144 public water-flushed toilets

The Fall of the Roman Empire

- End of running water in Europe for the next thousand years
- Depopulation, deurbanization
- Return to throwing waste into the streets

500 - 1500 AD: Bad Times

Drinking Water and Wastewater: Together Again

Raging epidemics, rampant disease and death

- dysentery, typhus, typhoid fever
- rats, ticks, fleas

Linkage between waste and disease forgotten

Rivers became sewers

14th Century:
Time to Do Something, But What?

Following the major plagues of the 12th century, waste management became a priority.

1388: Act of English Parliament “forbade the throwing of filth and garbage into ditches, rivers, and water”

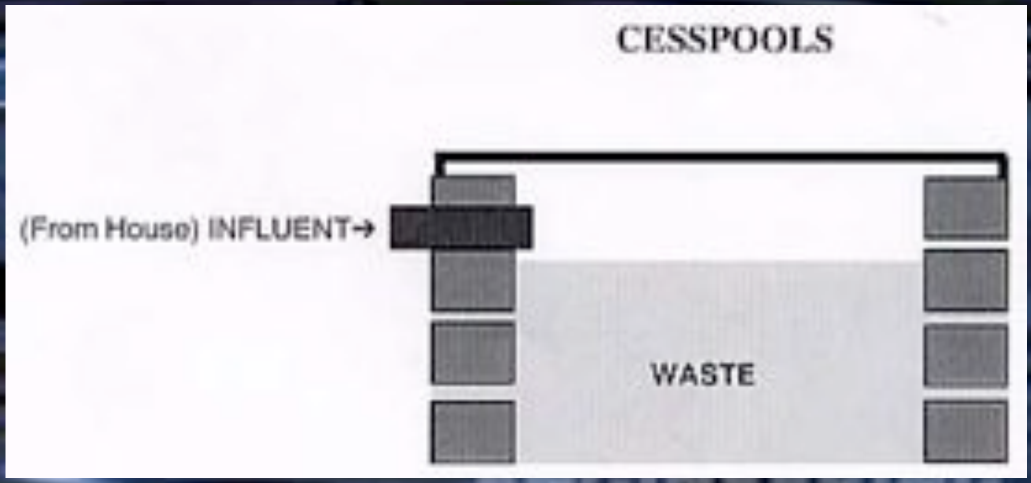
Legislation was ineffective, as offenders and offended alike were unable to devise adequate alternatives to the available methods of collection and disposal

Except for those in heavily polluted areas, popular opinion was very much against such measures

Renaissance: 1500-1700

- Renewed awareness of the link between sanitation and human health
- More laws about polluting streams
- Development of the Cesspool
  (pit that allows solids to settle and liquid to seep into the ground)

- Asphyxiation common due to hydrogen sulfide, oxygen deficiency
- Methane explosions
- Used “night soil” for fertilizer
- Small children harvested cesspit wastes



1700 - 1860

Increases in Awareness, Stagnation of Options

Chamber Pots into Street Gutters

Outhouses

Cesspools

Get it to the River

Chamber Pot

Chamber Pots

The Outhouse

- Latrine
- Privy
- Earth-closet
- Dunny
- Loo
- Jake
- Comfort Station

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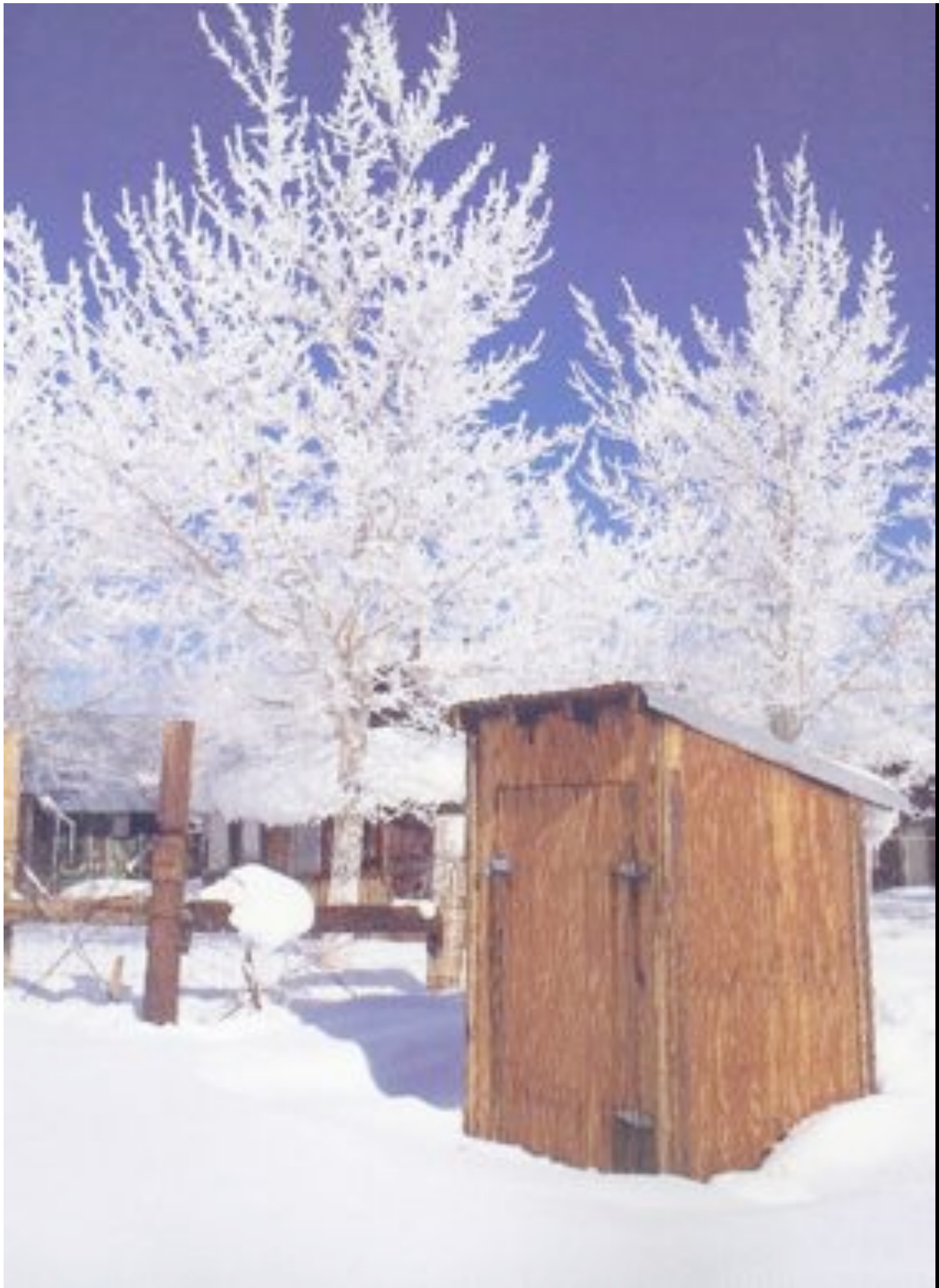


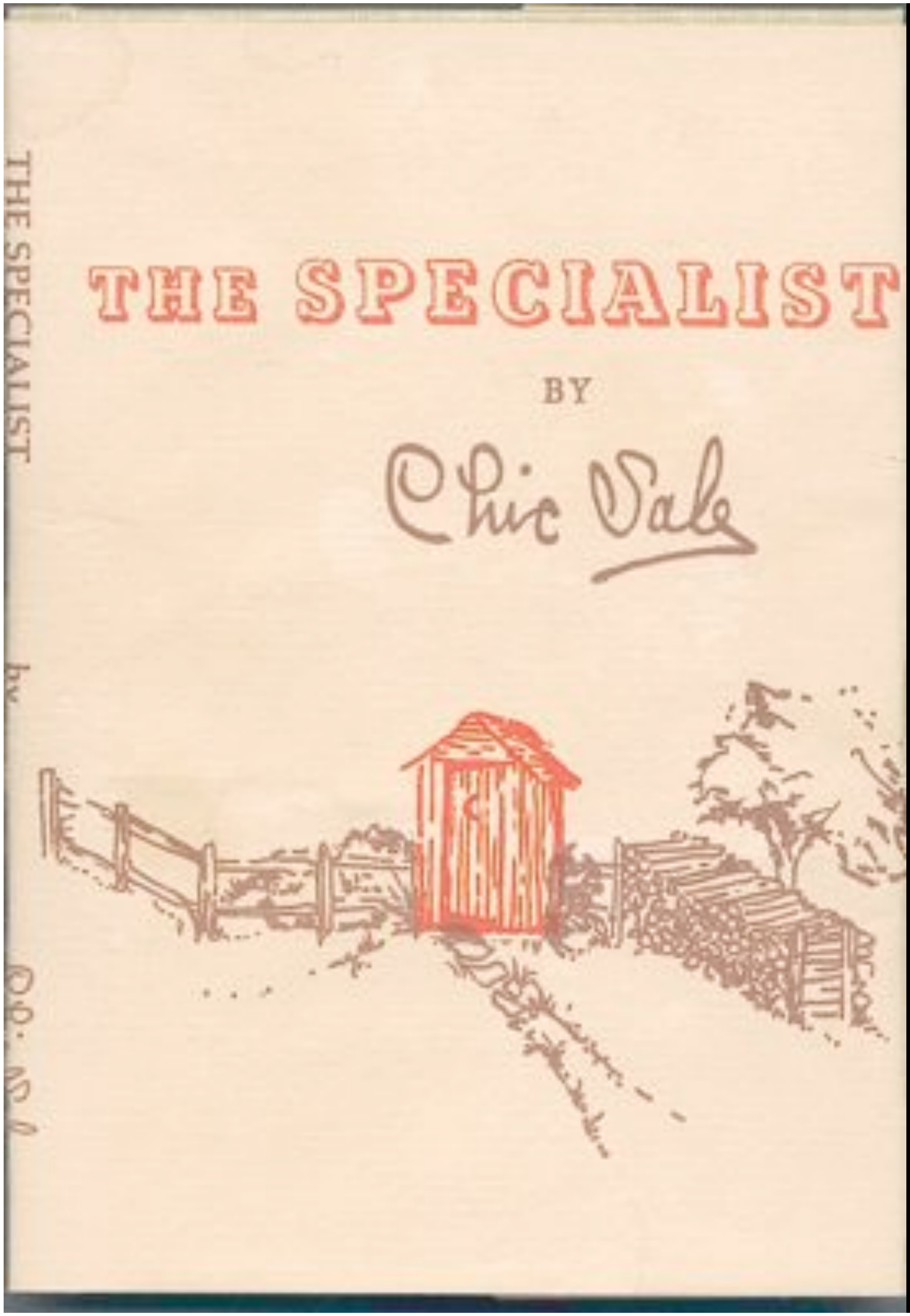
Earth-Pit Privy

Design Criteria

6 feet deep
50 cu. ft.

"… lean-to roof has two less corners for the wasps to build their nests in…"

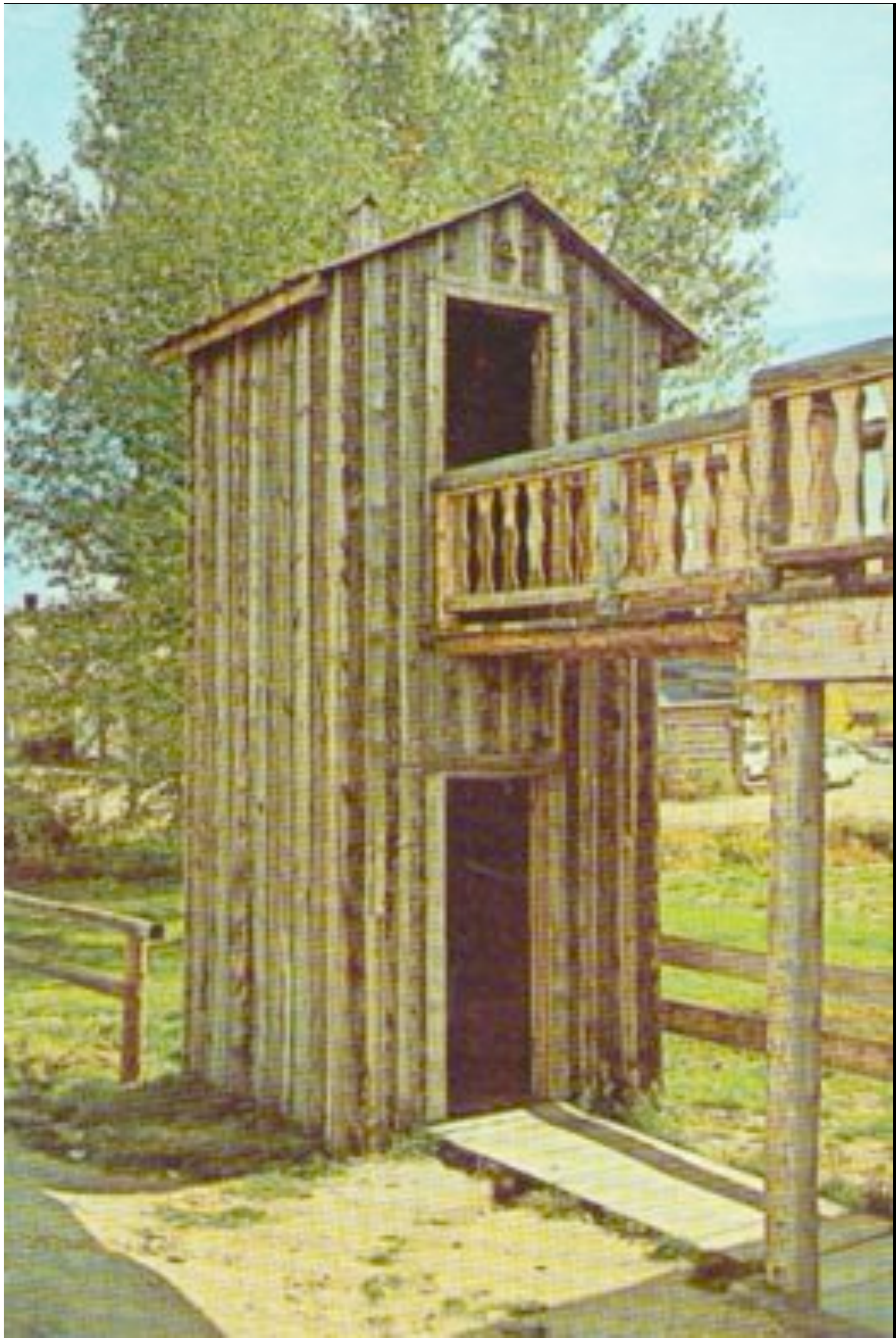

Privy with a View



Charles (Chic) Sales

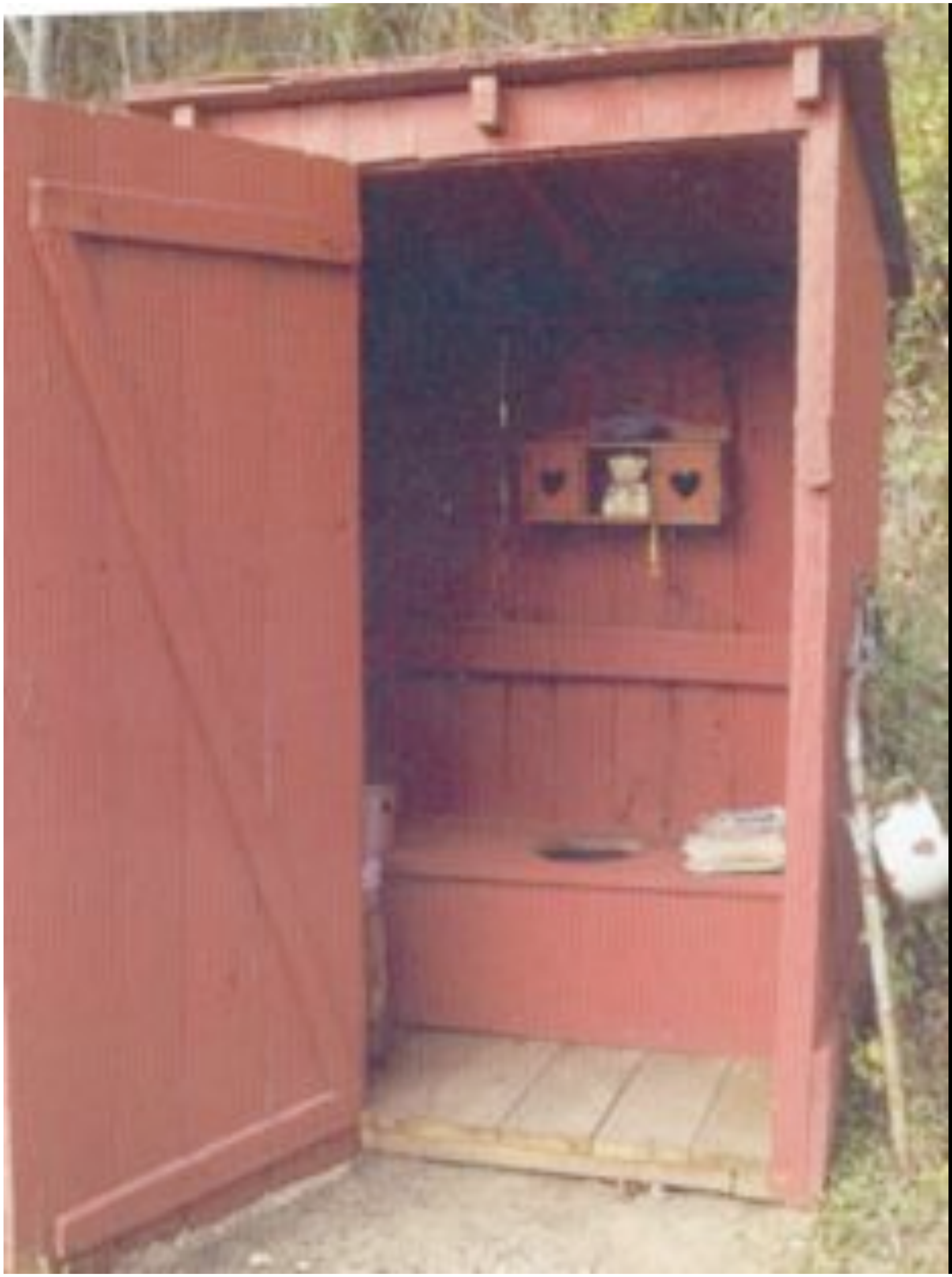
The Specialist (1927)

"..dig her deep and dig her wide.."



Two-Story Outhouse

for two-storied houses
with two families

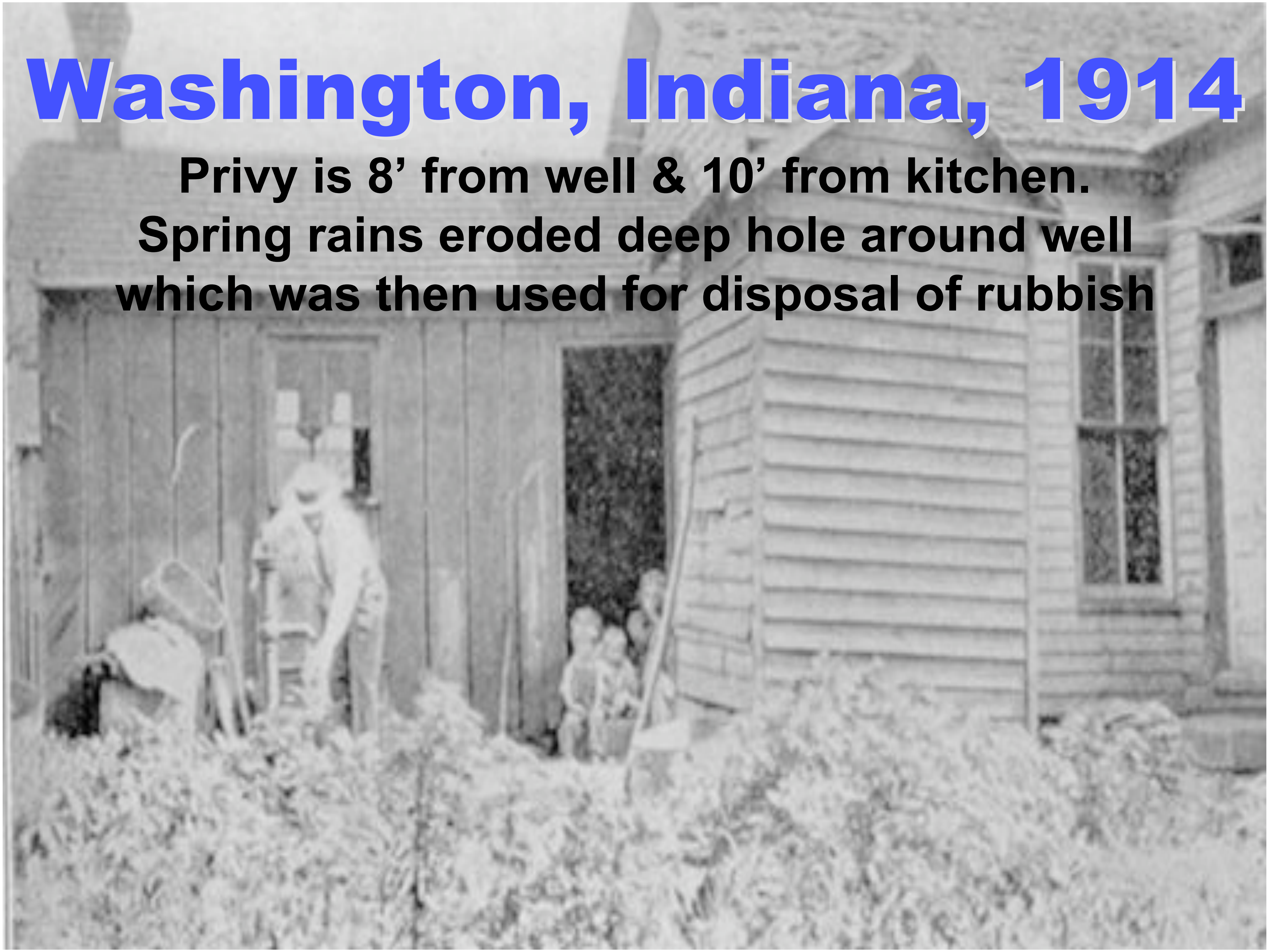


Sears Roebuck Catalogs, Newspapers, and Corn Cobs

packaged toilet paper, introduced in 1857, sold poorly

Washington, Indiana, 1914

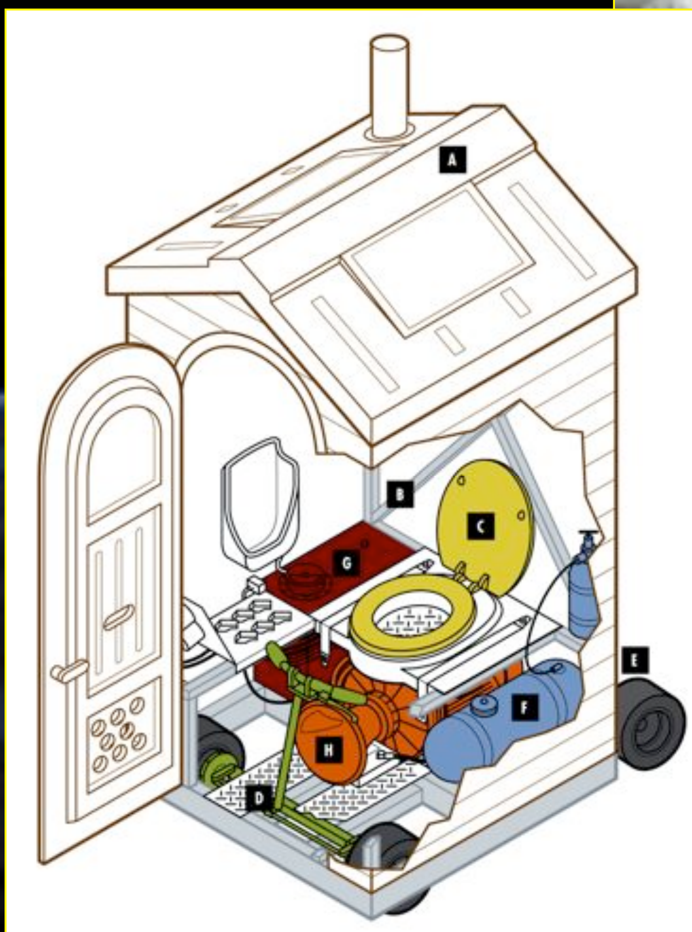
Privy is 8’ from well & 10’ from kitchen.
Spring rains eroded deep hole around well
which was then used for disposal of rubbish



Outhouses in Australia 1950

New Zealand 2004 - Loo with a View


The Jet-Propelled Outhouse



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The Space Shittle

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The Space Shittle

The Out-in-the-Open Outhouse

The Sanisette


SUPER
LOO
SUPER
LOO

Islam and the Outhouse

Qadaahul Haaja: Islamic Toilet Rules

- Say before entering the toilet: In the name of Allah, O Allah! I seek refuge with You from all offensive and wicked things
- One should enter the toilet with the left foot and leave with the right foot.
- It is not permissible to enter the toilet whilst carrying or wearing anything bearing the name of Allah, such as the Quran, or any book with the name of Allah in it, or jewelry such as bracelets or necklaces engraved with the name of Allah.
- One should remain silent whilst on the toilet. Talking, answering greetings or greeting others is forbidden.
- One should not face nor turn your back on Mecca whilst relieving yourself. One should sit at 90 degrees.
- One should be out of sight of people when going to the toilet.
- It is forbidden to relieve oneself whilst standing up, lying down or if you are completely nude.
- One should avoid going to the toilet anywhere where people may take rest or gather for any purpose.
- Do not raise clothes until you get close to the ground and do not uncover the body any more than is needed.
- One should sit on the feet (e.g. squat) keeping thighs wide apart with the stress on the left foot.
- Do not look to the private parts of the body nor the waste matter passed from the body.
- Do not sit more than needed.
- Do not spit, blow nose, look hither and thither, touch the body unnecessarily nor look towards the sky but relieve oneself with the eyes downcast in modesty.
- After relieving oneself it is essential to perform Istinjaa (washing with water) of the anus and/or genitals with the left hand and water. The precise mode of performing Istinjaa has also been defined by religious leaders.
- Other than toilet paper, water and the left hand Istinjaa can be performed with earth, grit, stones and worn-out cloths provided they are all clean. It is forbidden to perform Istinyaa with bone, any edible item, dry dung, baked brick, potsherd, coal, fodder, writing paper and anything which has even a small value.
- After this process the hands should also be washed.
- When leaving the toilet one should say the following prayer: Praise be to Allah who relieved me of the filth and gave me relief.

Meanwhile,
Back in the 19th Century...

Cholera

Worldwide epidemic in 19th Century

1832 in New York
1854 in London

"King Cholera dispenses contagion: the London Cholera Epidemic of 1854" by George John Pinwell (1842-1875). This illustration depicts the historical event whereby during a cholera epidemic in the Soho district of London in 1854, Dr. John Snow determined that the epidemic was centered around one particular well on Broadsteet.

Wastewater Treatment

- Screen
- Settle
- Skim
- Accelerate Natural Biological Processes
- Destroy Pathogens

19th Century

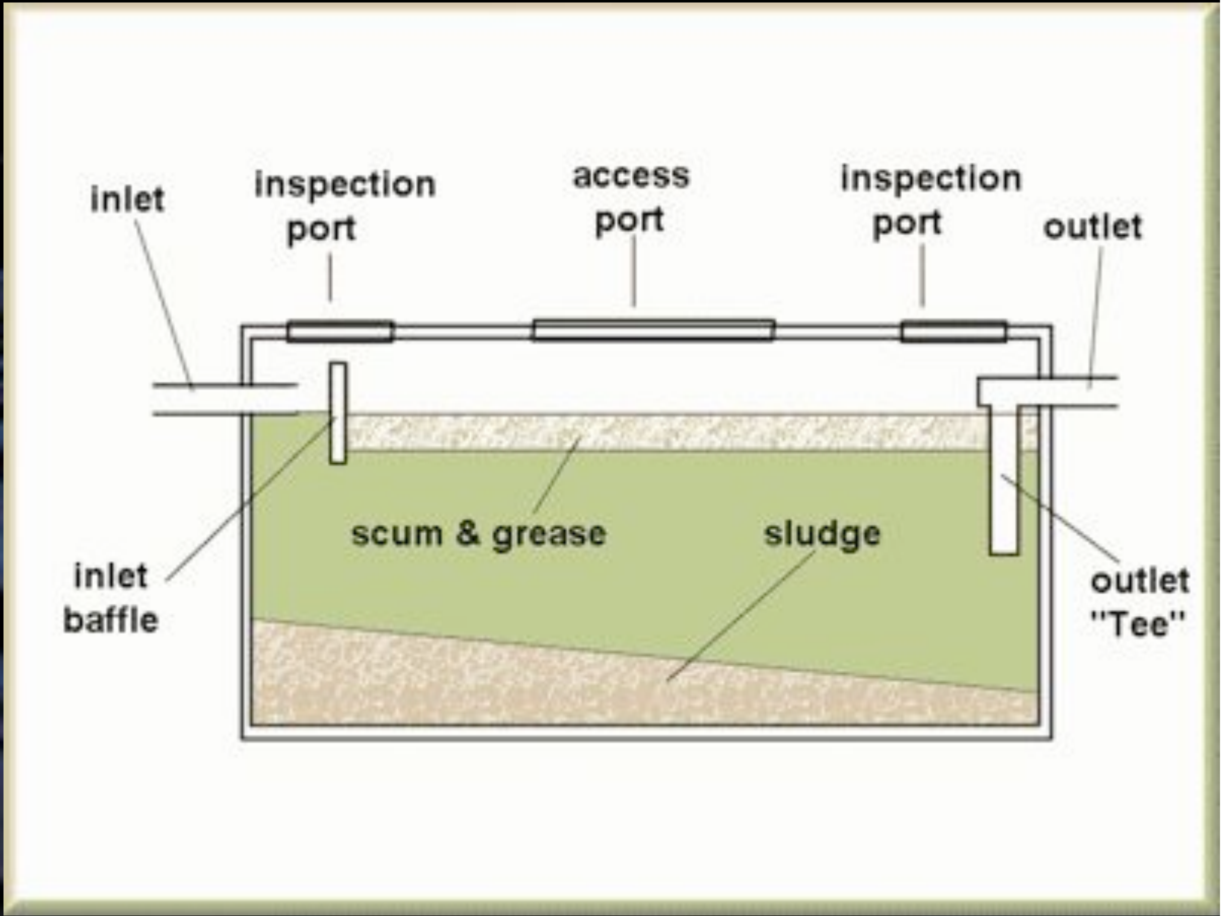
1860 Louis Moureas invents the septic tank

- Allows solids to settle out before liquid is discharged to the nearest stream or river
- Used for communities
- People also experimented with sand filters

Septic Tank

Invented by Louis Moureas in 1860

- Large scale: used to treat sewage from communities
- Purpose: “To remove gross solids before discharge into the nearest stream or river.”



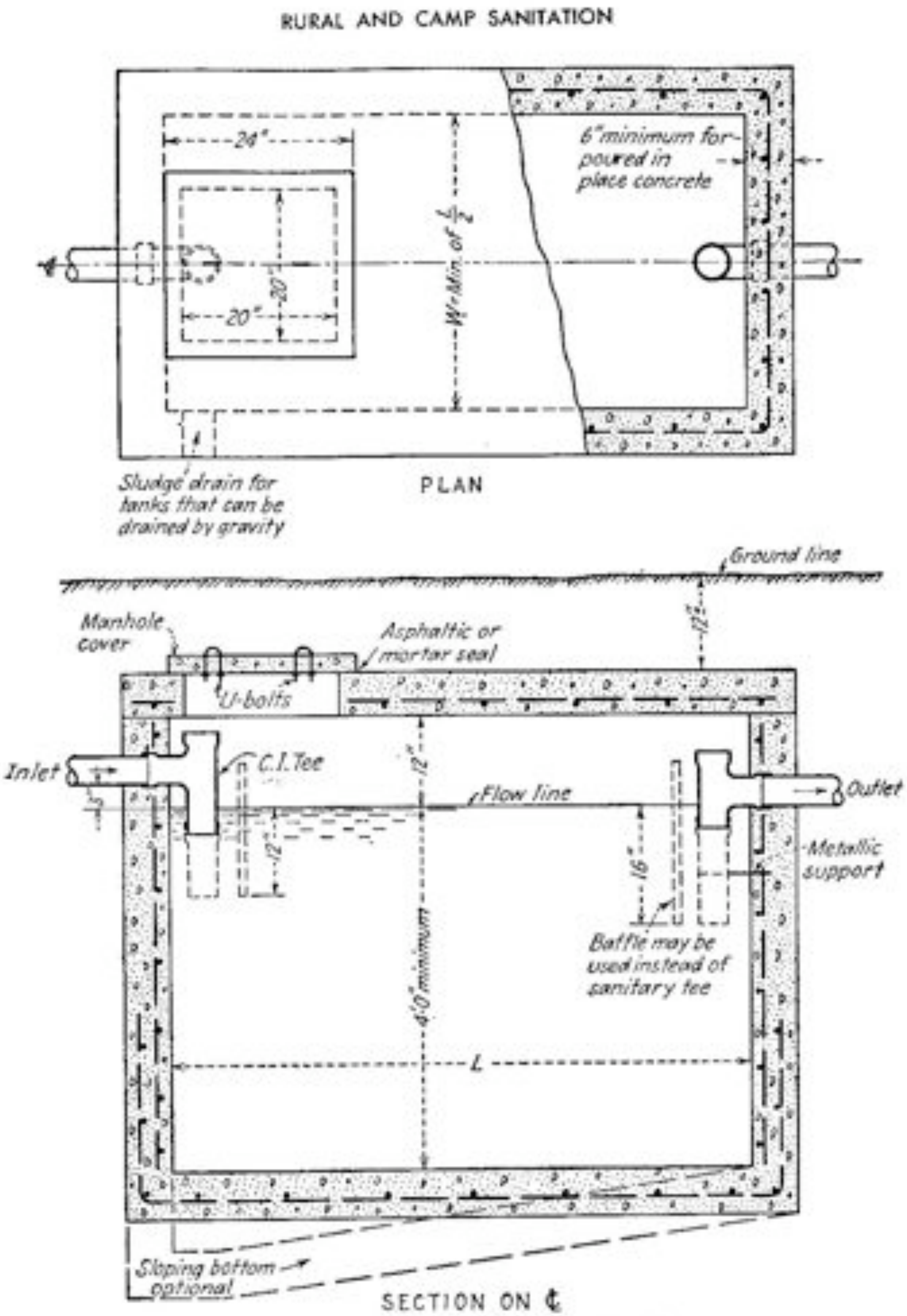


FIG. 51. A single-compartment septic tank.

Septic Tank

Unit Capacity:

4 to 16 people

500 - 2000 gallons

90 – 300 cubic feet

1–3 compartments

L/W: 3/1; D: 4-6 ft.

Scum, gas baffles

PVC Filter Vault

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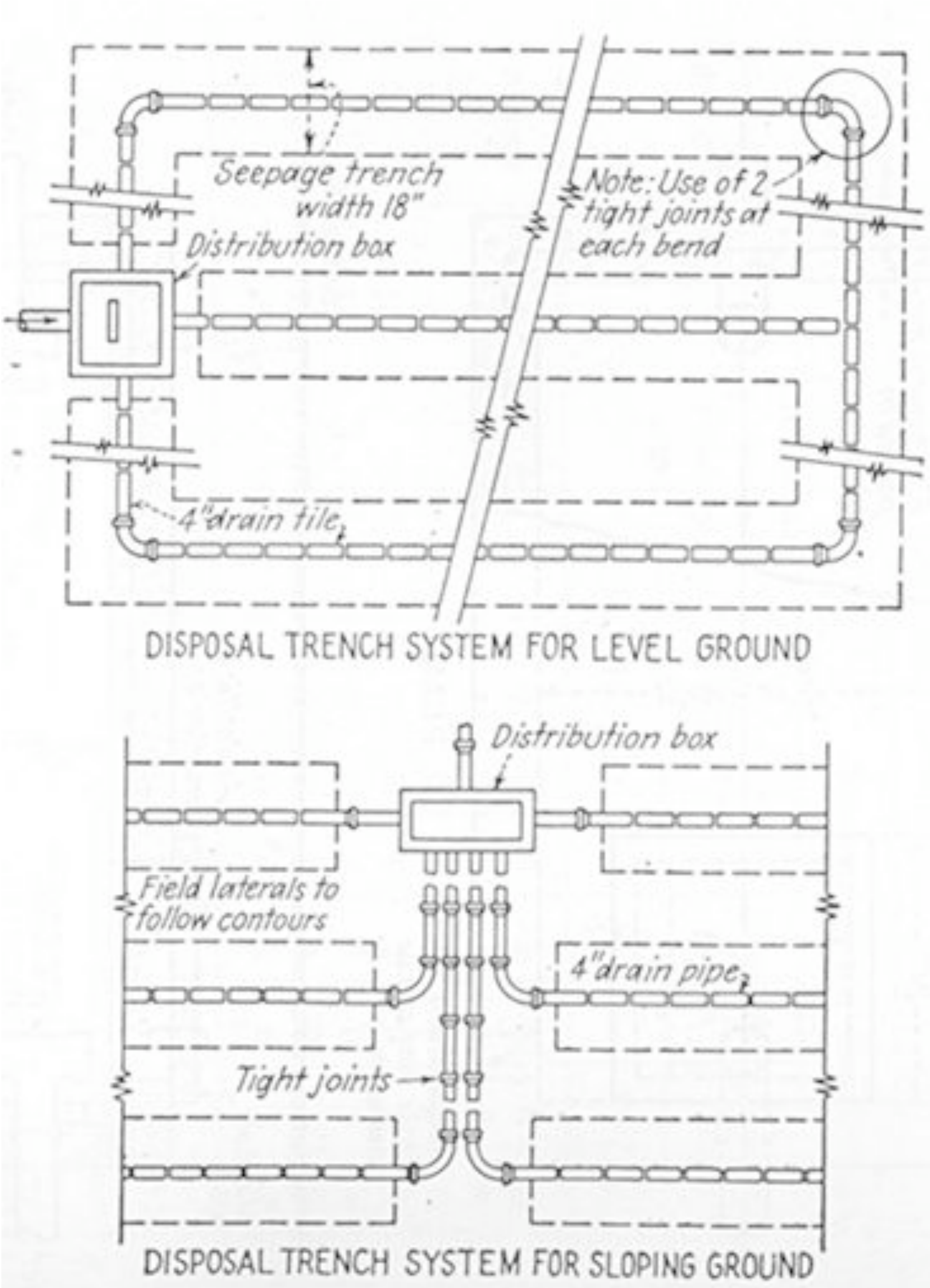

Sub-Surface Disposal

Gravel-filled Trenches

Open-Joint Tiles

Infiltration to Ground

Biological Slime Formation

Mineral Precipitates, FeS

Release of Gases, H_2S, CH_4

Soil Acceptance Rate

0.3 to 0.5 gpd/sf

New York City: Early 1800's

Drinking water from wells and cisterns

Private waste disposal (privies for temporary storage) "vault and haul"

Belief: *running water purifies effluent*

Potential for water pollution not recognized

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New York City: Late 19th Century

- Sewers initially developed for storm water
- Limited water supply made water-based disposal unworkable
- Water brought in by aqueduct
- Sewers improved to handle new influx created by more water use
- Connecting all houses to sewers took awhile
- Connections achieved by public funding pushed by public health concerns

1900

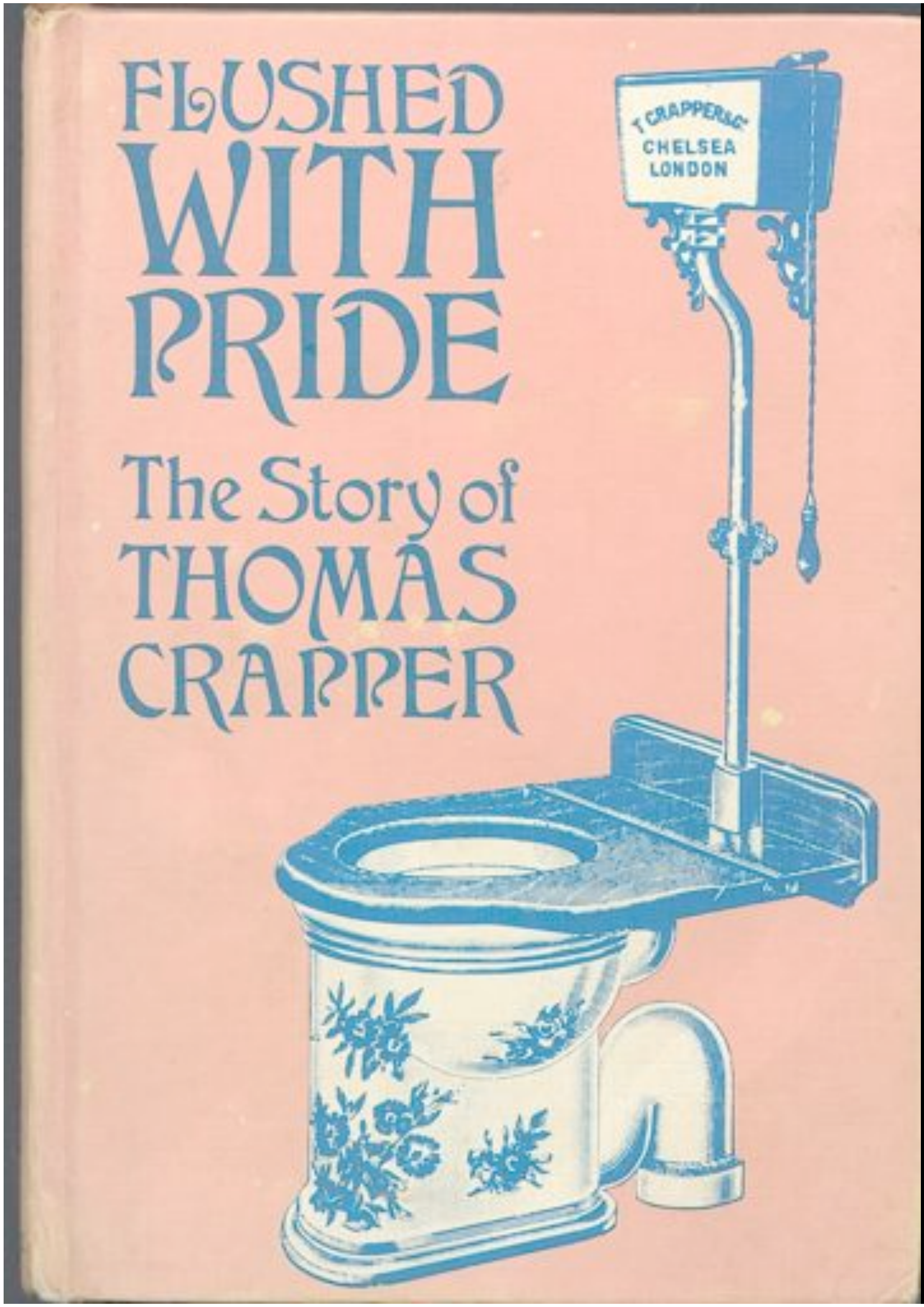
Toilets and Water Carriage: The Birth of Sewage

Valveless Water Waste Preventer (aka toilet)

Indoor Plumbing

Demise of the Outhouse

Early Disposal of ‘Flushings’



Indoor Plumbing

circa 1900

to eliminate disease, fumes, explosions

T. J. Crapper's Valveless Water Waste Preventer

"Pull and let go!"


Telegrams: CRAPPER CHELSEA

Telephone No. 357 Kensington

THOMAS CRAPPER & CO.,

PATENTEES AND MANUFACTURERS

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AND

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Show Rooms and Offices:

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CATALOGUE AND PRICE LIST,

MAY, 1902.

(Subject to alterations without notice.)

ALL PREVIOUS ISSUES CANCELLED

0-13-322560-7

Ventilation of House Drains

Air Pump and Smoke Generating Machines

Disconnecting Traps for Safety Purposes

Self-Rising Closet Seats

Cantilever Toilet

Flusherette Valve

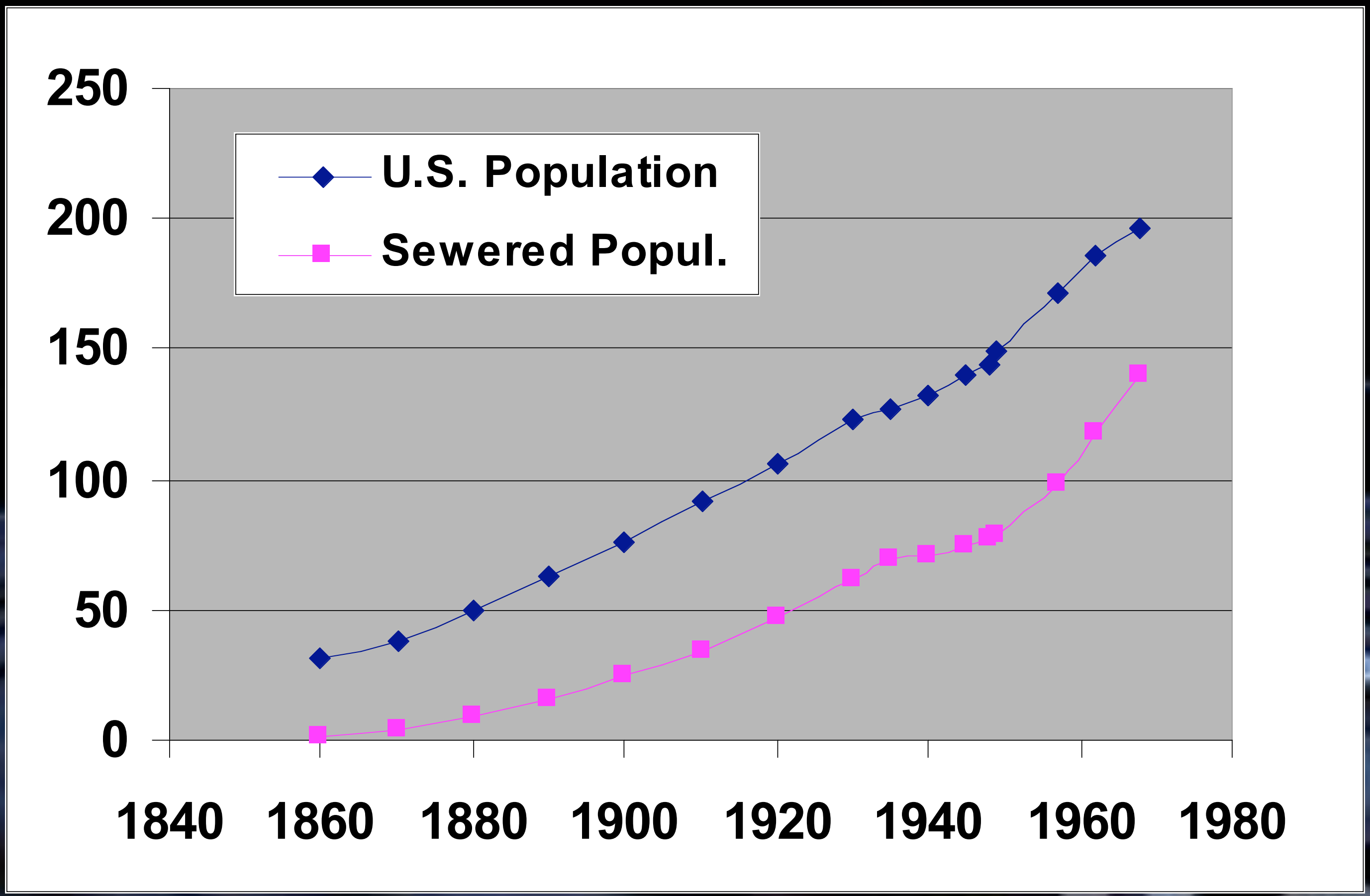
Stair Treads

United States Population

1910: 92 million
38% sewered
89% of waste discharged untreated

1968: 197 million
70% sewered
11% untreated

Sewered Population



Disposal Systems – 1910
Unsewered Households

Residential Waste Disposal

Waste Quantities and Strength

Evolution of the Septic Tank

Soil Absorption Systems

Residential Flow Rates

Residences*	gallons/person/day
Low Income	50
Median	60
Luxury	80

Peak Flow Factors	
Month	2
Day	4
Hour	6

* Average: 3 residents per household

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Residential Water Use

Household Use	gallons / day
Laundry	25
Dishwashing	10
Miscellaneous	5
Personal (per capita) Use	
Bathing	20
Toilet Flushing	17
Cooking and Drinking	3

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Unsewered Systems

On-Site Treatment and Disposal

Flow Range: 0.2 to 2 m^3/ day

Septic Tanks (Settling; Fermentation)

1 to 2 day retention; 2 meters deep

scum, sludge removal every 6 to 12 months

sludge to lagoons, earth-covered trenches

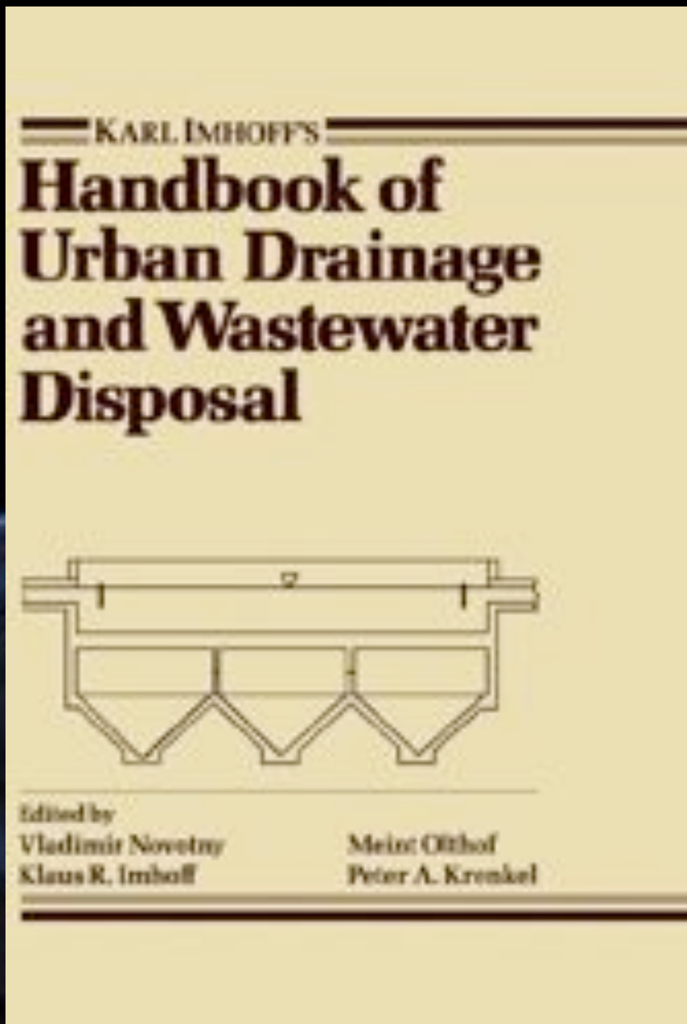
or plowed into land after partial drying on surface

Soil absorption systems for tank overflow

Waste Disposal 1920-1950

- Sewage Collection (Sewerage)
- Sewage Treatment:
  - Imhoff Tanks
  - Primary Treatment
  - Chemical Precipitation

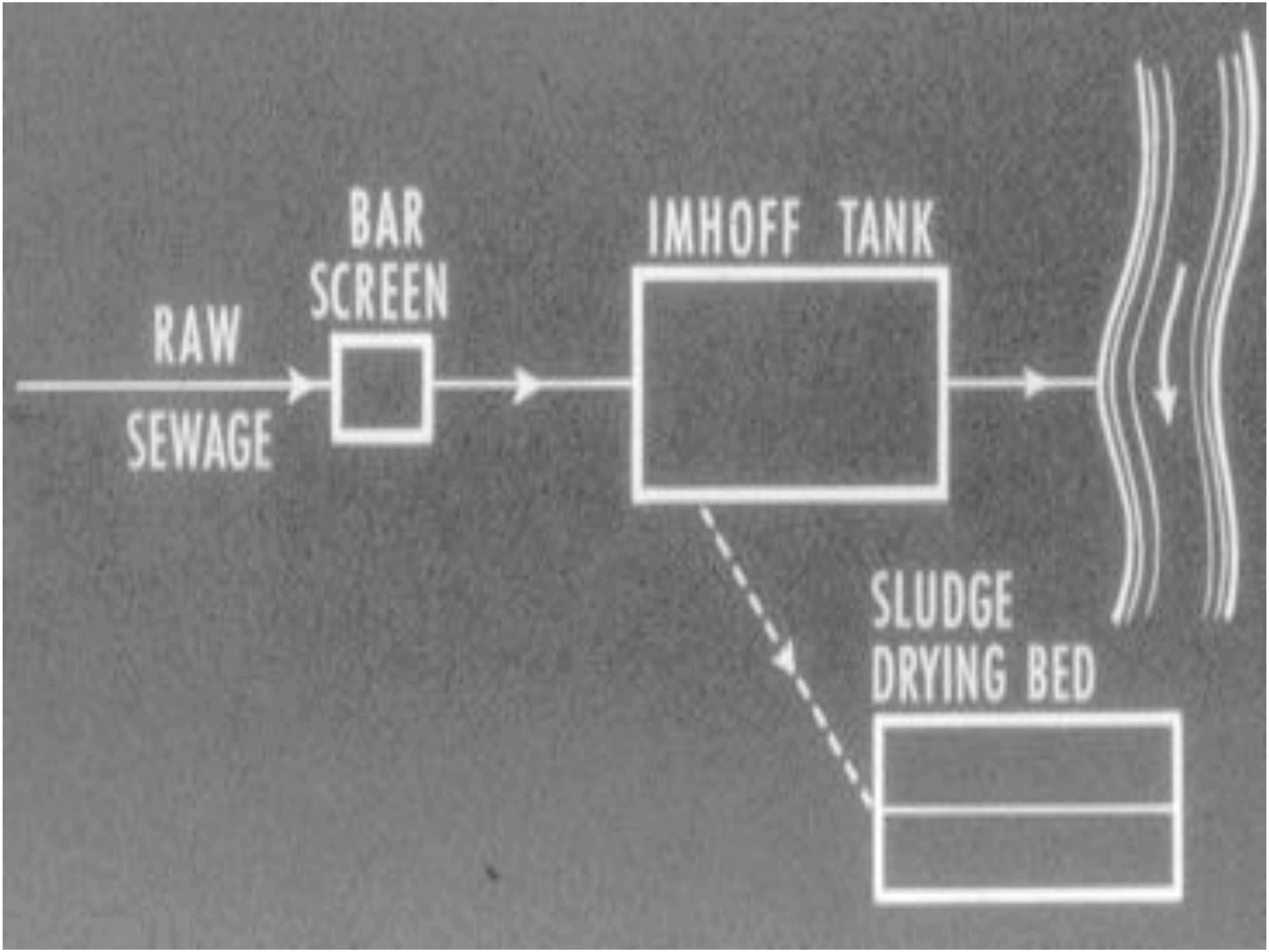
Karl Imhoff



Sewers: Open ditches with concrete slabs
Two-Storied Settling and Digestion Tanks
The Arithmetic of Sewage Treatment Works


US Public Health Service
Training Slides from 1950
1

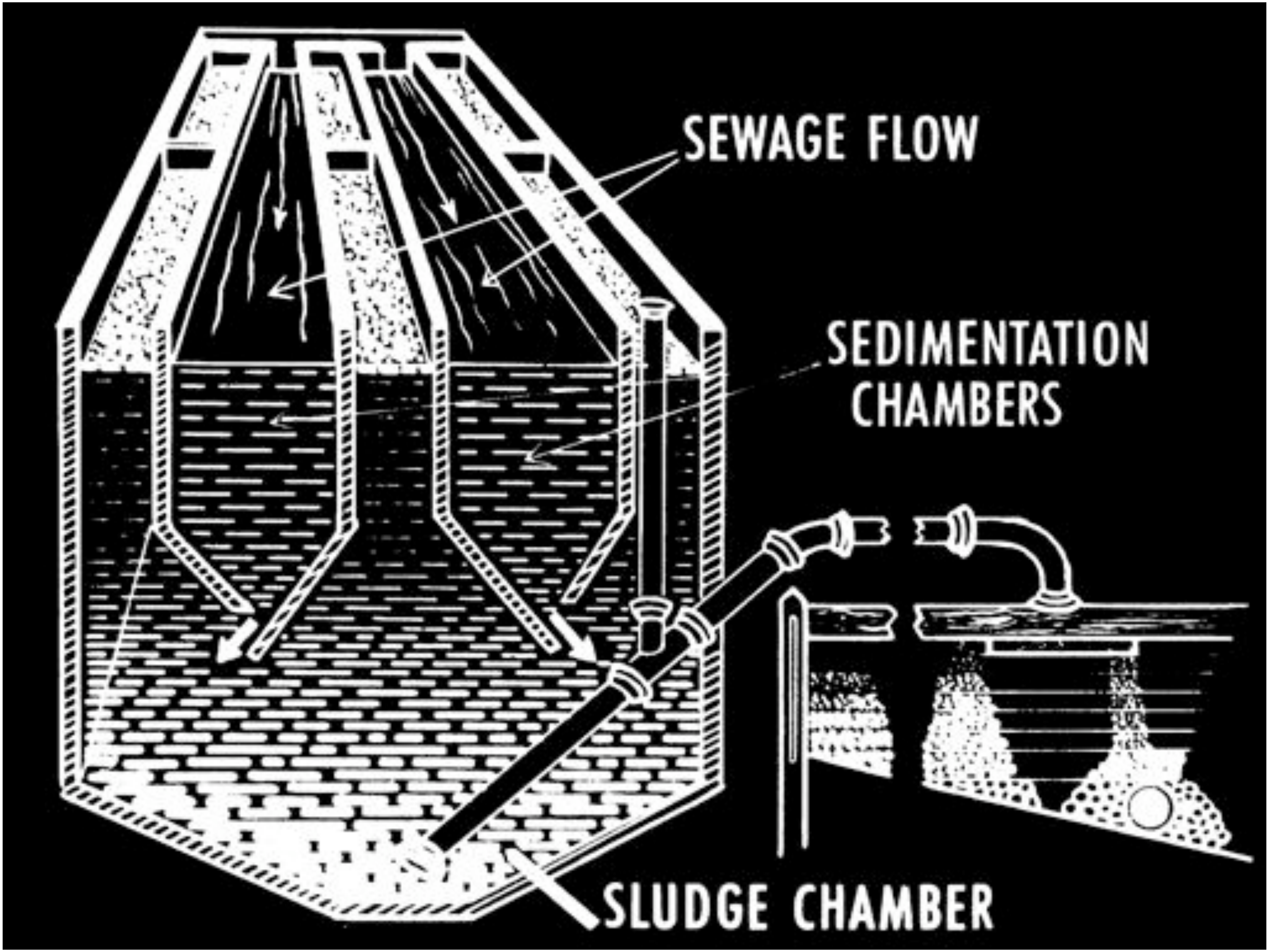
Imhoff Tank Treatment Plant


BAR
SCREEN
RAW
SEWAGE
IMHOFF TANK
SLUDGE
DRYING BED

Manually-Cleaned Bar Rack

Imhoff Tank

Settling Compartments and Gas Vents

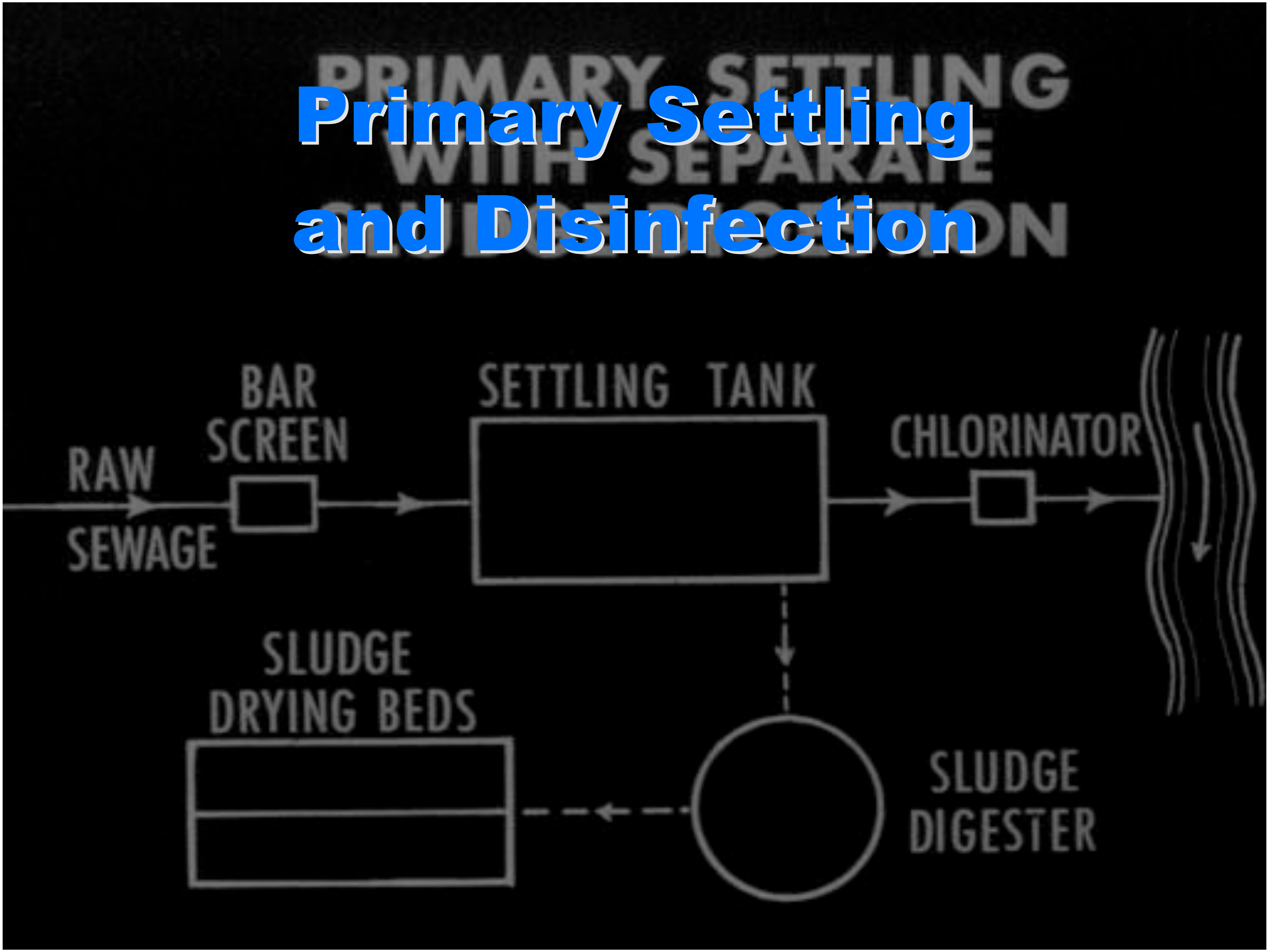

SEWAGE FLOW
SEDIMENTATION
CHAMBERS
SLUDGE CHAMBER

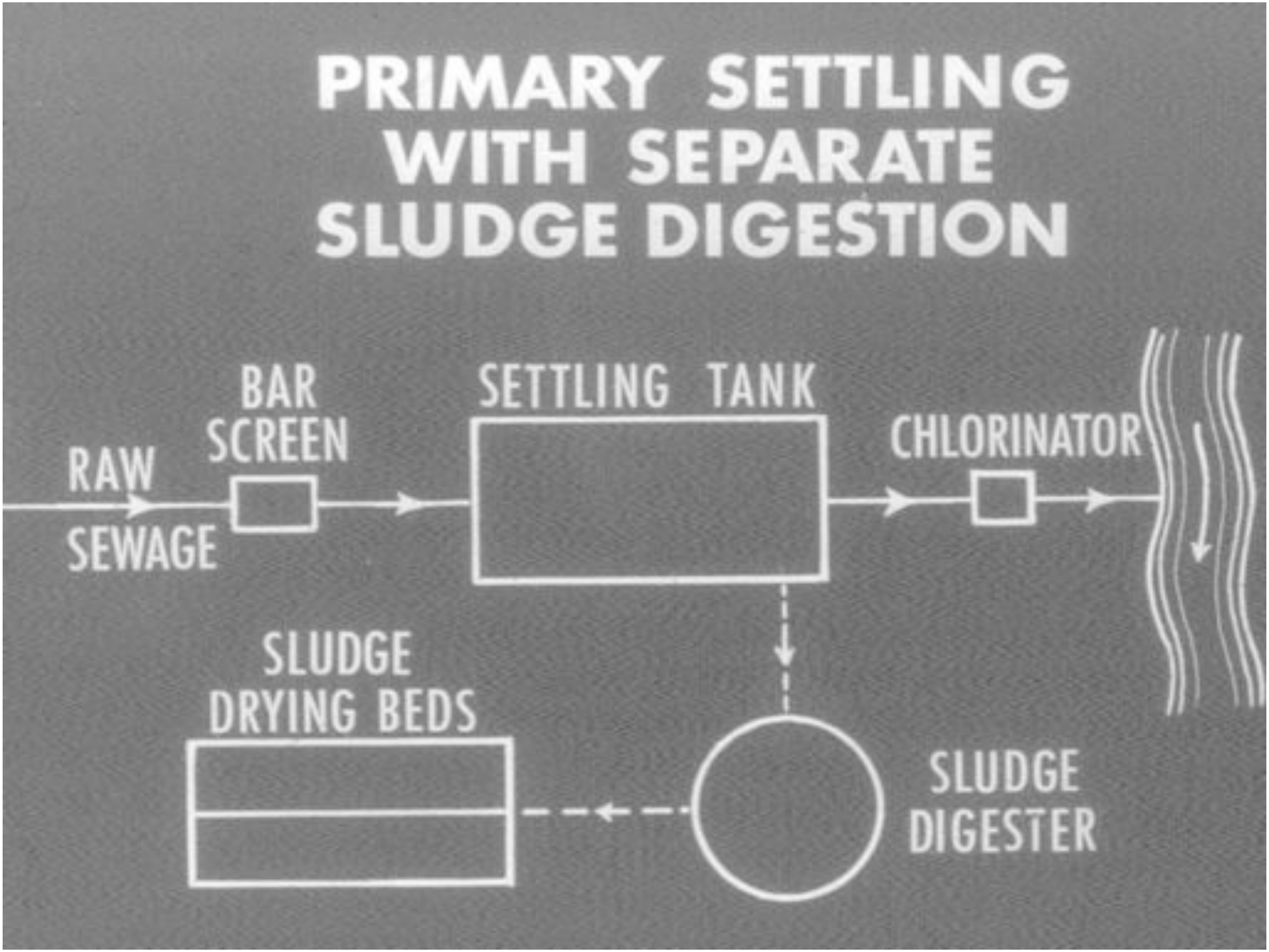
Gas Rising from Gas Vent

Raw Sludge Drying Beds


Sewage Effluent
entering Stream
50% Suspended Solids Removal
50% Reduction in Oxygen Demand

Primary Settling and Disinfection




PRIMARY SETTLING
WITH SEPARATE
SLUDGE DIGESTION
RAW
SEWAGE
BAR
SCREEN
SETTLING TANK
CHLORINATOR
SLUDGE
DRYING BEDS
SLUDGE
DIGESTER

Primary Treatment 4,500 / 0.5 mgd

Prechlorination (odor control)

Primary Clarifiers

Chlorine Contact Chamber

Heated Sludge Digester

Sand Drying Beds

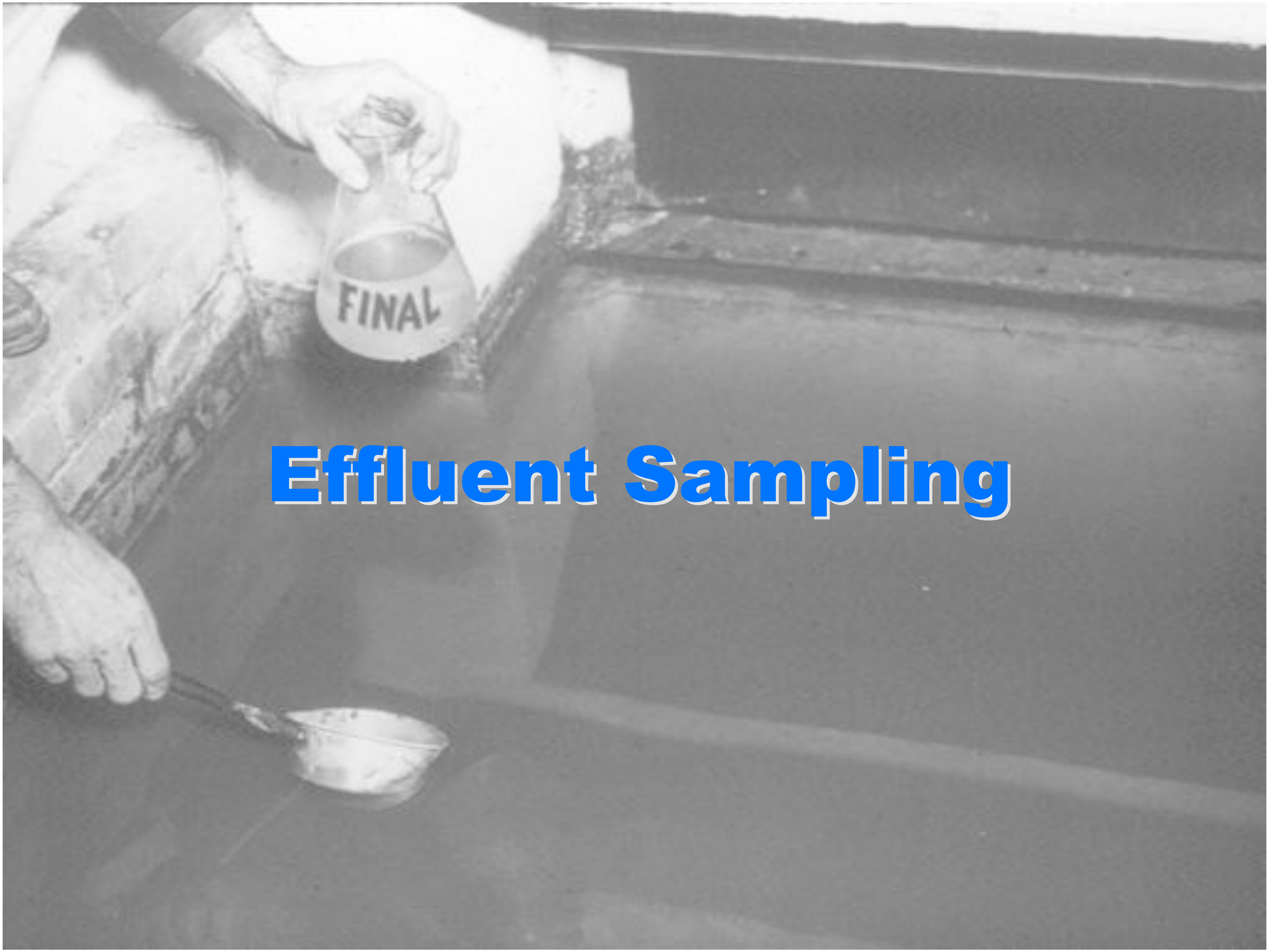
Prechlorination and Sampling

Dual, Manually-Cleaned Bar Screens

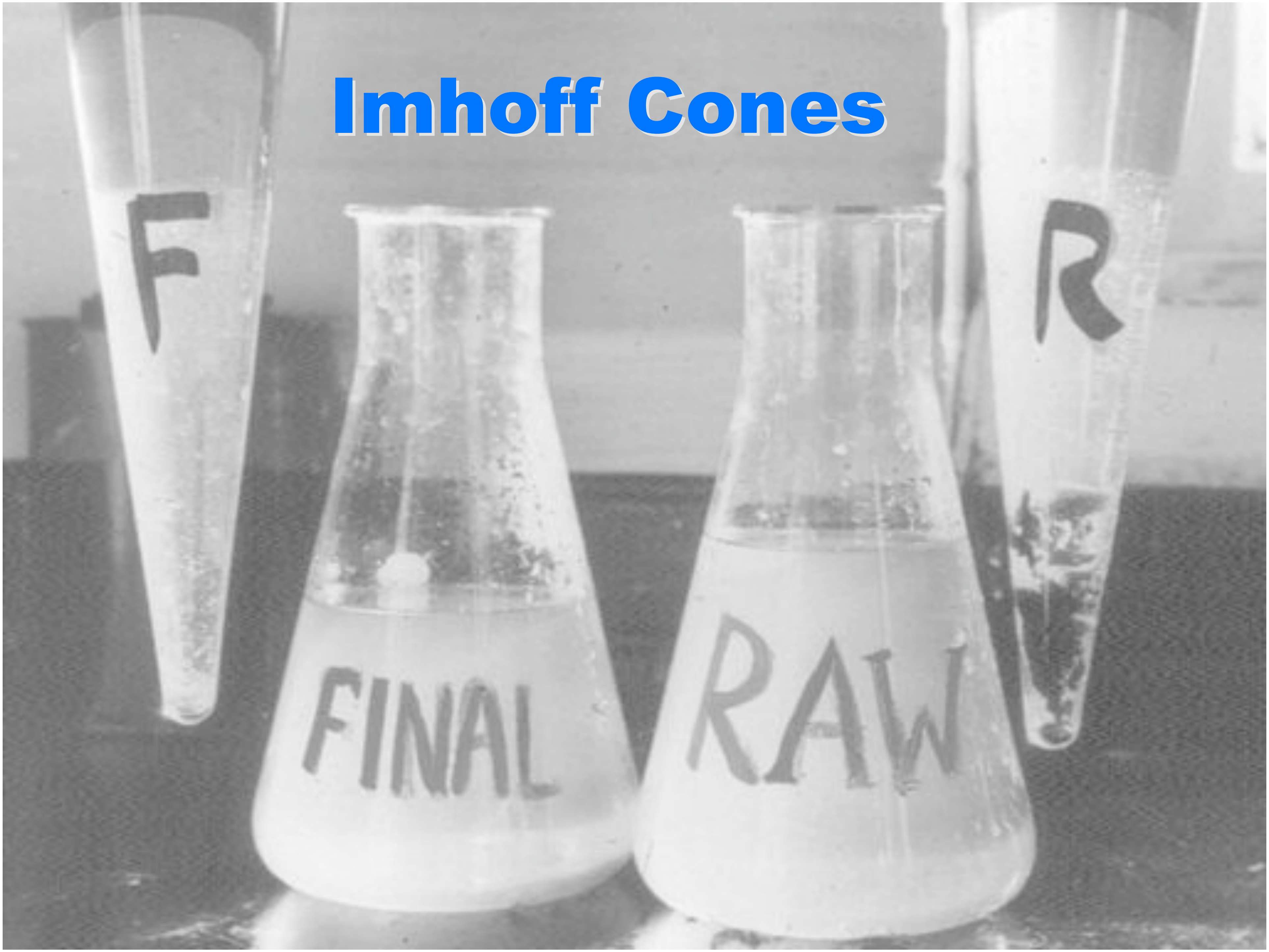
Rectangular, Mechanically-Cleaned Clarifiers

Scum Removal

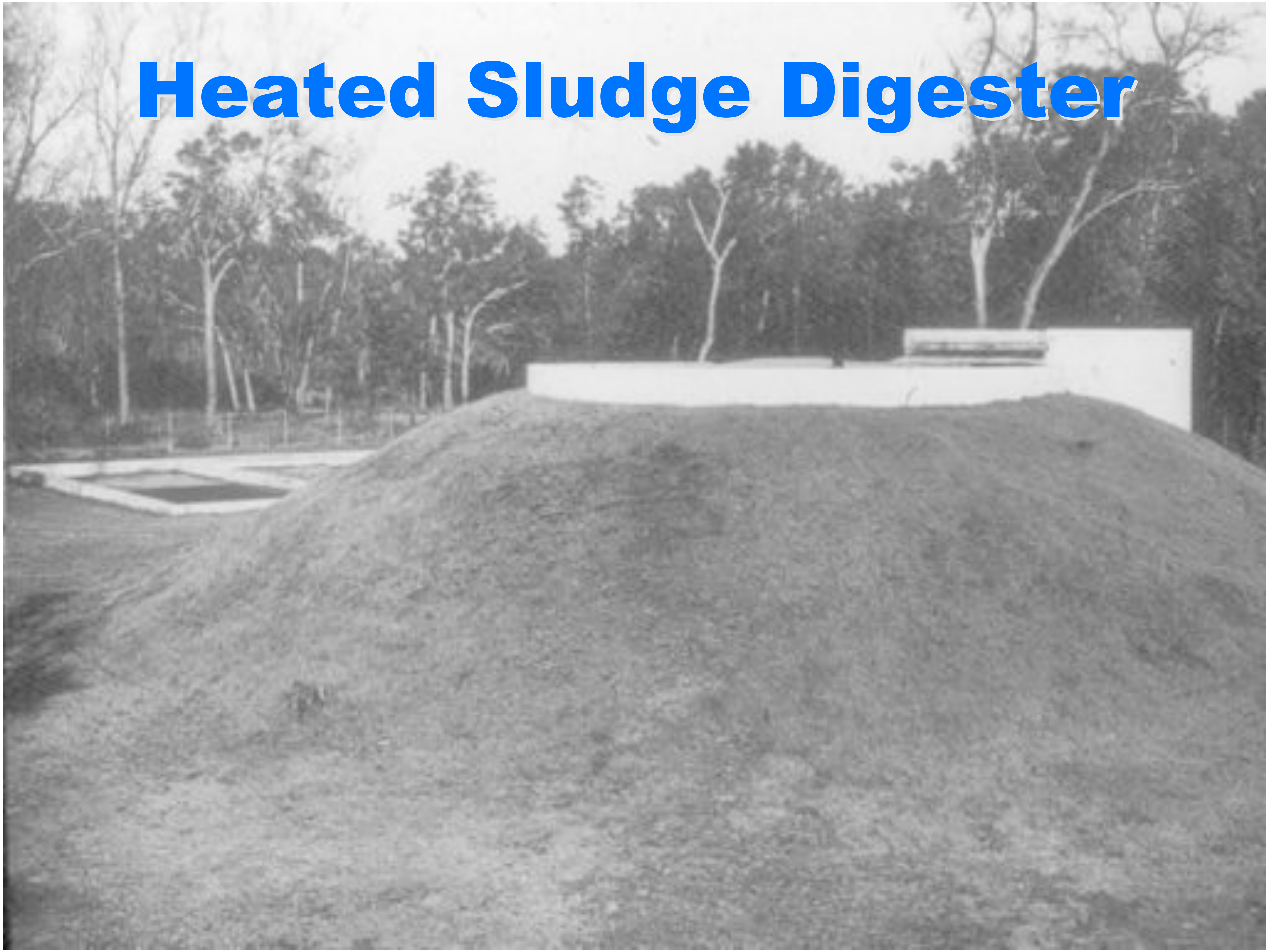
Chlorine Contact Chamber


FINAL
Effluent Sampling

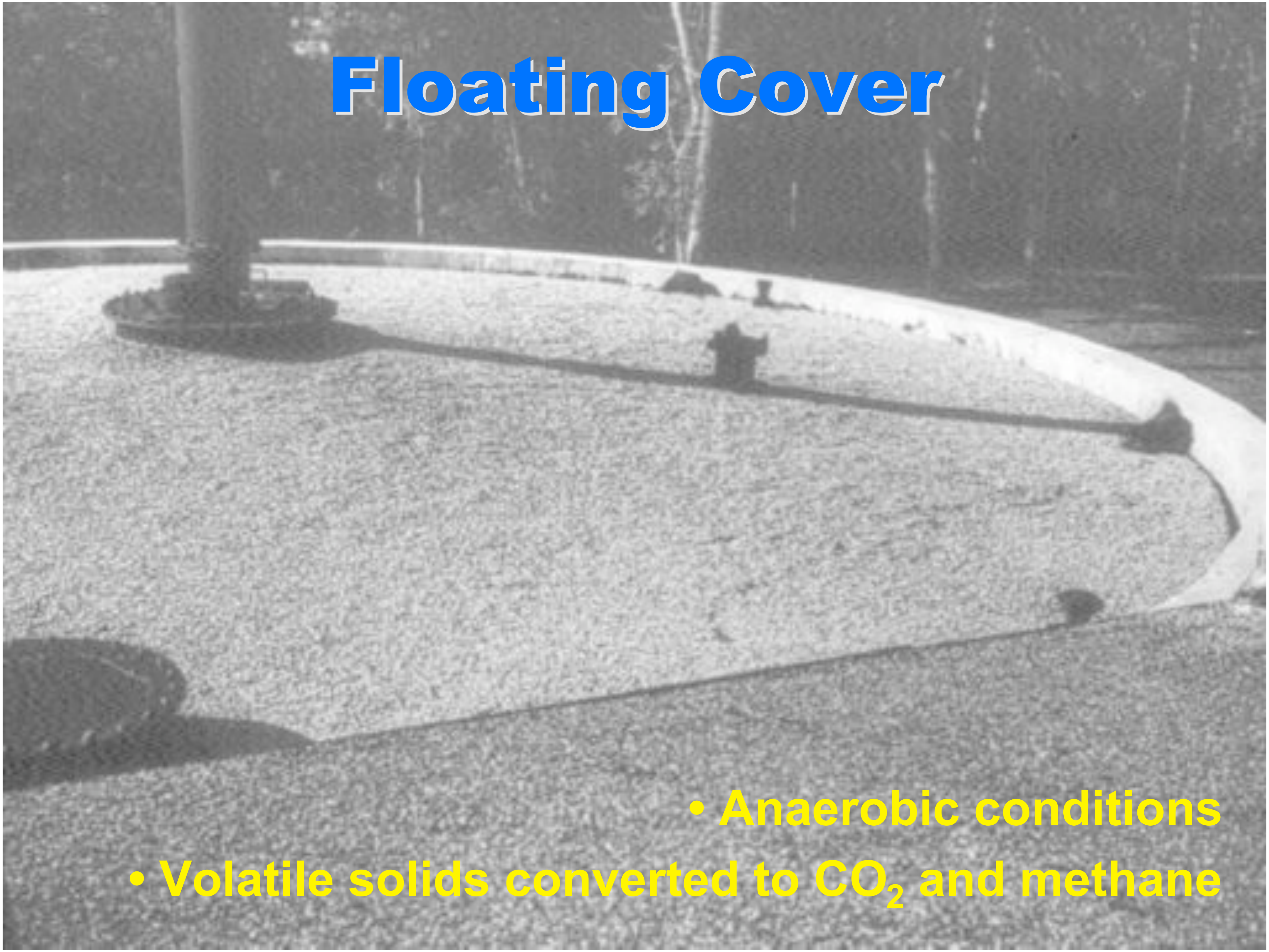
Imhoff Cones



Heated Sludge Digester



Floating Cover

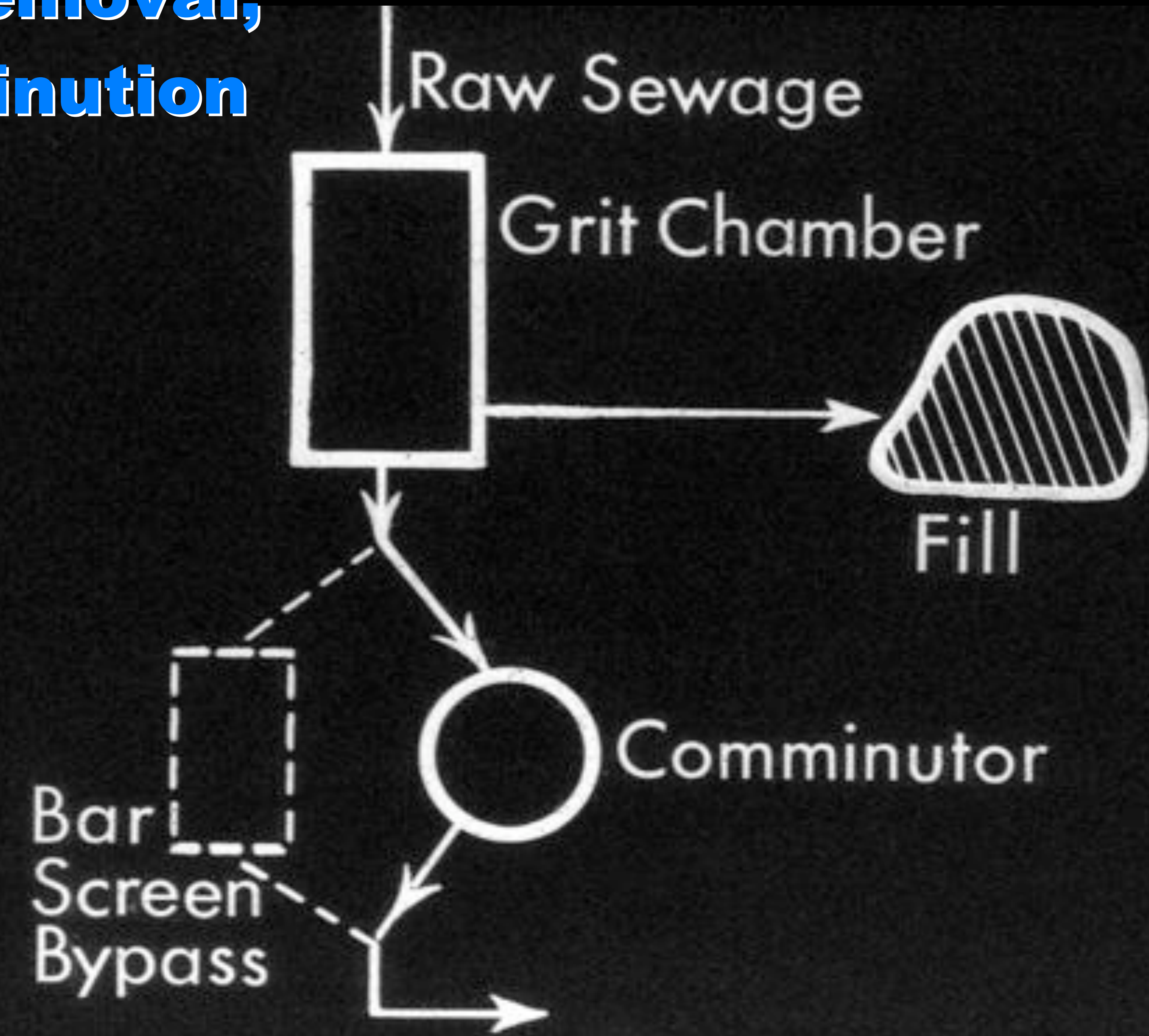


- Anaerobic conditions
- Volatile solids converted to CO_2 and methane

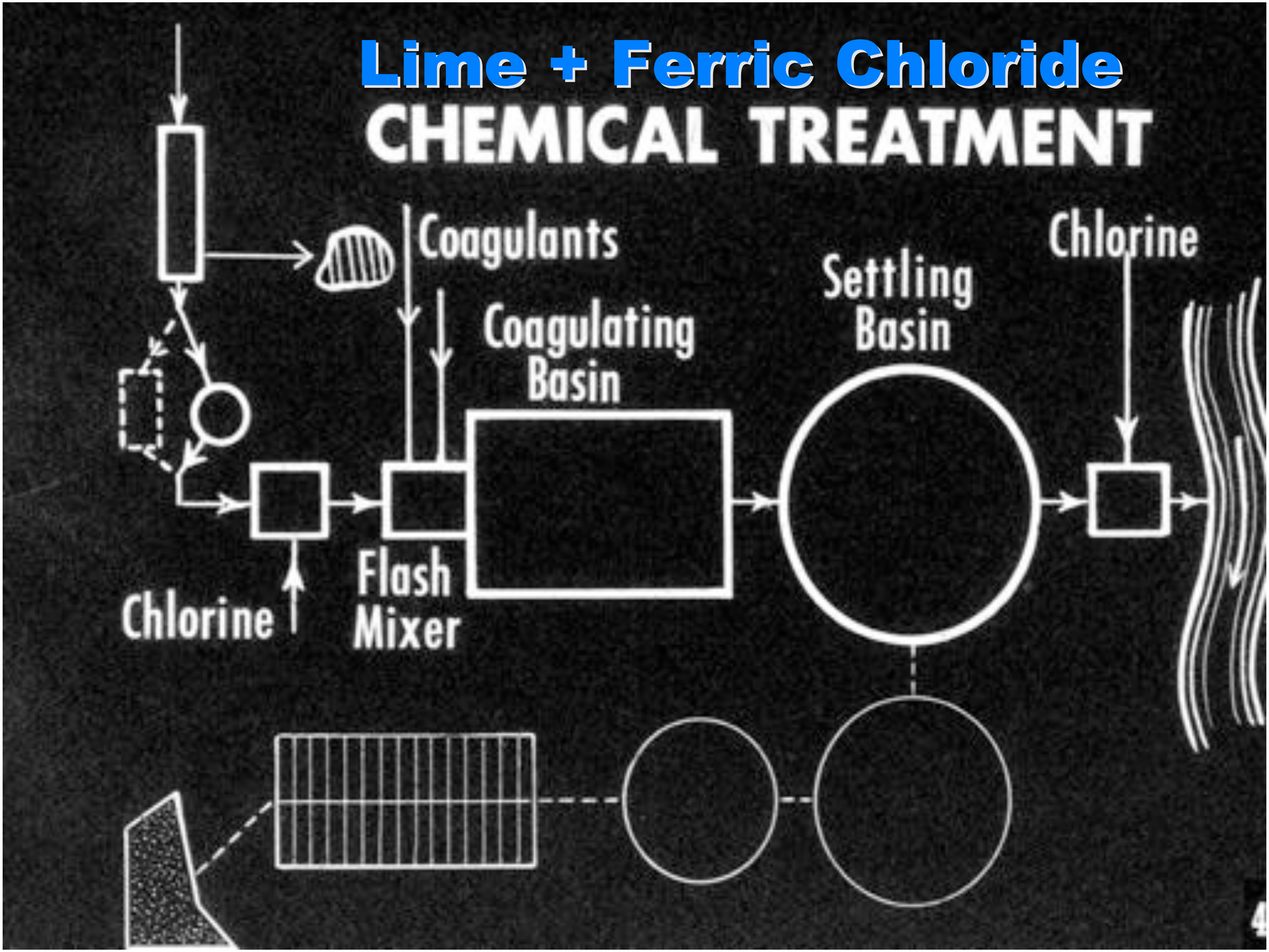
Digested Sludge Goes to Sand Drying Beds

Chemical Treatment

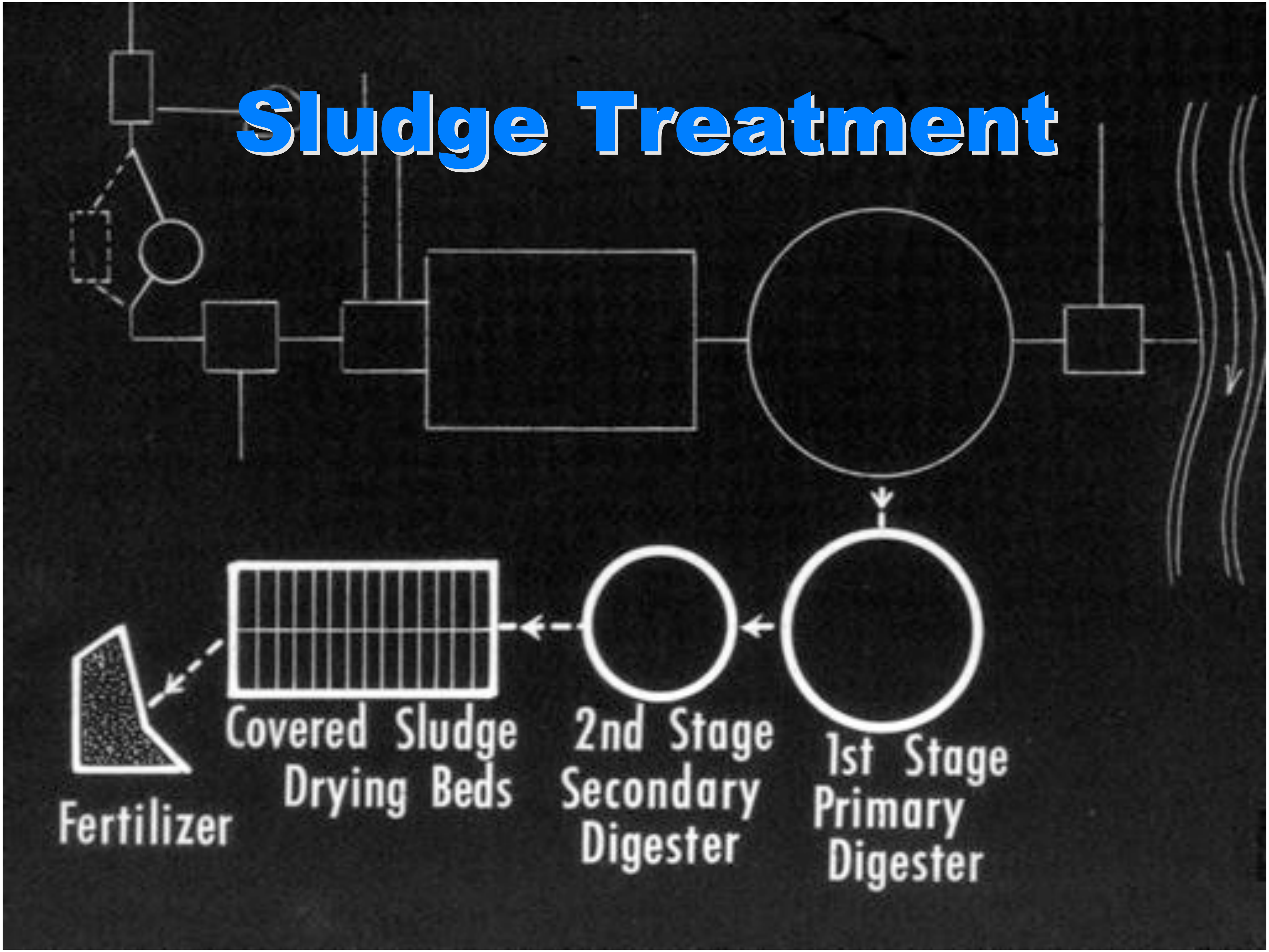
Grit Removal, Comminution



Lime + Ferric Chloride



Sludge Treatment

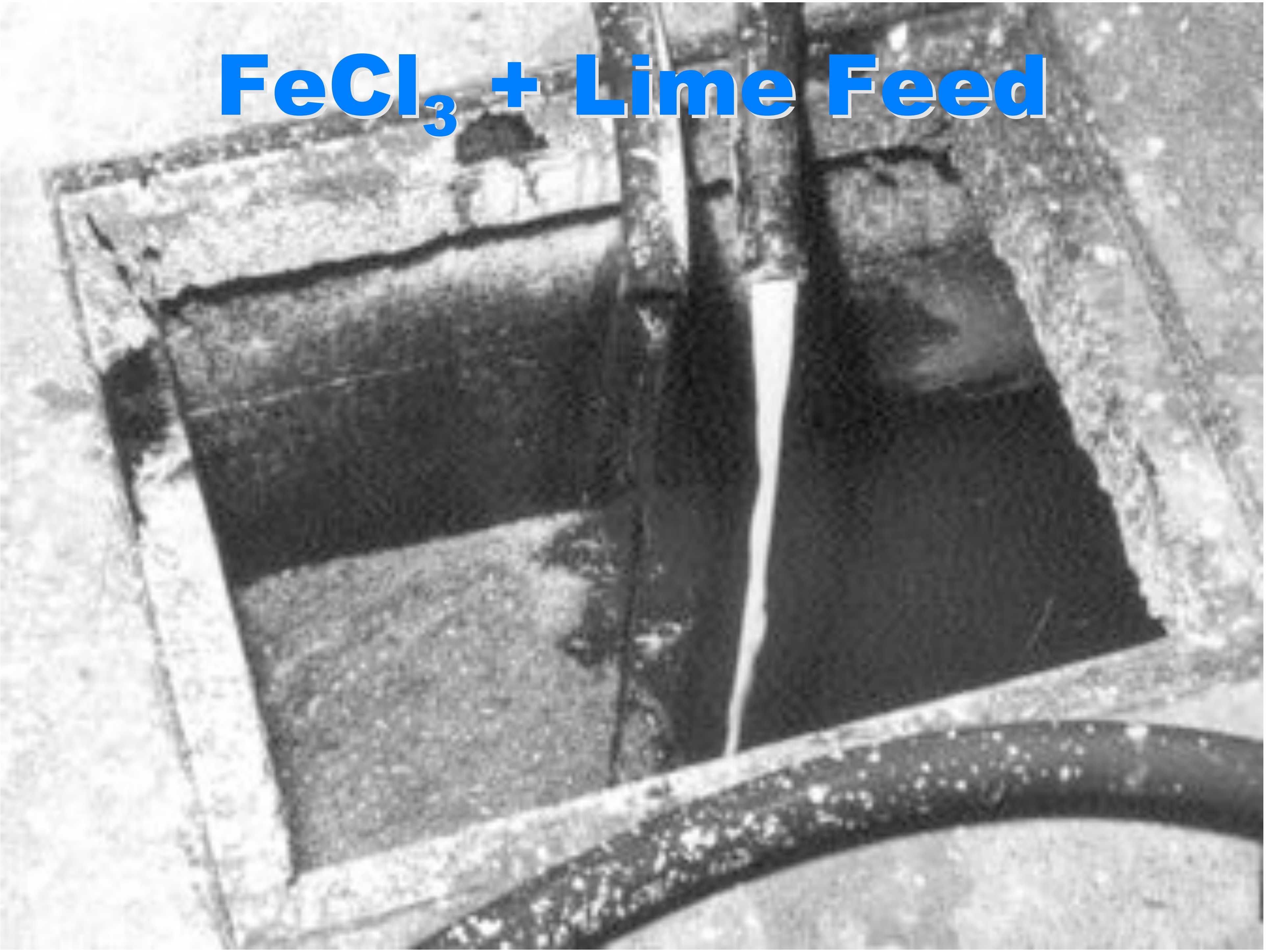


Lime Feeder

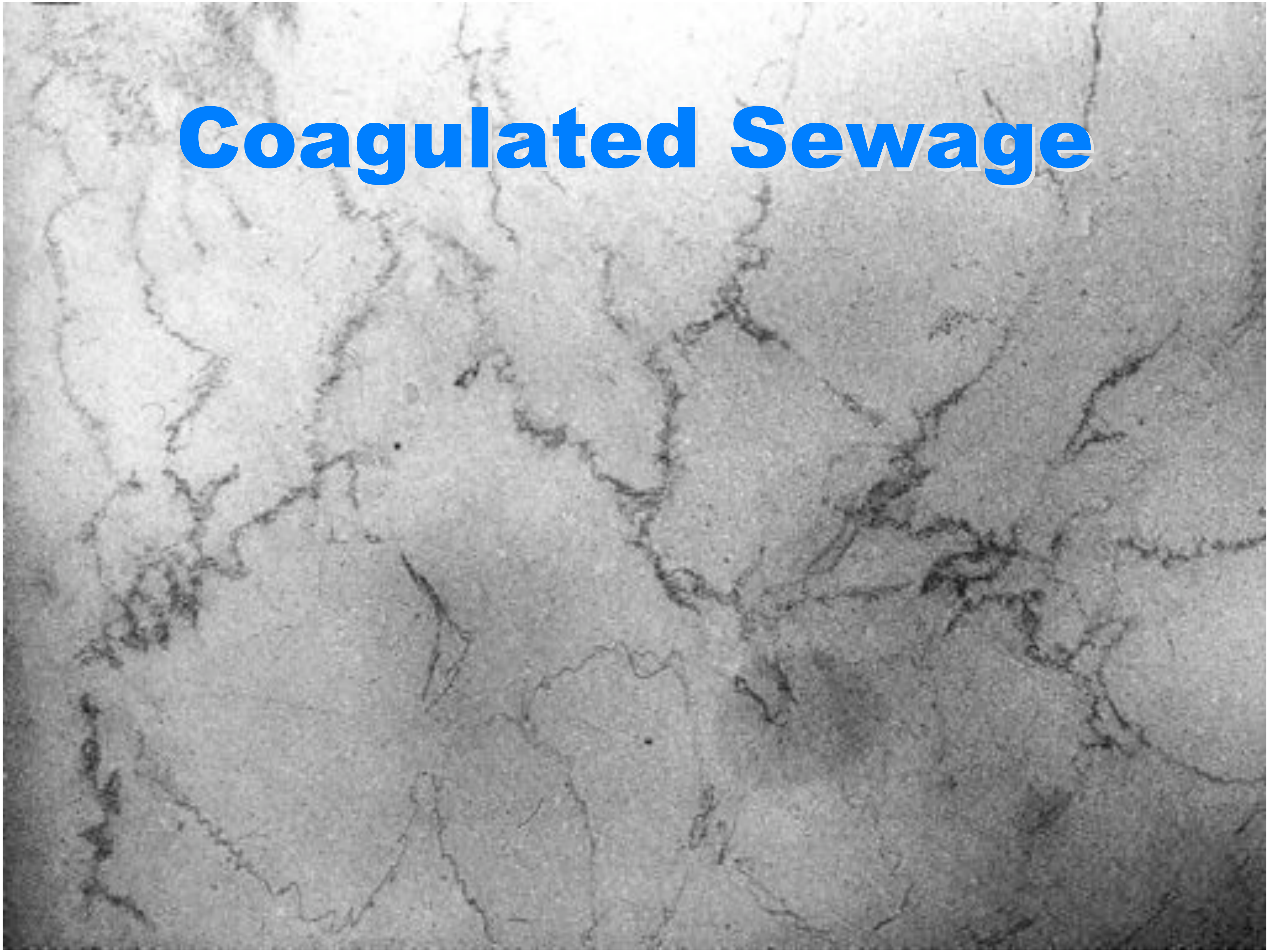
Lime Feed

Ferric Chloride

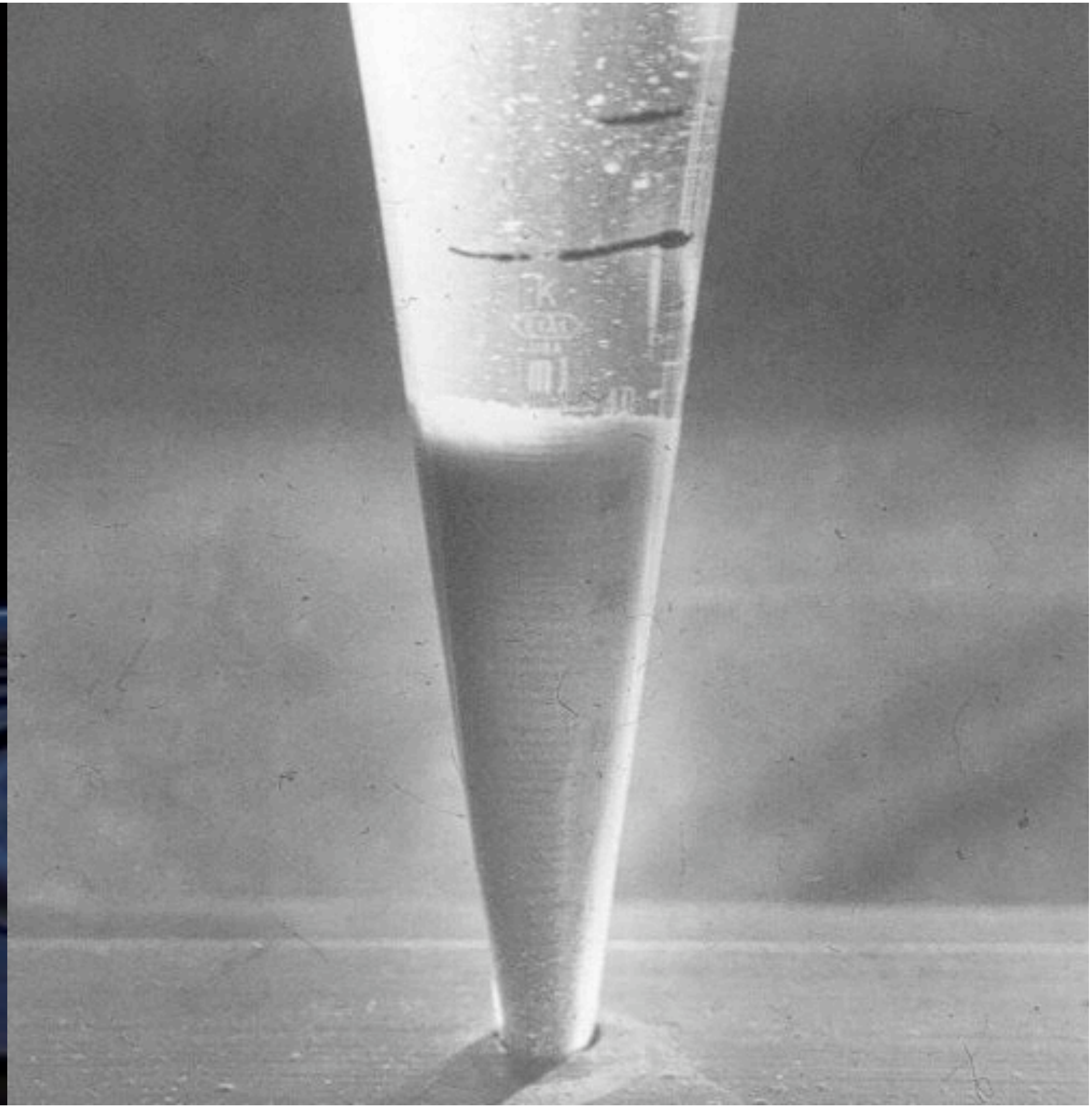
$FeCl_3$ + Lime Feed



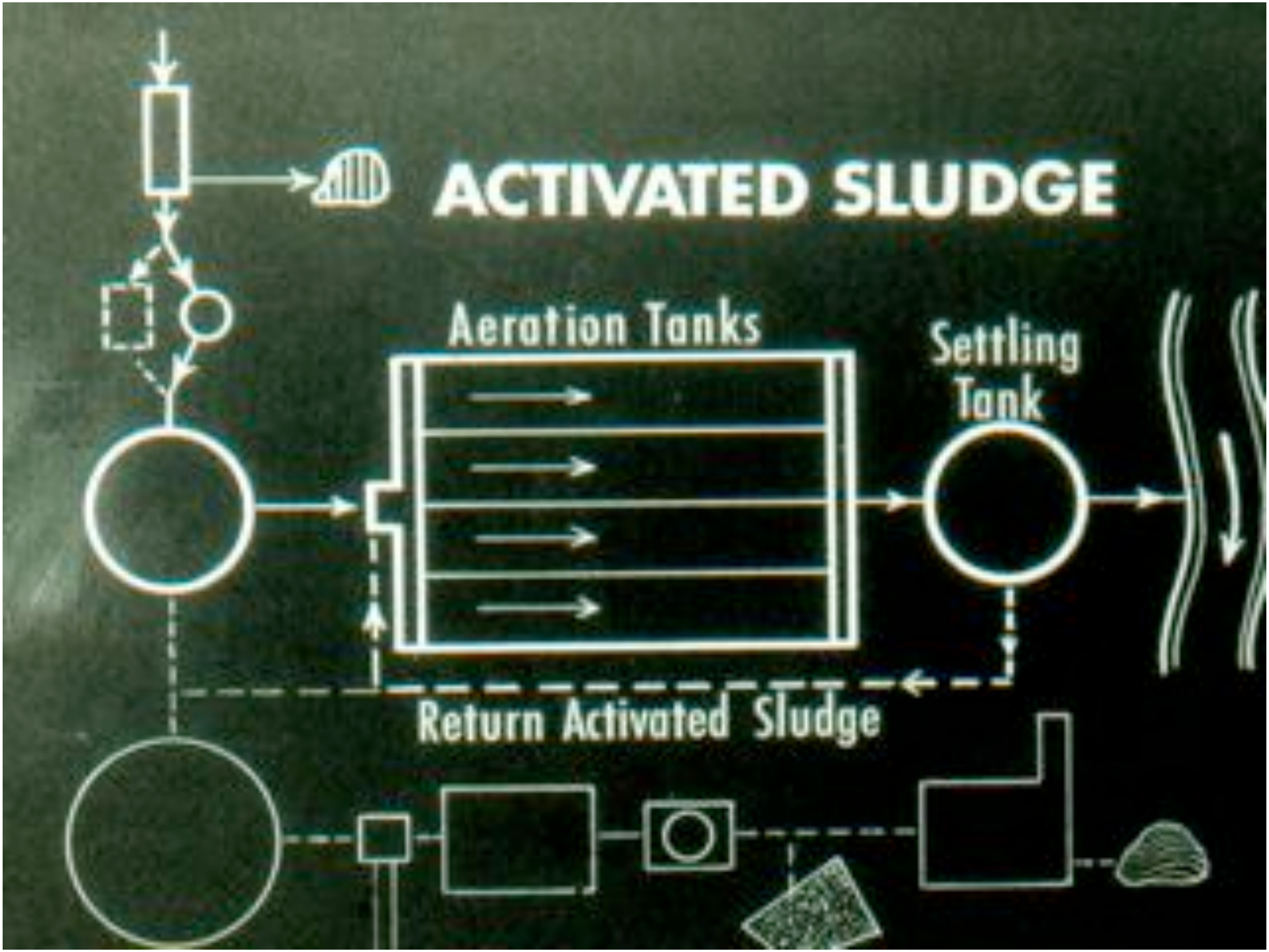
Chemical Treatment Basin


Coagulated Sewage

Physical Treatment
Solids Removal



Activated Sludge Plant

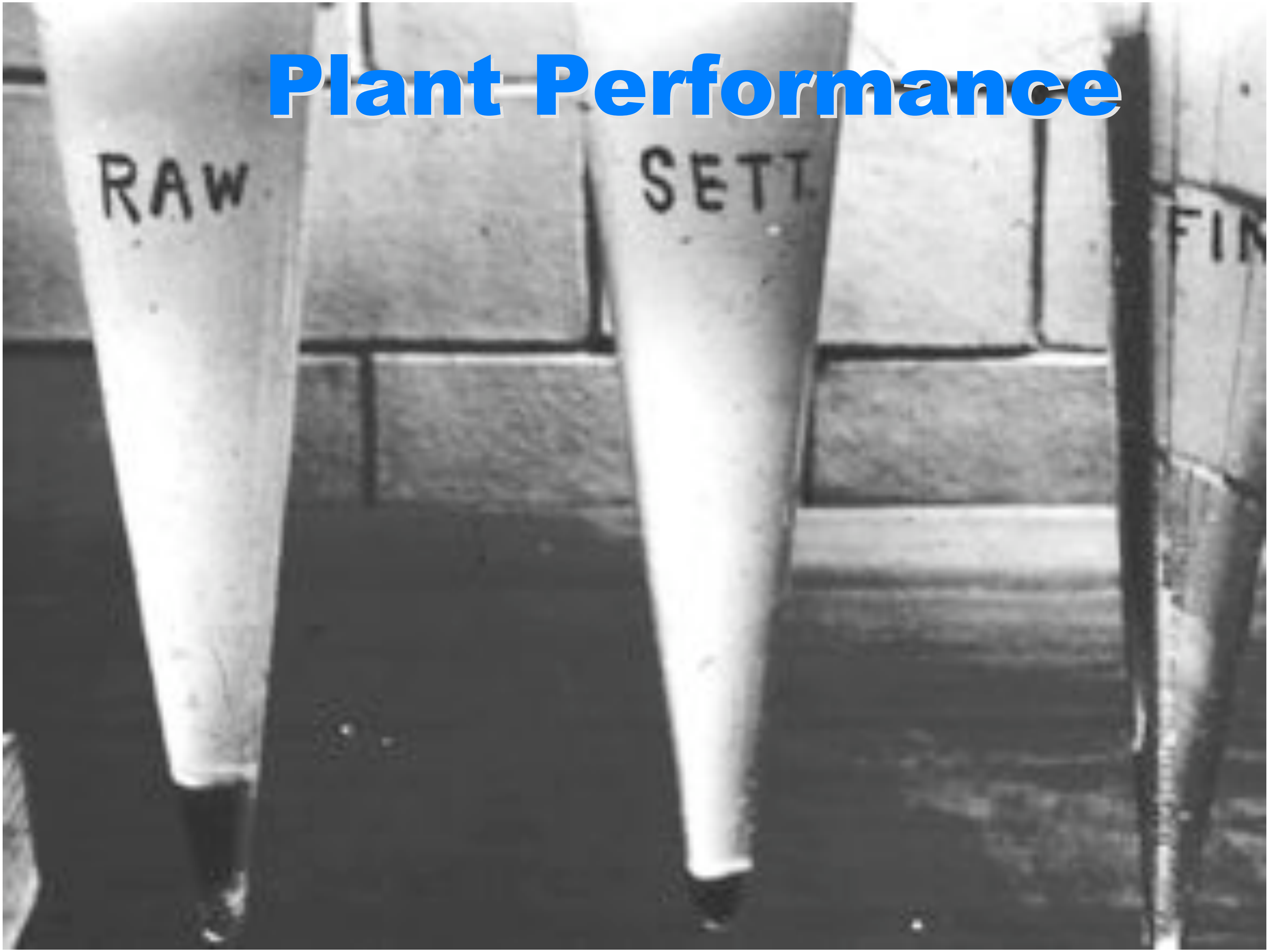

ACTIVATED SLUDGE
Aeration Tanks
Settling
Tank
Return Activated Sludge

Aeration Tanks

Covered Drying Beds

Return Sludge, Mixed Liquor

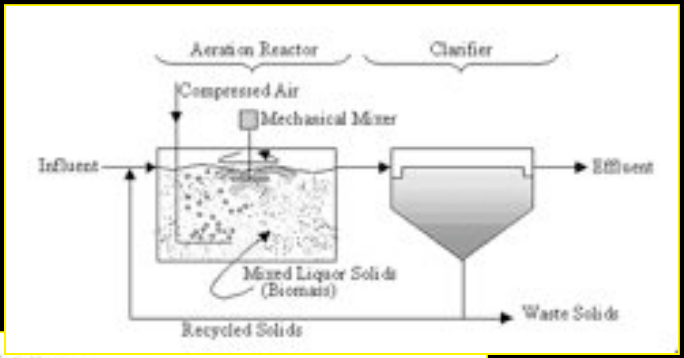
Plant Performance



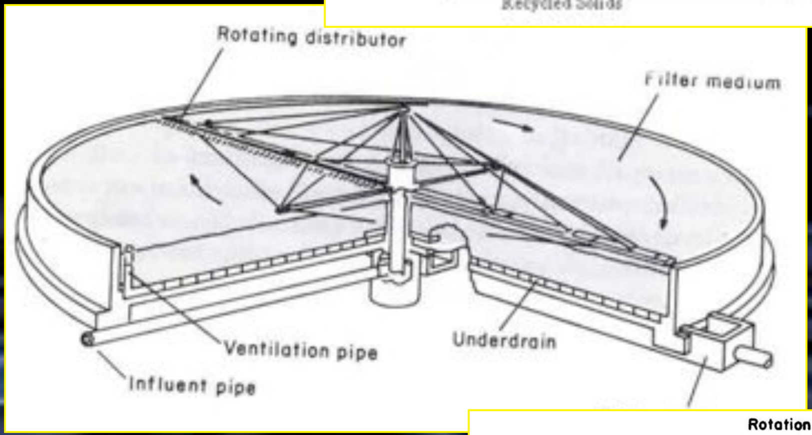

Pollution Control Legislation
1948 Water Pollution Control Act
1956 Fed. Water Pollution Control Act
1961 Amendments to FWPCA
1965 Water Quality Act
1966 Clean Water Restoration Act
1970 USEPA Established
1972 FWPCA Approved
1981 Construction Grants Amendments
1987 Water Quality Act

Secondary Treatment

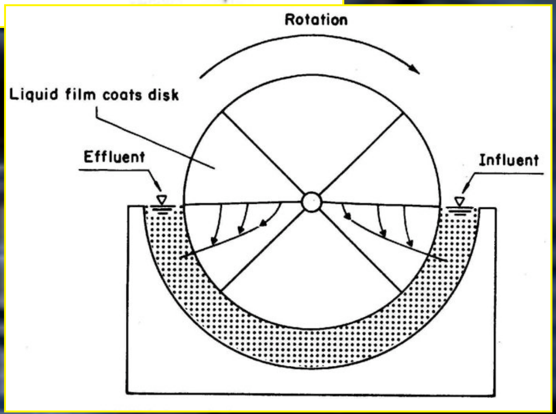
Activated Sludge



Trickling Filters



Rotating Biological Contactors



Trickling Filters

Trickling Filters

- Bed of rocks, fist size (lots of air spaces)
- Water from primary treatment trickles over rocks
- Rocks coated with slime of aerobic organisms
- Bacteria aerobically digest organic solution

Rotating Biological Contactors

Rotating Biological Contactors

- Bed of rocks, fist size (lots of air spaces)
- Water from primary treatment trickles over rocks
- Rocks coated with slime of aerobic organisms
- Bacteria aerobically digest organic solution

After 1972:

Process Optimization

Complete Mix Activated Sludge

Step Aeration

Contact Stabilization

Extended Aeration

Oxidation Ditch

Kraus Process

Pure-Oxygen Activated Sludge

Process Optimization

Complete Mix Activated Sludge

Step Aeration

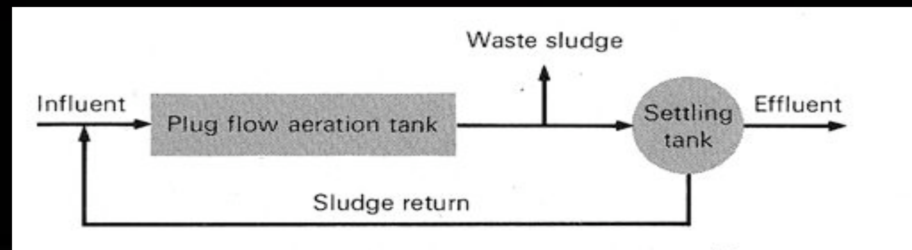
Contact Stabilization

Extended Aeration

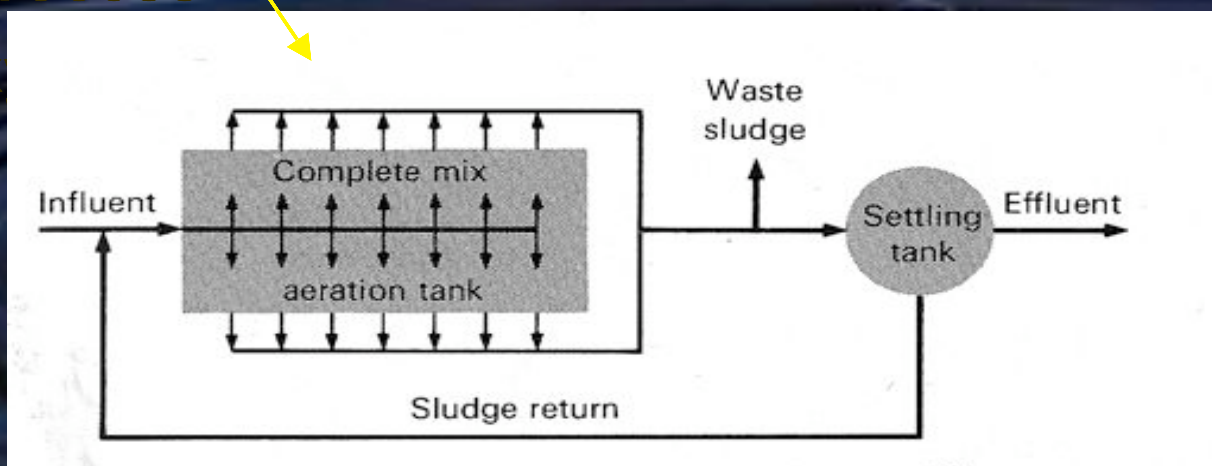
Oxidation Ditch

Kraus Process

Pure-Ox



Standard plug flow activated sludge



Organic load and oxygen demand are uniform throughout the tank

Process Optimization

Complete Mix Activated Sludge

Step Aeration

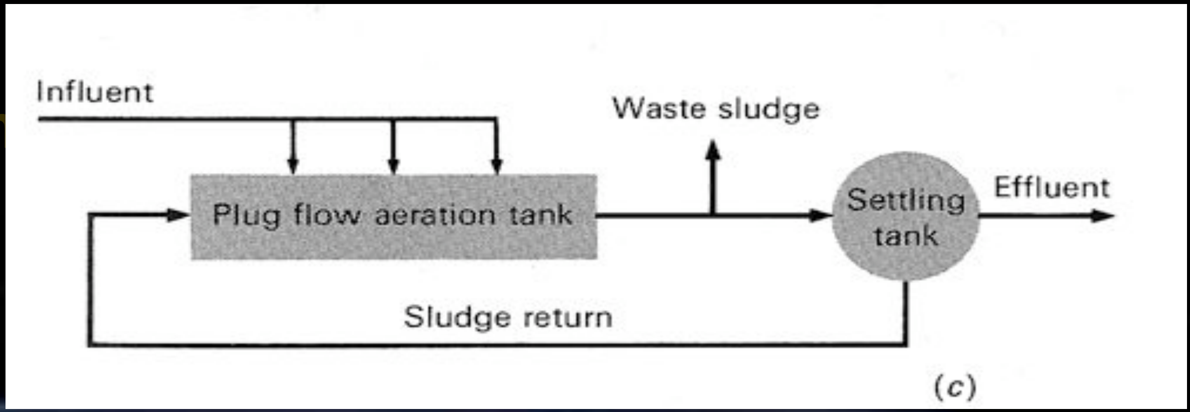
Contact Stabilization

Extended Aeration

Oxidation Ditch

Kraus Process

Pure-Oxygen Activated Sludge



- Influent introduced at multiple points
- Equalizes the food to microorganism ratio (F/M)
- Lowers peak oxygen demand

H2O'C ENGINEERING

Process Optimization

Complete Mix Activated Sludge

Step Aeration

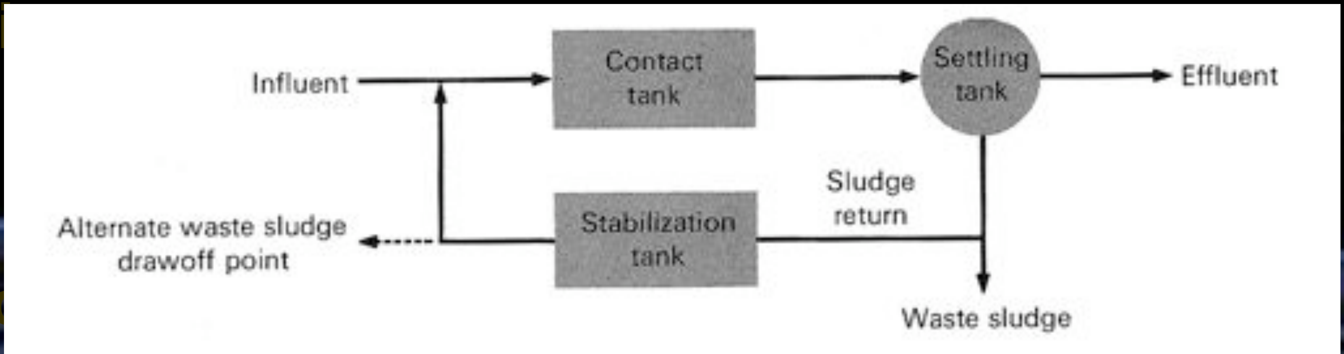
Contact Stabilization

Extended Aerati

Oxidation Ditch

Kraus Process

Pure-Oxygen Ac



- Separate aeration of activated sludge
- Aeration requirements reduced by 50%

Process Optimization

Complete Mix Activated Sludge

Step Aeration

Contact Stabilization

Extended Aeration

Oxidation Ditch

Kraus Process

Pure-Oxygen Activated Sludge

- low organic loading
- long aeration time
- small, prefabricated package plants

H2O'C ENGINEERING

Process Optimization

Complete Mix Activated Sludge

Step Aeration

Contact Stabilization

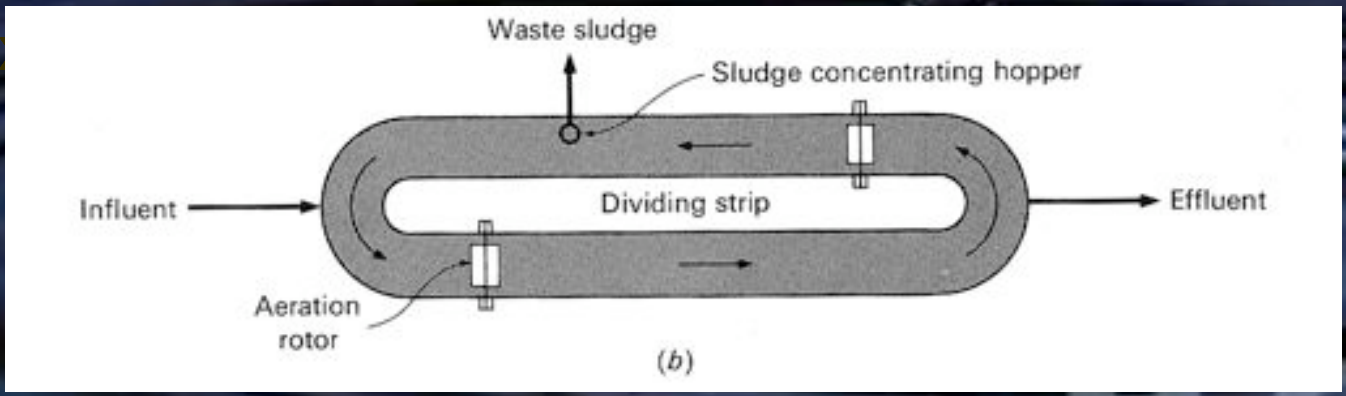
Extended Aeration

Oxidation Ditch

Kraus Process

Pure-O

- Ring or oval-shaped channel
- Mechanical aeration and circulation devices
- Extended aeration
- Long detention times



Process Optimization

Complete Mix Activated Sludge

Step Aeration

Contact Stabilization

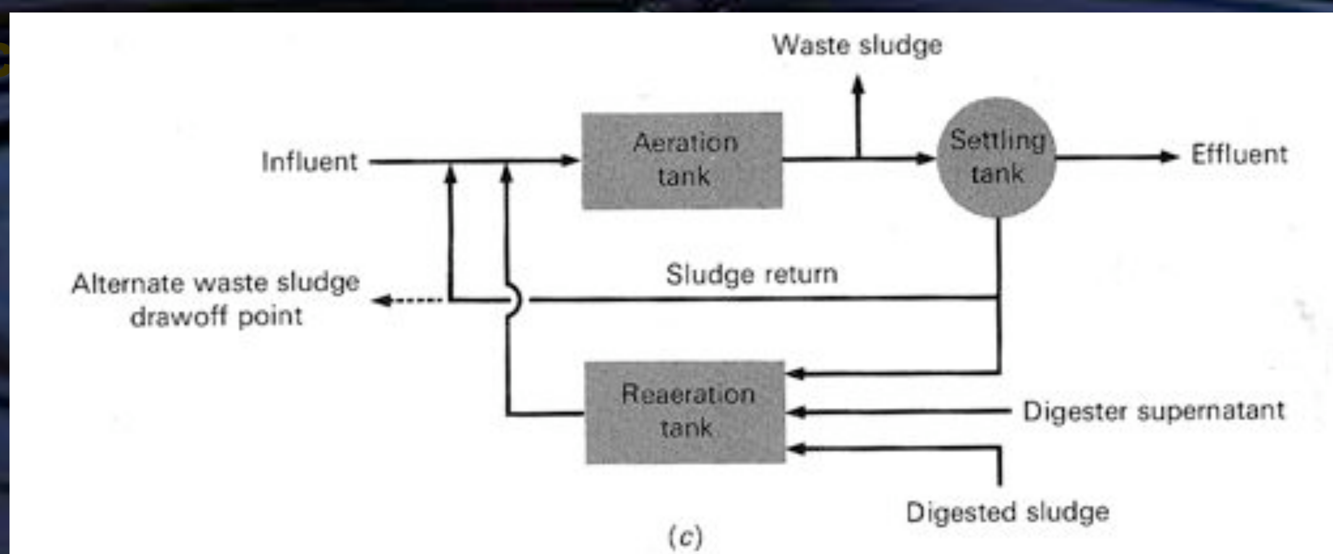
Extended Aeration

Oxidation Ditch

Kraus Process

Pure-Oxygen Ac

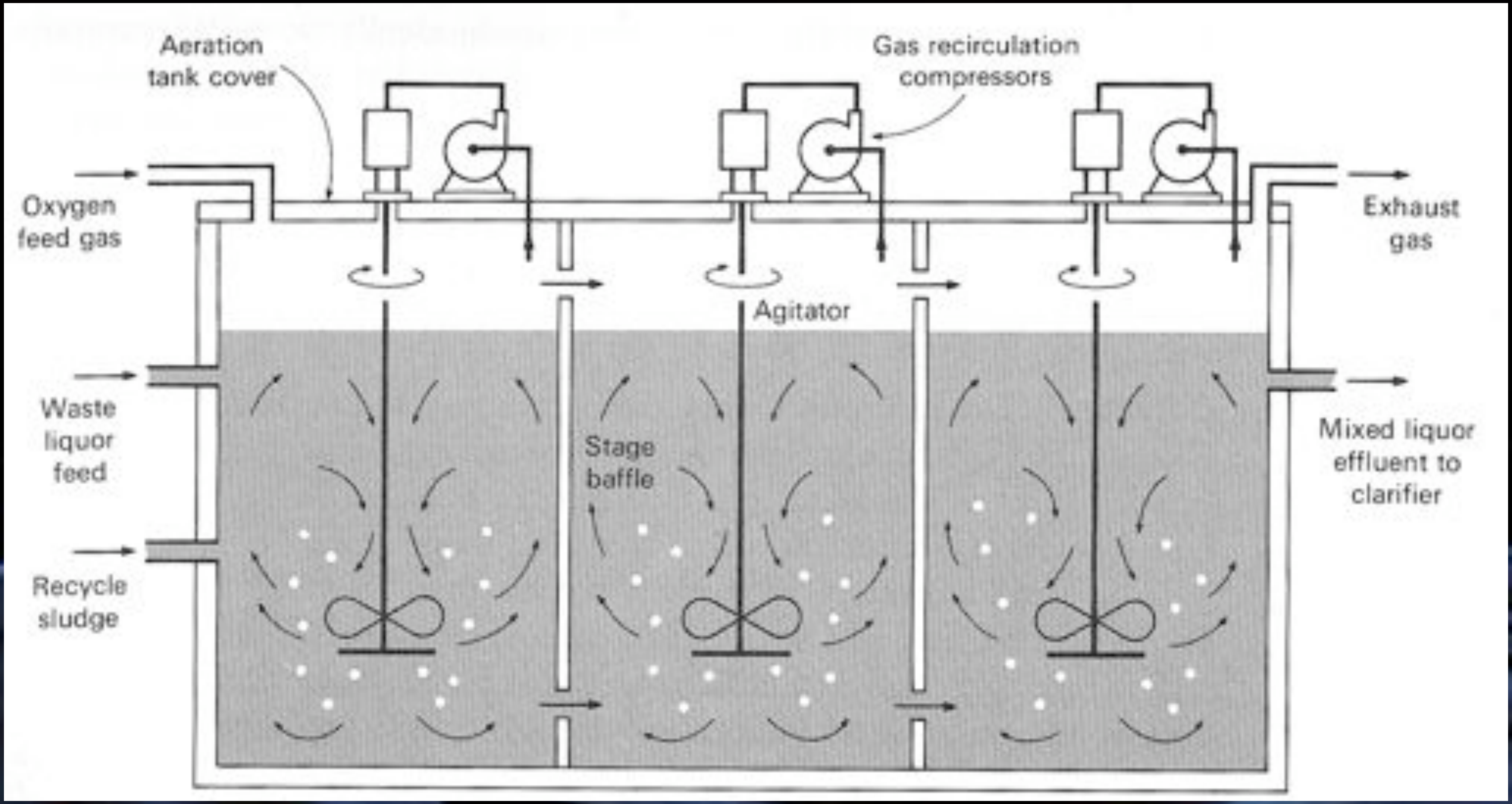
- Variation of Step Aeration process
- Used for WW with low nitrogen levels
- Sludge digester supernatant added to RAS as nutrient source



Process Optimization

- Complete Mix Activated Sludge
- Step Aeration
- Contact Stabilization
- Extended Aeration
- Oxidation Ditch
- Kraus Process
- Pure-Oxygen Activated Sludge

Pure Oxygen Activated Sludge



- High-purity oxygen is used instead of air in the activated sludge process
- Series of complete mix reactors with gas recirculation compressors
- Used with high-strength waste and limited available space

New Treatment Goals and Advanced Waste Treatment

Disinfection
Dechlorination

Trickling Filters
Rotating Biological Contactors
Phosphorous Removal
Ammonia Removal

Advanced Waste Treatment

Phosphorus Removal

Ammonia Removal

Wetlands

Phosphorus Removal

Biological Removal

Lime Precipitation

Aluminum Sulfate Flocculation and Precipitation

Phosphorus Removal

Phosphorus is Food for Algae

Biological Removal: Manipulation of conditions to maximize biological uptake of phosphorus (“luxury uptake”)

Lime Precipitation

Aluminum Sulfate Flocculation and Precipitation

Phosphorus Removal

Biological Removal

Lime Precipitation: High pH precipitates $CaCO_3$, P

Aluminum Sulfate Flocculation and Precipitation

Phosphorus Removal

Biological Removal

Lime Precipitation

Aluminum Sulfate Flocculation and Precipitation:

Precipitates aluminum phosphate

Ammonia (Nitrogen) Removal

It's Algae Food, Too

Physical Removal

- sedimentation
- gas stripping

Chemical Removal

- breakpoint chlorination
- ion exchange

Biological Removal

- activated sludge process
- trickling filter
- rotating biological contactor
- oxidation pond
- land treatment processes (overland flow)
- wetland treatment systems (Hyacinth cultures)

Wetlands

- Water flows through ponds (wetland cells)
- Nutrients are taken up by cattails

Effluent Disinfection

To inactivate waterborne pathogens
(typhoid, dysentery, cholera, etc.)

1900: 25,000 typhoid deaths
1960: 20 typhoid deaths

Disinfection of Wastewaters

- Chlorine
- Ultraviolet Light
- Chorine Dioxide
- Ozone
- Bromine

Chlorine Dosages

MDNR Design Guide

Type of Treatment	chlorine, mg/l
Trickling Filter Plant	10
Activated Sludge Plant Effluent	8
Tertiary filtration effluent	6
Nitrified Effluent	6

(15 minutes minimum contact time)

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Why Dechlorinate?

To protect aquatic life

Dechlorination

Reducing agents:

- sulfur dioxide — SO_2
- sodium bisulfite — $NaHSO_3$
- sodium sulfite — Na_2SO_3
- sodium thiosulfate — $Na_2S_2O_3$

UV Disinfection

I already talked about it this morning.

It's pretty cool.

India


MH 16


PRESHIT AVENUE
प्रेषित एव्हेन्यू


GENTS TOILET
पुरूषांकरीता प्रसाधनगृह

Manikchand
Oxyrich
TM
हेल्दी ड्रिंकिंग वॉटर
300%


चाय


EFFLUENT TREATMENT PLANT.
E.T.P.

Japan


必殺仕事
K·YO·ICHI
KENWOOD
まんが


Lake Biwa

Lake Biwa Environmental Monitoring Station

Lake Biwa

- **Japan's largest lake**
- **Water source for 14 million people**
- **Ordinance Concerning the Prevention of Eutrophication of Lake Biwa (1979)**

Ordinance Concerning the Prevention of Eutrophication of Lake Biwa (1979)

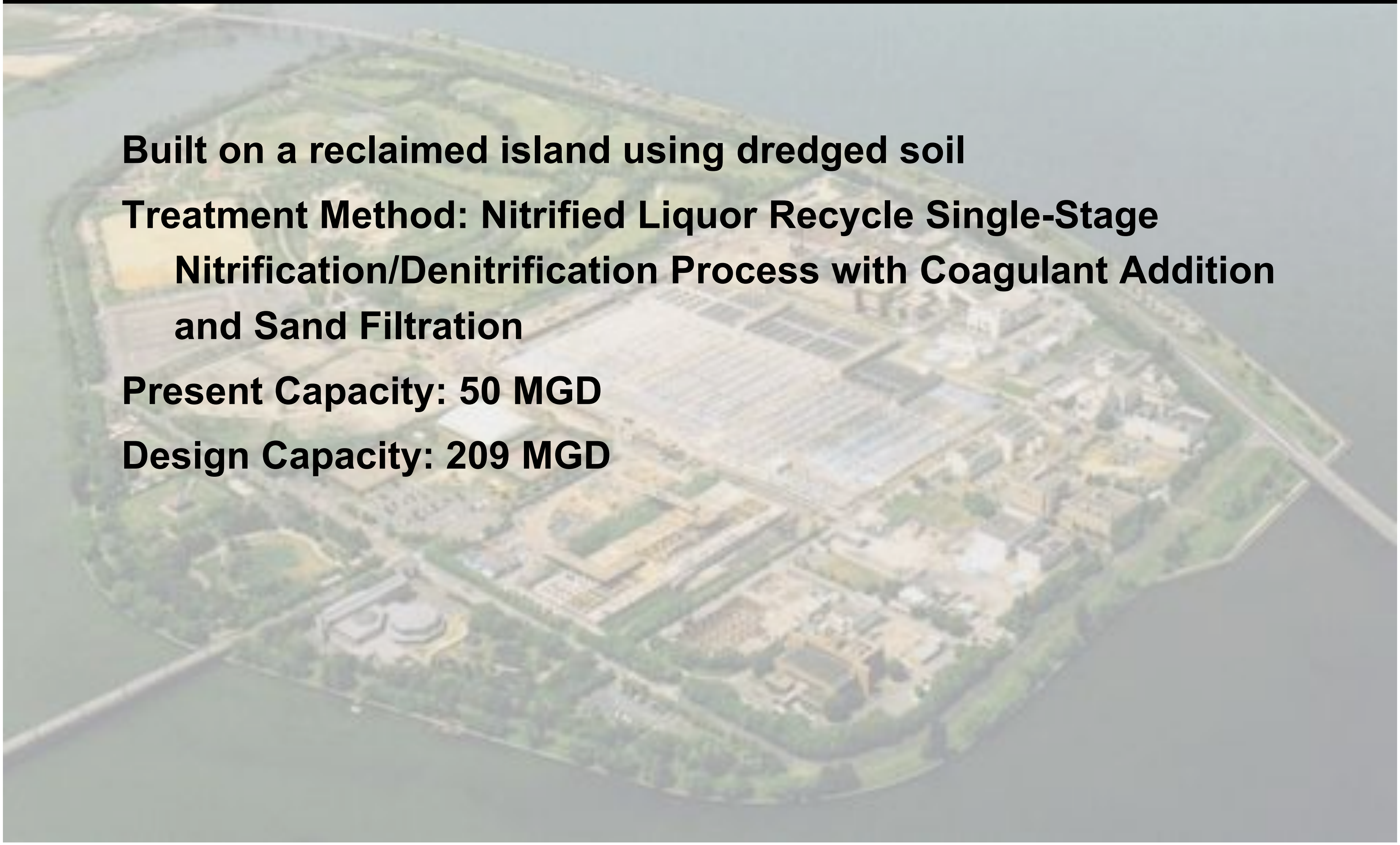
- prohibited detergents containing phosphorus
- regulated wastewater from factories
- expansion and improvement of sewer system
- advanced treatment of sewage to remove nitrogen and phosphorus


Hello, Toto


汚水

Konan-Chubu Water Reclamation Plant

Konan-Chubu Water Reclamation Plant

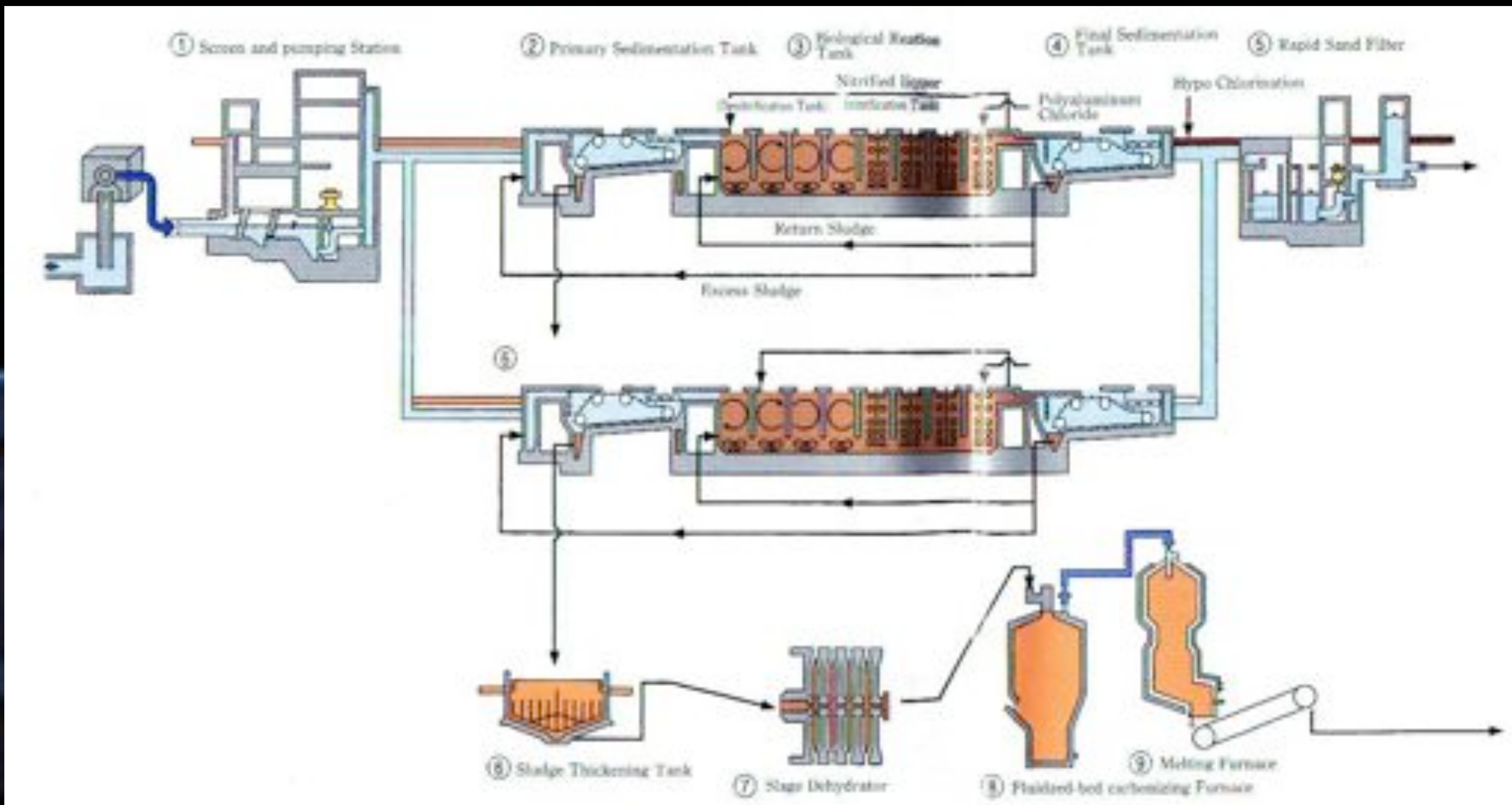


- Built on a reclaimed island using dredged soil
- Treatment Method: Nitrified Liquor Recycle Single-Stage Nitrification/Denitrification Process with Coagulant Addition and Sand Filtration
- Present Capacity: 50 MGD
- Design Capacity: 209 MGD

Plant Performance

mg/l	INFLUENT	EFFLUENT	REMOVAL
BOD	180	0.7	99.6%
TSS	184	0.6	99.7%
COD	94.5	5.6	94.0%
Total N	31.1	5.4	82.6%
Total P	3.38	0.04	98.8%

Konan-Chubu Plant Flow Diagram

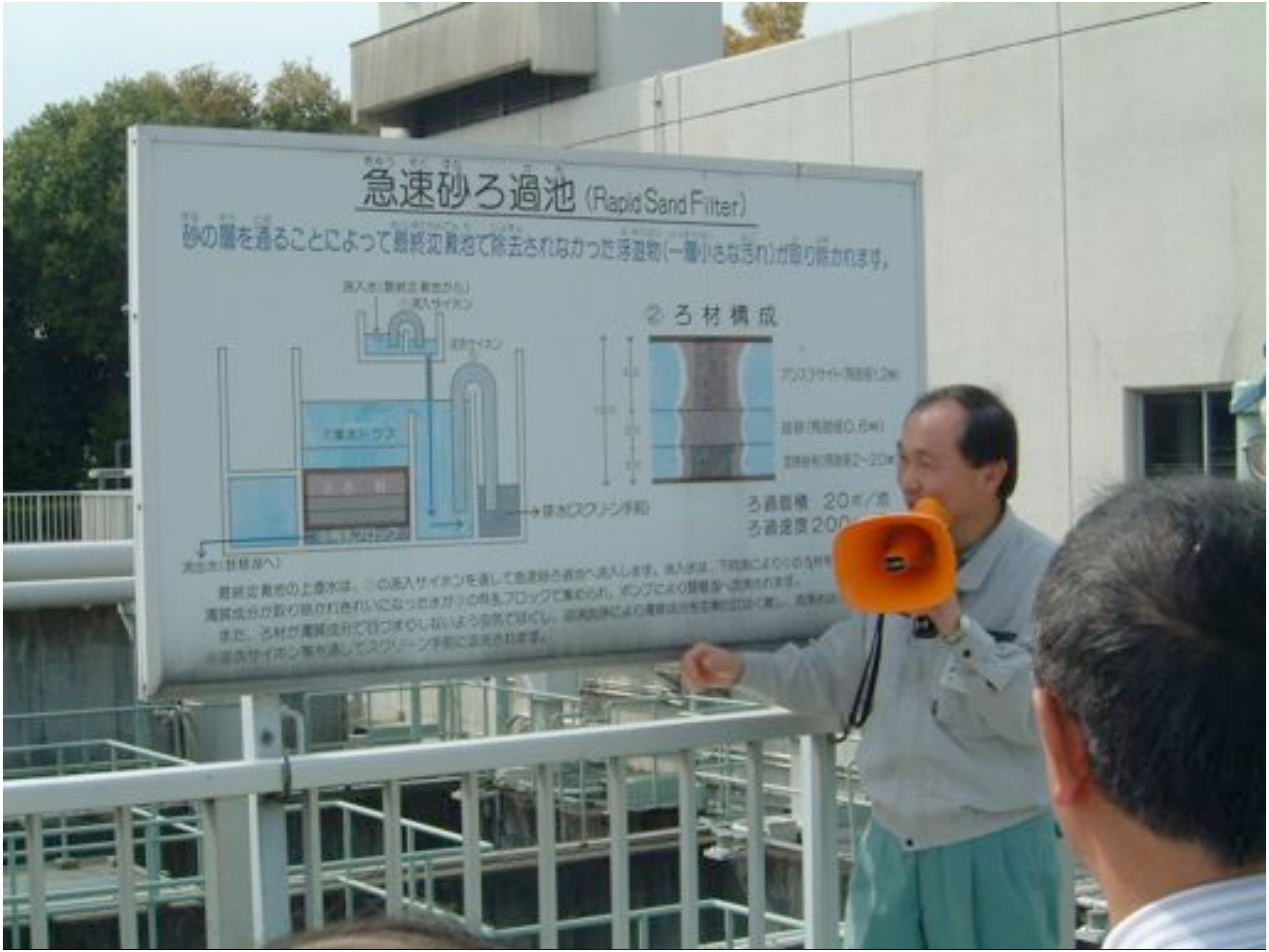


Control Room


最初沈殿池
Primary Sedimentation Tank


生物反応槽
Biological Reaction Tank


指差呼称
ヨシ!!


急速砂ろ過池 (Rapid Sand Filter)
砂の層を通ることによって最終沈殿池で除去されなかった浮遊物(一層小さな汚れ)が取り除かれます。
② ろ材構成

Covered Gravity Thickener

Sludge Dehydrator

Kerosene Furnaces

Slag

- Strength equivalent to natural stone
- TCLP (Leaching test) < detection levels

Slag

Concrete pipes

Blocks

Bricks

Pavers

Aggregate

Backfill

Advanced Waste Treatment Techniques

"Advanced waste treatment techniques in use or under development range from biological treatment capable of removing nitrogen and phosphorus to physical-chemical separation techniques such *filtration, carbon adsorption, distillation,* and *reverse osmosis."*

-EPA, May 1998

The Future of Wastewater Management

Don’t make so much?

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How to Not Make So Much

- Graywater Recycle Systems
- Composting Toilets
- Solar Toilets
- Sawdust Toilets (bucket and chuck it)
- Incinerating Toilets
- Urine Diversion Toilets

Graywater

Graywater Recycle Systems: Water from bath, shower, washing machines, bathroom sinks is used for irrigation

The Humanure Handbook

Composting Toilets

Bucket and Chuck It

Sawdust Toilets

Solar Toilet

H2O'C ENGINEERING

The Future of Wastewater Management

Don’t make so much?

When we’re forced to.

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A Brief History of Wastewater

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