PDHonline Course C627W (4 PDH)

Operation of a Modern Day Sewerage Plant (4-Hour Session) (Live Webinar)

Instructor: Jim Newton, P.E., DEE

2020

PDH Online | PDH Center

5272 Meadow Estates Drive
Fairfax, VA 22030-6658
Phone: 703-988-0088
www.PDHonline.com

TOUR OF A MODERN WASTEWATER TREATMENT FACILITY

Topics

- Basics of wastewater treatment
- Uses Kent County Regional Wastewater Treatment Facility (KCRWTF) as example
- Making a WWTP sustainable

STARTS WITH A FLUSHING TOILET

Collection System

- Gravity sewers
- Force mains
- Pump stations
- Combined sewers

KCRWTF Collection System

- 500 miles of force main and gravity sewers
- 85 pump stations

Pump Station

- Wet well
  - Inside or outside
  - Contains sewage
- Dry well
  - Houses pumps
- Pumps
- Electrical
- Building

Dry Well with Pumps

Pump Station Bldg.

Influent Types

- Domestic (household)
- Commercial (restaurants, cafeterias, schools, convention centers, etc.)
- Industrial
- Medical (hospitals, doctors, dentists)

Typical Domestic Pollutants

- Biochemical oxygen demand (BOD)
- Chemical oxygen demand (COD)
- Total suspended solids (TSS)
- Nutrients
  - Nitrogen
  - Phosphorous
- Pathogens
- Personal care products
- Medicines

Typical Commercial Pollutants

- BOD
- COD
- TSS
- Fats, oils and grease (FOG)
- Nutrients
- Food waste

Typical Industrial Pollutants

- BOD
- COD
- TSS
- FOG
- Heat
- Chemicals (organic, inorganic, metals)
- Nutrients

Medical

- Hospitals
  - Detergents
  - Pharmaceuticals
  - Personal care products
  - Blood
- Dentists
  - Mercury
- Doctors
  - Medicines

INCLUDES SEPTAGE

- Septic Tank Pump Outs
  - Very high COD
  - High BOD
  - High solids
- Grease Trap Wastes
  - Fats, oils and greases (FOG)
  - Detergents (Phosphorous)

FATS, OILS AND GREASES (FOG)

- Restaurants
- Convention Halls
- School Cafeterias
- Churches
- Fire Halls

INDUSTRIAL DISCHARGES

EXAMPLES from KCRWTF

- Food Processing (chicken, clams, dry products, canned produce)
- Steam Electric (power plants)
- Chemical Manufacturing (paints, glues, biodiesel)
- Metals Manufacturing (cooling towers, steel shelving)
- Clothing (gloves, fabric, suits, baby wipes)
- Others (,

Marriage of Science and Engineering

- Science:
  - Physics
  - Chemistry
  - Biology
- Engineering
  - Hydraulics
  - Structures
  - Electrical
  - Mechanical
  - Thermal

Physics

- Influent Screens
- Grit Chambers
- Primary and Secondary Clarifiers
- UV Disinfection
- Biosolids Dewatering
  - Centrifuges
  - Belt Presses

Chemistry

- Nutrient removal
- Disinfection
- Enhancing settling
- Biosolids conditioning
- Biosolids stabilization
- Biosolids digestion

Typical Chemicals

- Ferric Chloride
  - Phosphorous removal
  - Biosolids conditioning
- Polymers
  - Biosolids conditioning
- Chlorine, Ozone, Bromates
  - Disinfection
- Lime
  - Biosolids stabilization

Biology

- Secondary Treatment
  - Removing BOD, COD, nutrients
- Biosolids Treatment
  - Pathogens in biosolids
- Disinfection
  - Pathogens in water

Microorganisms

- Facultative bacteria
- Anaerobic bacteria
- Aerobic bacteria
- Activated sludge
- Filamentous Organisms
- Protozoans and Metazoans

Facultative

Adaptable to either aerobic or anaerobic conditions in order to survive and multiply

Anaerobic bacteria

- Live and reproduce in the absence of free oxygen
- Use sulfates and nitrates for energy
- Metabolize more slowly
- Electromechanical equipment and mixing not required
- Found in septic tanks and digesters

Aerobic Bacteria

- Live and multiply in the presence of free oxygen
- Use dissolved oxygen is the primary source of energy
- 90% fewer organisms are needed to treat the water than anaerobic bacteria
- Byproducts are carbon dioxide and water
- Live in colonial structures called floc and are kept in suspension by mechanical mixing

Examples


Stalked ciliate


Free swimming ciliate


Rotifer


Waterbear


Nematode

Activated sludge

- Aerobic floc in a healthy state
- Reduces organic material in 4-6 hours vs. several days for anaerobic
- Increased process efficiency
- KCRWTF removes 98% of BOD

Filamentous Organisms

- Majority bacteria with some fungi and algae
- Strengthen the floc in low numbers; larger floc particles are more easily settled in a clarifier
- In large numbers they can make the floc to large and cause interfloc bridging not allowing the sludge to settle as well
- Could cause a washout of solids and can create a floating scum mat
- Can inhibit the growth of more desirable species

Examples

Protozoans and Metazoans

- Protozoans next higher life from above bacteria
  - Single celled animals
  - Involved in
    - Floc formation
    - Cropping of bacteria
    - Removal of suspended solids
- Metazoans are multi-celled animals
  - Nematodes
  - Rotifers
  - Found in well developed biomass
- Existence indicates operational changes that require adjustments

Hydraulics

- Collection system
- Pump stations
- Gravity flow
  - Pipes
  - Treatment plant
- Flow in pipes
- Flow through facility

Structures

- Concrete:
  - Clarifiers
  - Buildings
  - Grit Chambers
  - Basins
- Wood
  - Buildings
  - Pump stations
- Metal
  - Roofs
  - Buildings

Electrical

- Solar farm
- Switch gear
- Distribution system
- Operations

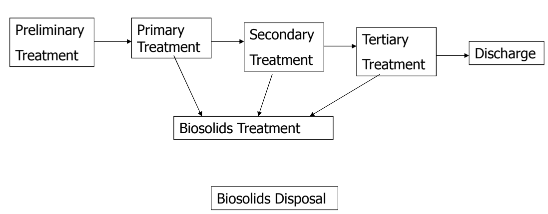
Mechanical

- Pumps
- Conveyors
- HVAC

Thermal

- Biosolids dryers
- HVAC

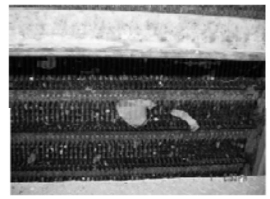
General WWTP Process Description



Preliminary Treatment

- Screening
- Grit Removal
- Equalization

Screening




Screening

- Hair
- Paper
- Metal
- Toys
- Only wastestream landfilled at KCRWTF

Grit Removal


Grit removal

- Sand
- Gravel
- Otherwise fills up in basins requiring the basins to be cleaned more frequently

Primary Treatment

- Clarification
- Not at KCRWTF

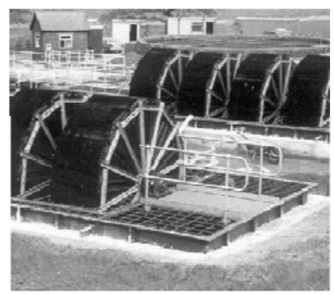
Secondary Treatment

- Biological treatment
  - Activated sludge
    - Solids retention time near 8-10 days
  - Extended activated sludge (KCRWTF)
    - Solids retention time greater than 20 days
  - Trickling filters
  - Sequencing batch reactors
  - Oxidation Ditches
  - Rotating Biological Contactors (RBCs)
  - Pure Oxygen
  - Lagoons
- Clarification

Trickling Filters

Oxidation Ditch

RBC



Sequencing Batch Reactor

Lagoon

KCRWTF Extended Aeration Example

- Parkson Biolac® System
  - Solids retention time 30-60 days
  - Hydraulic residence time 1-2 days
  - KCRWTF has two 10MG basins
  - Includes biological nitrogen removal by turning on and off aeration chains
  - Can remove phosphorous with ferric chloride addition

Secondary Clarification

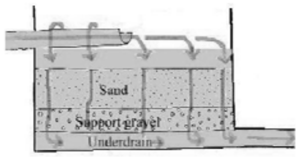
Secondary Clarification

- Activated sludge from basins
  - 3,000-4,000 mg/l total suspended solids from basins
- Separates solids from water
  - 4-10 mg/l in effluent
- Recycles 90% of solids back into basins
- Wastes 10% of solids to biosolids treatment

Tertiary Treatment

- Sand filters
- Ammonia Stripping
- Activated carbon
- Membranes
- Reverse Osmosis

Sand Filters



Membrane System

Disinfection

- Chlorination/dechlorination
- Sodium hypochlorite
- Calcium hypochlorite
- Ultraviolet
- Ozonation
- Bromation

Chlorine System

UV

Disinfection

- Energy
- Contact time
- Pathogens
  - Enteroccocus (KCRWTF)
  - E. Coli
  - Fecal Coliform
- Colonies per 100 ml

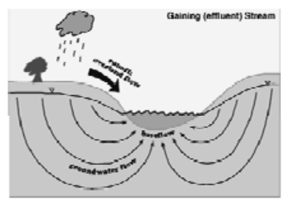
Discharge

- Rivers
- Lakes
- Bays
- Land application
  - Rapid Infiltration
  - Spray irrigation
  - Overland Flow
- Groundwater injection

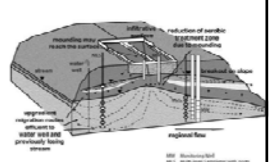
KCRWTF Discharge


Spray Irrigation

Overland Flow



Rapid Infiltration

Biosolids Treatment

- Conditioning
- Dewatering
- Stabilization

Biosolids Conditioning

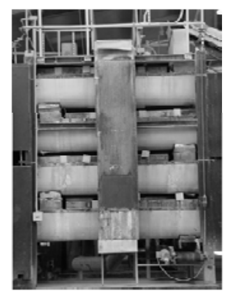
- Help the biosolids dewater
  - Addition of ferric chloride
  - Addition of anionic polymers
  - Addition of cationic polymers

Dewatering

- Remove water from biosolids
- Typical start at 98-99% water
  - Vacuum filters
  - Belt presses (can reach 20-25% solids)
  - Centrifuges
  - Heat drying
    - Incineration
    - Indirect drying (can reach 50-70% solids)
    - Passive solar (can reach 75-90% solids)

Belt Filter Presses


Indirect Drying

Passive Solar Drying

Stabilization

- Kill pathogens
  - Lime (raise ph above 12)
  - Anaerobic digestion
    - Can capture gas and use to heat plant or generate electricity
  - Aerobic digestion

Lime Stabilization

Anaerobic Digestion

Anaerobic Digesters

- Microbes use oxygen in solids
- Produce biogas which is 60% methane
- Captured and used to produce electricity and heat
- Part of EPA's combined heat and power (CHP) program
- Can produce 100 KW/1 MGD treated

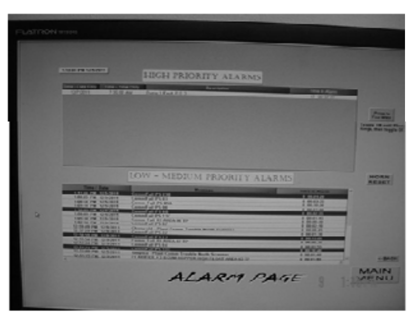
Biosolids Disposal

- Landfill
- As a fuel source
- Land application
  - Some nutrient quality
  - Soil amendment (lime stabilized)

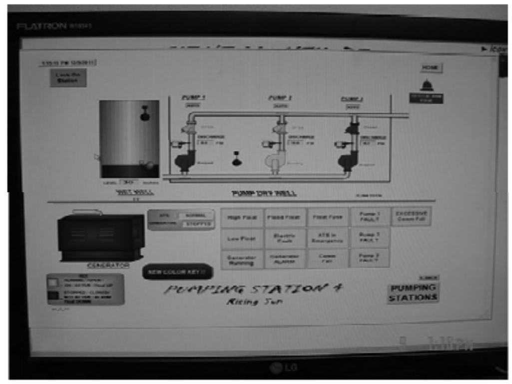
Supervisory Control and Data Acquisition (SCADA)

- Alarms
- Operating characteristics
- Controlling operations

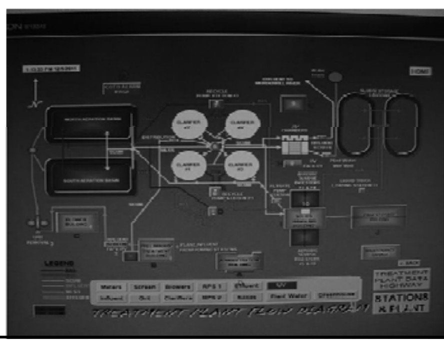
ALARMS



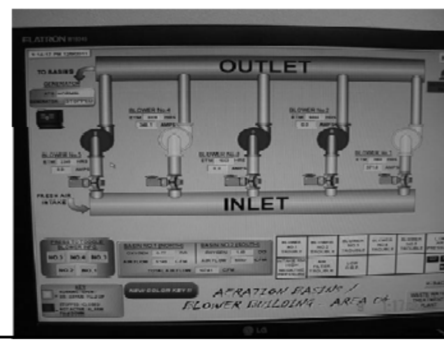
Pump Station Information



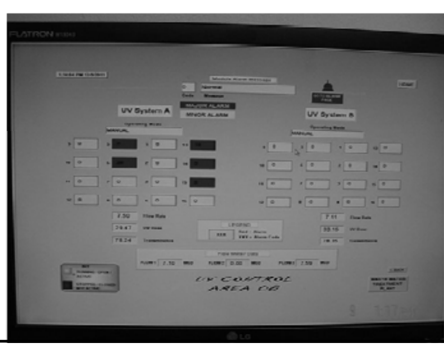
Operating Data



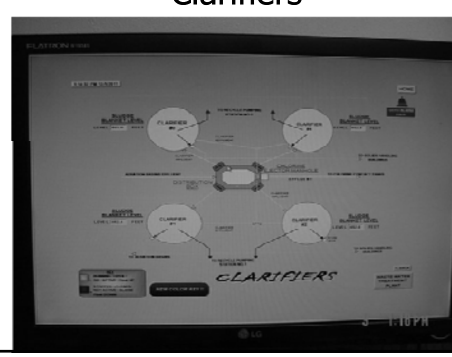
Aeration System



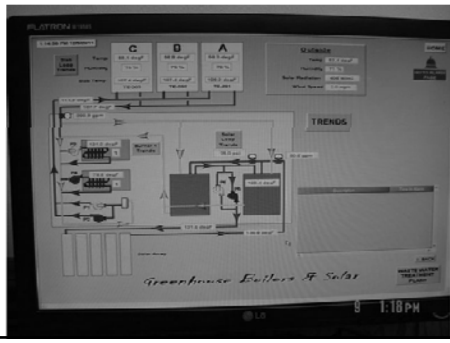
Ultraviolet Disinfection



Clarifiers



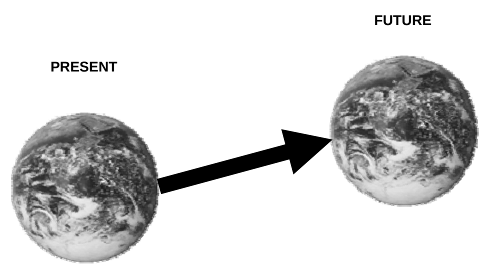
Solids Drying Greenhouses



MAKING A WWTP SUSTAINABLE

WHAT IS SUSTAINABILITY?

SUSTAINABILITY

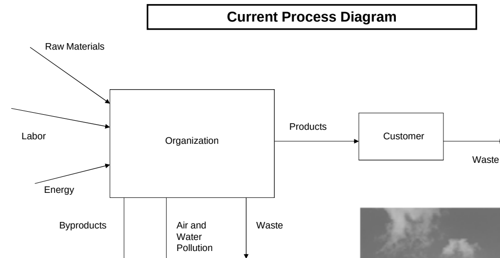


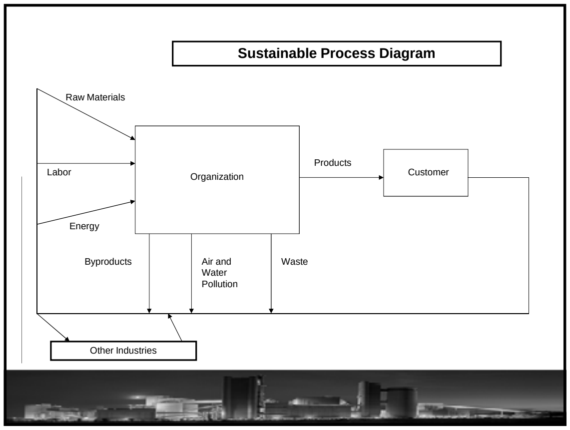
Meeting the needs of the present without

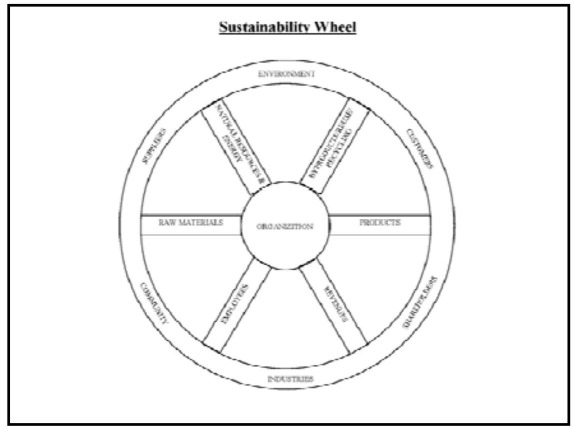
Compromising the ability of future generations to meet their own needs.

Brundtland Commission, 1987

Current Process Diagram



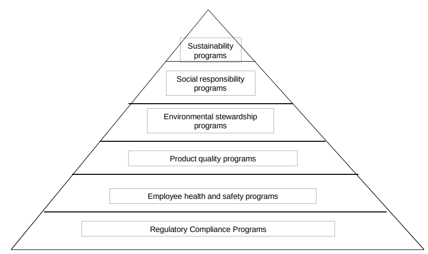




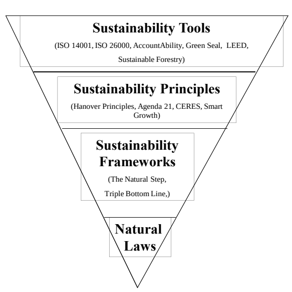
Why Be Sustainable

Reduced energy, wastes and costs	**Differentiating sustainable organizations from others**
Sidestepping future regulations	**Creating innovative processes and products**
Opening new markets	**Attracting/retaining the best employees**
Reduced improper labeling of products	**Reduced legal risks and insurance costs**
Providing a higher quality of life	**Reduced liability from pollutants**
Being closed out of certain markets	**Reduced attacks on an organization's image**
Improving the organization's public and shareholder image	**Reducing supply problems due to raw materials and energy**

Sustainability Pyramid



Sustainability Triangle



SUSTAINABILITY MODELS

Sustainability Models

- Over 50 models
- Types
  - Sustainability principles
  - Sustainable development
  - Sustainable manufacturing
    - Cradle to cradle

Example Sustainability Models

- Ahwahnee Principles
- Hanover Principles
- Ceres Principles
- Bellagio Principles
- Hargrove/Smith Principles
- **AtKisson Principles**
- **Triple Bottom Line**
- **The Natural Step (TNS) Framework**

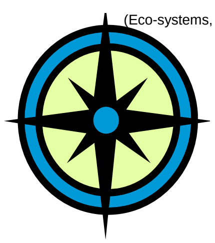
AtKisson Sustainability Compass

Nature

(Eco-systems, natural resources, environment)

Well-being

(Individual health and safety)



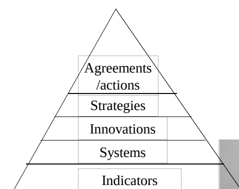
Economy

(Producing things and services)

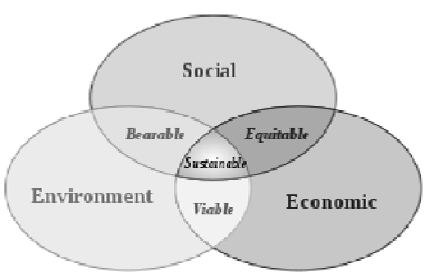
Society

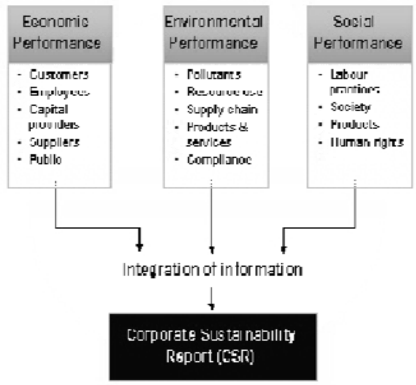
(Social systems, collective actions)

AtKisson Sustainability Pyramid



TRIPLE BOTTOM LINE





THE NATURAL STEP FRAMEWORK

The Natural Step Framework

- Conceived by Dr. Karl Henrik Robert, Swedish oncologist
- First developed in 1988
- Sought scientific confirmation and consensus
- Practiced extensively in Sweden

The Natural Step

- Based on scientific principles:
  - Matter cannot be created or destroyed
  - Matter and energy tend to disperse
  - Material quality can be characterized by the concentration, purity and structure of matter
  - The net increase in material quality on earth is produced by sun-driven processes

The Natural Step System Conditions

In a sustainable society:

- Nature should not be subject to increasing:
  - Concentrations of substances extracted from the earth's crust;
  - Concentrations of substances such as chemicals manufactured by man
  - Degradation by physical means
- Human needs should be met worldwide

In other words

- Minimize what we take from the earth (mining and fossil fuels)
- Minimize what we make (chemicals, plastics and other substances)
- Minimize what we do to the earth (biodiversity, ecosystems, forests, soils, wetlands, lakes and oceans)
- Meet basic human needs (economics, food, shelter, source of income)

Natural Step Objectives

1. Eliminate our community's contribution to fossil fuel dependency and to wasteful use of scarce metals and minerals
2. Eliminate our community's contribution to dependence upon persistent chemicals and wasteful use of synthetic substances
3. Eliminate our community's contribution to encroachment upon nature
4. Meet human needs fairly and efficiently

A-B-C-D Approach

Awareness of what sustainability is

Baseline mapping and inventory of present situation

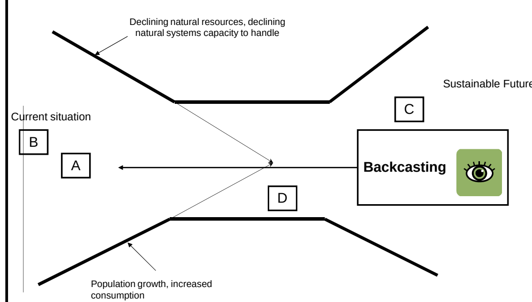
Create clear and compelling vision and solutions

Develop and implement an action plan

Balanced TNS Sustainability Scorecard

Materials taken from the earth's crust	**Man-made materials**
•Reduce the use of fossil fuels •Reduce the use of exotic metals and other materials •Seek renewable energy sources •Recycle all metals	•Reduce the use of non-biodegradable chemicals •Reduce the use of non-biodegradable items •Manufacture biodegradable products
Effects on the earth	**Meet basic human needs**
•Prevent or reduce destruction of habitats, wetlands etc. •Build wetlands and restore forests •Prevent clear cutting and use more efficient design procedures	•Support the community in which reside •Pay a respectable wage and provide benefits •Support local, national and international charities

Sustainability Funnel and ABCD Approach



DEVELOPING A SUSTAINABILITY MANAGEMENT SYSTEM

Sustainability Management System

- Modeled after ISO 14001
- Soon to implement ISO 26000
- ISO 50001 (Energy)
- 17 Basic elements

Elements of an EMS

Environmental Policy	Identifying Environmental Aspects
Legal and Other Requirements	Objectives and Targets
Environmental Management Program(s)	Structure and Responsibility
Training, Awareness, Competency	Communications
EMS Documentation	Document Control
Operational Control	Emergency Preparedness/Response
Monitoring and Measuring	Nonconformance and Corrective Actions
Records	EMS Auditing
Management Review	

Sustainable Element of an ISO 14000 EMS

Environmental policy

Identifying significant aspects

Setting objectives and targets

Developing environmental management plans

Training, awareness, and competency

Measuring progress

Management review

Effective Utility Management

- 10 Attributes
- 5 Keys to Success

10 Attributes

1. Product quality
2. Customer satisfaction
3. Employee and leadership development
4. Operational optimization
5. Financial viability

Attributes continued

6. Infrastructure stability
7. Operational resiliency
8. Community sustainability
9. Water resource adequacy
10. Stakeholder understanding and support

Keys

1. Leadership
2. Strategic business planning
3. Organizational approaches
4. Measurement
5. Continual improvement programs

WAYS A UTILITY CAN BE SUSTAINABLE

Sustainable Activities

- Energy
  - Generation
  - Conservation
- Water
- Biosolids
- Chemical Usage

Energy Generation/Sources

- Solar (PV and passive)
- Wind
- Biomass (Anaerobic Digestion)
- CHP
- Hydro

Energy Conservation

- **Pumps**
- **Geothermal**
- **Wastewater**
- **Blowers**
- **Lighting**

Water Conservation

- Reuse
- Recycling
- Cleaning

Biosolids

- Land application
- Land fill alternate daily cover
- Fuel

Chemical Usage

- Disinfection (Chlorine vs. UV)
- Polymers
- Ferric Chloride
- Nitrification/Denitrification

Kent County Example

Sustainability Management System

- ISO 14001
- OHSAS 18001
- SMS
- Energy MS

Policy

Comply with applicable environmental, health and safety laws and regulations, and appropriate occupational health and safety practices

Have practices that are consistent with the principles of the National Biosolids Partnership's Code of Good Practice.

Improve continually its environmental, health and safety performance.

Readily communicate with interested stakeholders about its environmental, health and safety performance.

Promote pollution prevention, energy efficiency and conservation, and the use of renewable energy sources to the maximum extent technically and economically feasible

Support sustainability efforts that follow the four system conditions in The Natural Step Framework.

SMS Objectives

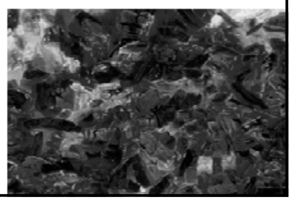
- Reduce air pollution
- Reduce fossil fuel use
- Reduce chemical use
- Improve employee health/safety

Reduce Air Pollution

- Reduce natural gas usage
- Reduce electricity
- GHG inventory
- Change dryer fuels

Reduce fossil fuel use

- Alternate energy
- Passive solar biosolids dryers
- Blower controls
- LED Lights

PV Solar

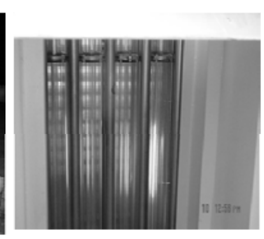

Wind

Passive Biosolids


Reduce Chemical Usage

- Chlorine
- Sulfur Dioxide
- Ferric Chloride
- Lime
- Polymer

UV vs. Chlorine Gas

Improve H/S

- Procedures
- Equipment
- Chemical

More Information

Jim Newton, P.E., BCEE
Environmental Program Manager

Kent County Dept. of Public Works
139 Milford Neck Rd.
Milford, DE 19963

302-335-6000
james.newton@co.kent.de.us