NATURAL RESOURCE AND ENVIRONMENTAL SCIENCES CAPSTONE

A suggested approach to achieving clean water in the Kansas River Basin

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12/9/2010

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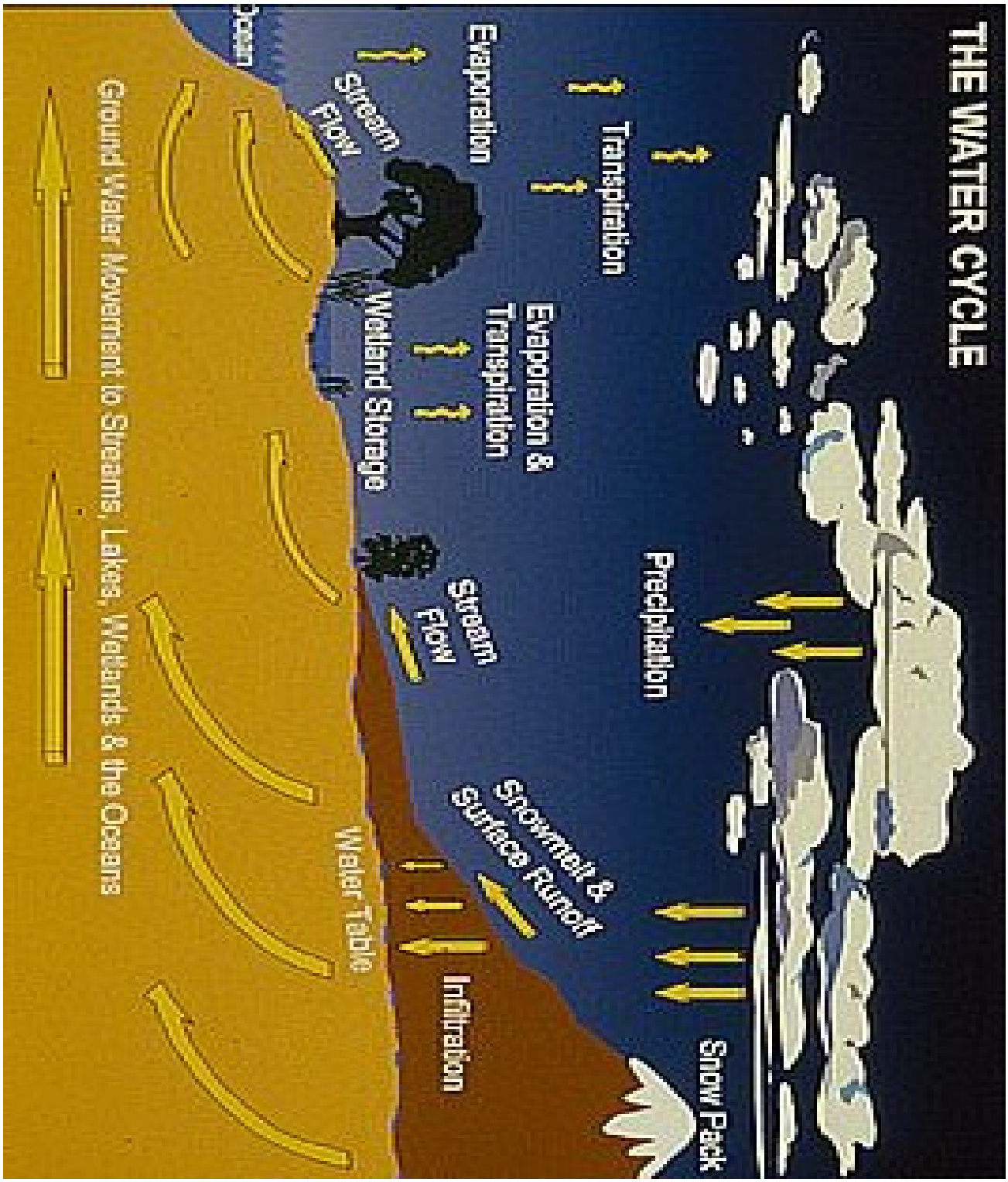
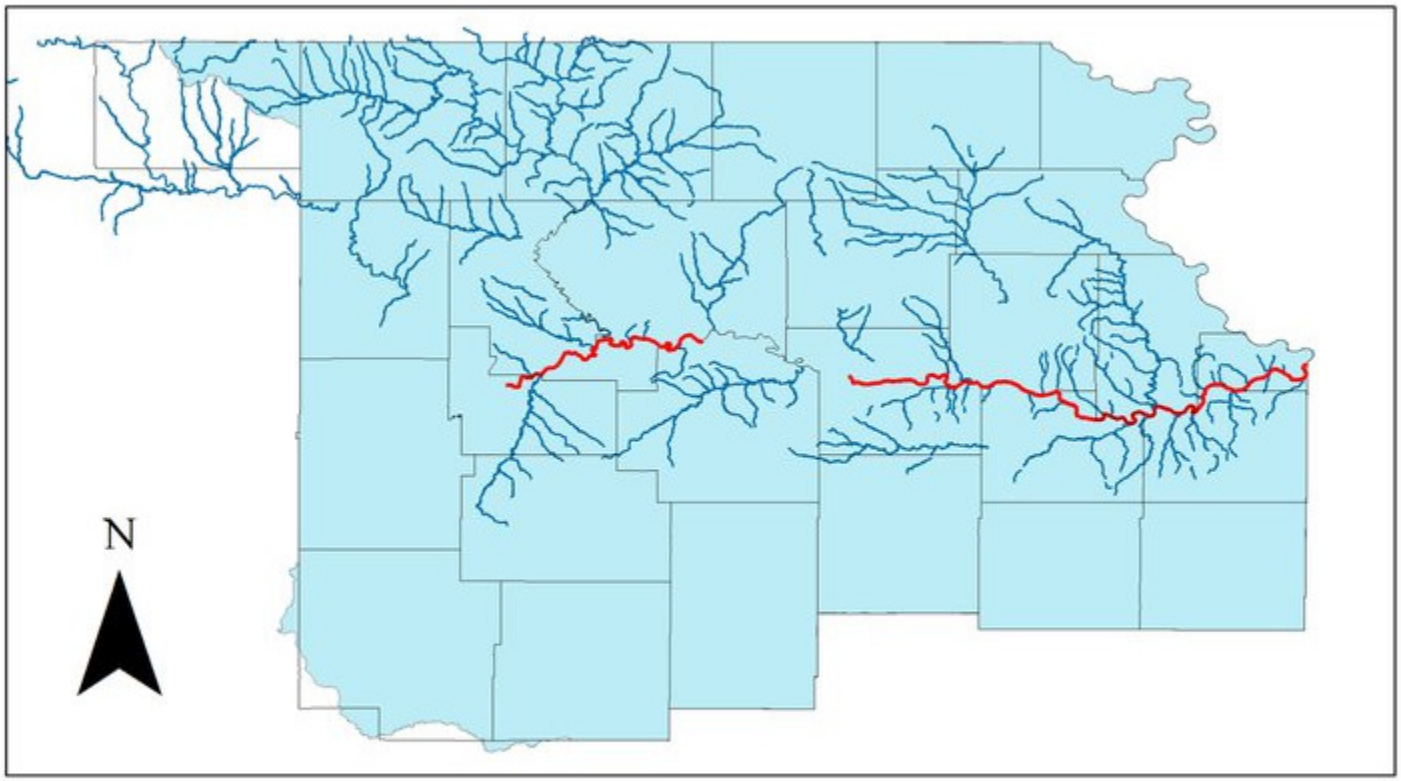


[1] This picture, provided by the EPA displays the movement of water in the water cycle.

[1] (Environmental Protection Agency n.d.)

Area of Reference



Kansas River

Kansas River Basin

0 20 40 80 Miles

Data Provided by: Kansas GIS, DASC

Created By: NRES Water Quality Group

INTRODUCTION

The United States Environmental Protection Agency has composed a document; "Coming Together for Clean Water."[2] This document was intended to advance the water quality movement in the United States. Coming Together for Clean Water was the foundation for this document. Although there have been numerous statements of problems, very little suggestions have been made about solutions. The purpose of this paper is to not only educate, but also suggest how contamination issues along the Kansas River Basin can be controlled and maintained. After reading this document one will have a better understanding of the history which lead to the need for clean water movements and an idea of the most abundant contaminations in the Kansas River Basin from urban and agricultural industries. Suggested Best Management Practices and alternative ways to handle contaminations in the urban area are proposed to help alleviate the strain humans are putting on the Kansas River Basin, the supplier to numerous Kansans water.

HISTORICAL RELEVANCE:

Since the dawn of time, humans have relied on nature to supply them with the proper nutrients necessary for survival. Water, being the main composition of human bodies has become the main ingredient for health and longevity of mankind. With that being said, almost all living organisms depend on the chemical substance; after all, it does make up 70% of the earth. Unfortunately for the people of the world, exploitation of the earth's surface, for other means of survival and comforts, have jeopardized the quality of water mankind puts in their bodies. Because every being on the face of the earth cannot survive without water, respect for the substance is completely necessary. In many cases, Americans take for granted the amount of

[2](United States Environmental Protection Agency 2010)

water available and in regards to that, certain situations found throughout the United States could see it as a nuisance. The lack of care for water systems can be justified when looking at all of the unnaturally occurring changes humans have caused on our own source of life. At one time, water quality was never an issue, but as technology developed, cities grew and agricultural sprawled across the Midwest, diversification in the pure substance became apparent.

Historical Analysis will assist one in understanding the subjected nature of our water systems, why they are contaminated and what precautions have already been implemented to halt further catastrophes. A poem composed by Pare Lorentz, known as "The River"[3], illustrates the dramatic changes humans have instigated on the environment, but also summarizes the dependence mankind has towards water. Although the poem mainly correlates with the Mississippi, the beginning of the piece of art exemplifies how every drop of water flows down its path until the Gulf of Mexico.

Prior to the opening of the Great Plains Region in the United States, the Midwest, especially Kansas, suffered from over-exploiting the land for agricultural uses. Farmers were suggested to plant in variation, plow, and till. At this time in history, agriculture and industrial centers of America were booming. Almost a decade later, the over-tilled land came to a breaking point, pulling the agricultural systems of the United States downward rapidly. The plains people were then hit with the dust-bowl, while the Great Depression and the Stock Market Crash of 1929 lead the country to difficult times. Recovery finally reached the plains through the Resettlement Administration Acts of 1935. At this time in the middle of the 20th Century Americans began realizing how interactions on the environment impact the depended upon earth. The Resettlement Administration, as a portion of the New Deal Act constructed by Franklin D.

[3](Lorentz 1937)

Roosevelt, serves as the foundation to recognize the impact mankind has on the land, and established legislation over industry and agricultural development to ensure America the depression will not happen again.

The legislation passed in the Resettlement Act, was not the only reason America began taking a look on the environment, although it surely helped. New technological advancements were being introduced at rapid speeds and America as a whole was growing. According to the US Census Bureau, the population of the United States was 132,164,569 persons.[4] Today, the population is recorded as 310,728,847 persons.[5] Statistically speaking, that is an increase of approximately 23.5% from the first establishment of environmental issues to the present. The population expansion has led to the environment to be jeopardized once again.

The years of Richard Nixon proved to be quite beneficial to the American quality of the Environment. The most positive change he is best associated with would be the development of the Environmental Protection Agency. The development of this National Agency has greatly influenced mostly positive results when working towards healing the humanly manipulated environment. The EPA's mission statement is "to protect human health and the environment."[6]

The EPA provided a foundation for scientific growth throughout America. First and foremost, the Agency works to educate all persons of the United States on their one and only environment. New issues have risen at a very steady rate as the Earth ages and the population grows. Each little change, caused by one single person, can impact the environment in viscous ways. Because this is the only world we have, it is necessary to come up with alternative systems to help regulate the quality of water. For many of these issues, background and

[4](U.S. Census Bureau 1940)
[5](U.S. Census Bureau 2010)
[6](United States Environmental Protection Agency 2010)

intensive studying must be accomplished to understand where contamination problems come from.

This document has been composed doing various researches on the water quality issues in the state of Kansas. It is intended to advance education to those who do not understand all the aspects which are involved in the water quality of the Kansas River, many Kansans obtain their most valuable ingredient of life--water. It also goes into great detail about the most abundant contamination sources in the riverbed by focusing on the two types of communities in Kansas: Agriculture and Urban. The final portion of this document provides the reader with suggestions of how to generate a better water quality in the Kansas River and its tributaries. The foundation for this research was provided by the Environmental Protection Agency's Clean Water Act which was initially composed in 1972. Majority of this document has been composed as a reflection and response to "Coming together for Clean Water "the EPA's Strategy for Achieving Clean Water.

POINT SOURCE POLLUTION:

The Clean Water Act of 1972 has put into practice pollution control programs, for example, setting up wastewater standards for industry. "The CWA made it unlawful to discharge any pollutant from a point source into navigable waters, unless a permit was obtained." [7]

There are many different kinds of pollution. Two of them are point source and non-point source

[7](United States Environmental Protection Agency n.d.)

pollution. "Point source pollution is contamination that enters the environment through any discernible, confined, and discrete conveyance, such as a smokestack, pipe, ditch, tunnel, or conduit."[8] The Environmental Protection Agency (EPA) is responsible for regulating point source pollution.

In water systems point source pollution may come from municipal sewage treatment plant and industrial plant discharge. The effects of pollution from municipal sewage treatment plants can be a serious health hazard. They may introduce oxygen depleting nutrients and/or pathogens. Industrial point source pollution may introduce toxic chemicals and/or heavy metals.

The National Pollutant Discharge Elimination System (NPDES) is a permit program, under the direction of the EPA, which has authority over water pollution. In 2001 there were more than 400,000 facilities required to have permits.[9] Through the CWA non-storm water permits usually come with numeric effluent limitations, these numeric limitations enumerate the greatest pollutant load or concentration acceptable in the discharge. Exceeding these limitations is considered a violation and the permit holder will most likely be fined. Permit holders must periodically test samples of their discharge and submit Discharge Monitoring Reports. Storm water permit holders must prepare a Stormwater Pollution Prevention Plan and put into operation best management practices. Every five years NPDES permits are required to be reissued.[10]

The EPA manages effluent limitation in two ways: through technology based controls and water-quality based controls. Industrial discharge limitations are set based on technology. The minimum standards are supported by the currently obtainable treatment technology and

[8] (Leduc 2010)
[9](United States Environmental Protection Agency 2001)
[10](Wikipedia 2010)

pollution prevention practices. Water-quality standards are "scientifically defensible standards that ensure protection of designated uses of receiving water."[11]

Municipal sewage treatment plants are used to remove solids and organic matter and are disinfected to kill bacteria and viruses from waste water. After this has been done it is then generally discharged into surface water. The waste water being discharged back into the surface water generally has a reduction in dissolved oxygen but nutrients such as phosphorus are not removed. This can lead to an algae bloom or increase in other organisms, which in turn leads to lower dissolved oxygen content. An increased algae bloom can be detrimental to aquatic life and create aesthetic problems for the local community's water drinking supply.

In many municipal waste water systems both stormwater and sewage waste are combined. During heavy rain fall the increase in volume of stormwater can cause several serious problems. In many cases the treatment plants can be overwhelmed with the accumulation of precipitation and sewage waste and consequently be forced to bypass large quantities of untreated waste water into surface water.

The Kansas Department of Health and Environment (KDHE) is responsible for issuing permits for NPDES. Also the state of Kansas is responsible for establishing Total Maximum Daily Loads (TMDL) under the Federal Clean Water Act for all its rivers, lakes and other surface waters. "According to the Kansas Department of Health and Environment TMDL's are quantitative objectives and strategies needed to achieve water quality standards."[12]

[11](United States Environmental Protection Agency n.d.)
[12](RiverKeeper n.d.)

RUNOFF:

The Public Discussion Draft of the EPA's Strategy for Achieving Clean Water states "EPA's approach focuses around our two thematic lines: 1) healthy watersheds, and 2) sustainable communities…"[13] To better understand the contamination issues it is important to understand the transportation system. Although there are various ways to pollute water the most common is runoff. Runoff can be defined as the water from precipitation that flows over the land rather than being absorbed into the ground. After flowing over the land, the water will then join a water transportation or storage device such as a lake, stream, or river.[14]The variables that affect runoff quantity include the intensity, duration, and distribution of precipitation. The initial precipitation that falls is absorbed and stored in the vegetation and soil. The vegetation allows for a path into the ground. Water that reaches the ground infiltrates the soil until the soil is saturated, or reaches the infiltration capacity. Infiltration capacity is dependent on the texture, structure, and moisture content of the soil. Then, surface puddles are created and depending on the slope of the land, water may flow in any direction. The amount of water that runs off the site is designated as the run off quantity.

Runoff calculations at any time can be made with the application of the following equation:

$$\mathrm{SRi} = \mathrm{S}(\mathrm{pi} + \mathrm{SDi}^{-1} - \mathrm{Fi} - \mathrm{SDm})$$

Where: Ri = surface runoff (mm) for the time segment

SDi = Surface storage and detention (mm) for the time segment

[13](United States Environmental Protection Agency 2010)
[14]((Term) 2010) (Morin 1993)

SDm =maximum surface storage and detention (mm)

Fi = the potential infiltration (mm) of any time segment t_i(mm)

pi = rain intensity

It is more generally understood by the runoff balance equation:

$$\text{Runoff} = \text{Rainfall} - \text{Infiltration} - \text{surface storage}$$[15]

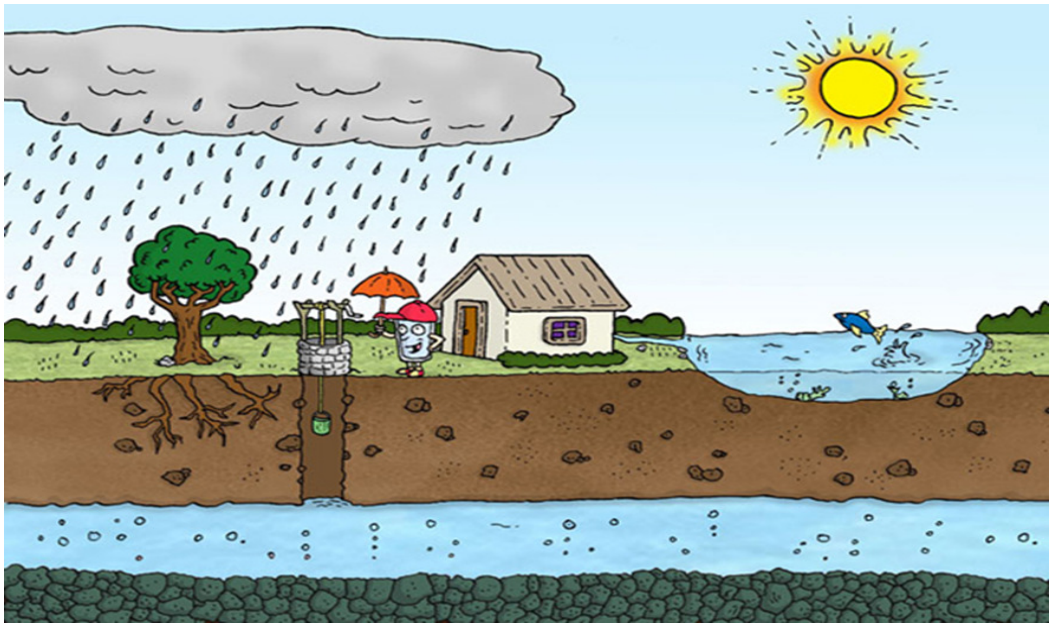
As noted above, the runoff quantity is affected by the infiltration capacity. When urbanization occurs and large areas of soil are replaced with pavement and concrete, the runoff increases greatly. This is due to the fact that, other than pervious pavement, concrete and pavement are impervious. Impervious surfaces do not allow infiltration of water to the soil below. Most all materials that are used in urbanization are impervious surfaces including those used in buildings and roads. The only conventional space in developed areas that is pervious is green space. Green space includes grass, trees, and other vegetation, preferably local and native in type. In site development, an increase in the amount of green space can not only make it more aesthetically appealing but decrease the amount of runoff.

In the case of urbanization and development, not only does the site have to be developed for its intended use, but also constructed hydraulically due to the increased runoff. Hydraulic design is based on the expected water quantity of an area. Flooding is avoided by the use of structures such as culverts, open channels, and storm sewer pipes as well as impoundment structures such as retention or detention ponds. Retention and detention ponds allow for the capture of water before exiting the site and have two major benefits: providing a natural filtration

[15](Morin 1993)

system through separation and decreased rate of flow through the slow discharge of water from the pond. New advances in design can allow for the use of pervious pavement to create a below surface retention or detention storage when space does not allow for one conventionally. Traditional retention and detention ponds, although meant for water control, can make a site more aesthetically appealing and increase the amount of green space.[16]

Urbanization is an inevitable occurrence with our continuously growing society. The high construction rate of buildings, roads, and other urban features increases the amount of impervious surfaces. Surface water runoff is a good indicator of urbanization and its impact on water resources.[17] Natural landscapes, such as forests and grasslands have a porous surface that allows rainfall to infiltrate into the ground at a slower rate versus an urban area. Therefore the rooftops, parking lots and roads created by urban development prevent rain and snowmelt from filtering into the ground due to the removal of surface vegetation and excavation of soils.[18]



[16](National Ready Mixed Concrete Association 2010)
[17](United States Geological Survey 2009)
[18](United States Environmental Protection Agency 2008)

As shown in an illustration by the Environmental Protection Agency, in the categories of evapotranspiration , runoff, shallow infiltration, and deep infiltration, natural ground cover is has a higher percentage rate in everything but runoff versus nonporous surfaces. Natural ground cover versus 75-100 percent impervious surface cover provide results such that evapotranspiration is 40 and 30 percent, runoff is 10 and 55 percent, shallow infiltration is 25 and 10 percent, and deep infiltration is 25 and five percent, respectively. The construction of sites does not allow percolation of the water down through the soil to the aquifer, which may reduce groundwater recharge, thus lowering the water table.[19]It then remains on the surface and rapidly runs off in excessive volumes to adjacent rivers.[20]

Humans are the most significant source of water pollution in urban areas. There is an increase in pollutant loads due to urbanization. Motor vehicles are a large contributor to water pollution and cause contamination from oil, grease, and toxic chemicals. Construction and maintenance of roads and building can lead to contaminants such as sediment, road salts, and heavy metals from roof shingles. Nutrients, viruses and bacteria in drinking water may result from improperly functioning septic systems and pet waste when not managed properly. An improper use of pesticides and fertilizers on household lawns and gardens should be monitored to decrease the amount of pollutant. All these things affect the aesthetics and health quality of drinking water supplies, make recreation areas unsafe or unpleasant, and are harmful to fish and wildlife.[21]

Although the previous information correlates with respect to the urban community, runoff is also a leader of contamination in the agricultural industries as well. Different forms of

[19](Balch, Phill 2010)
[20](United States Environmental Protection Agency 2008)
[21](United States Environmental Protection Agency 2008)

chemicals are applied to fields to better stabilize the growth of the crops. As soon as a precipitation occurs, these chemicals are washed away and as Pare's poem states;

"…Spring and fall the water comes down, and for years the old river has taken a toll from the Valley more terrible than ever she does in flood times. Year in, year out, the water comes down from a thousand hillsides, washing the top off the Valley. For fifty years we dug for cotton and moved West when the land gave out. For fifty years we plowed for corn, and moved on when the land gave out. Corn and wheat; wheat and cotton ... we planted and plowed with no thought for the future ...And four hundred million tons of topsoil, and four hundred million tons of our most valuable natural resources have been washed into the Gulf of Mexico every year."[22]

The runoff occurring in urbanized areas is very similar to that of agriculture; the only real difference between the two is what is being transported. Readers can think of runoff as the pollution highway between land and water.

EROSION AND SILTATION

Erosion of land is a natural process; it is the rate of erosion that is cause for concern.[23] High rates of erosion occur in wet, high elevation regions since there is a relatively constant flow from these regions. In the Kansas River basin, erosion rates are different between rural and urban areas due to their different influences on the river.

Urban siltation is caused my many things. Siltation fills the streams and water ways throughout the Kansas River basin. In these urban areas, the siltation largely comes from construction sites. Urban areas usually have continuous growth which leads to continuous

[22] (Lorentz 1937)
[23](Douglas n.d.)

construction. Construction in of itself changes the land and it also changes the nearby lakes and streams.

The main contributor to the siltation in the Kansas River basin in urban areas is construction. The grading and earthwork associated with construction projects requires the moving of soil that has been sedentary for a long period of time. The loosened soil can be picked up in the run-off. This water carries silt from these areas and while moving downstream, finds its way into the Kansas River. On its journey, the water deposits the silt and sediments along the banks at different points along the river. This silt fills the waterways and eventually changes the waterways. Because construction projects take months or potentially years, there is a lot of time for extended amounts of erosion and siltation to occur.

There are many methods to combat this problem of siltation from construction areas. Regulation is what many cities have implemented in an effort to control erosion and sediment. Many cities in the Kansas City area have adopted regulations for controlling erosion and sediment. This is very important because the Kansas City area is one of the largest urban areas along the Kansas River. After the river has traveled through the state, by the time it reaches the Kansas City Metro area, the cities have to work hard not to add any additional silt to the water.

This creates a challenge for local communities and suburbs around Kansas City because it is not necessarily the cities fault for what has happened to the river before it reaches their area. Cities such as Overland Park and Lenexa have Erosion and Sedimentation control manuals that describe the regulations that construction sites have to follow to prevent unnecessary erosion and sedimentation.

The biggest portion of this prevention is silt fences. These are fences established around the perimeter of a construction site to contain any soil run-off from leaving the site and entering a waterway. These construction sites cannot begin their projects until the site has passed a satisfactory inspection to prevent erosion.[24]This practice is something that can be implemented elsewhere in order to protect the water.

Siltation from urban areas in the Kansas River basin also comes from the practice of dredging. Dredging takes the sand from the river bed to be used in construction and materials. Although it is partially accurate to say that dredging would be a way to solve the siltation issue and not cause this problem, it's not entirely correct.[25] While dredging does remove sediment, its main purpose is to keep the river navigable. In the process if dredging, not all sediment is removed. Some of what is removed is washed away with the current or when being transferred falls back into the river creating more siltation just further downstream.

There are several dredging stations located on the Kansas River, with a few located outside of the Kansas City Area. The most efficient way to reduce the siltation caused by dredging is to better engineer the dredgers themselves and better the practices of dredging to reduce the siltation it causes. One of the ways to improve the actual dredgers is to develop a way in which once the material is dug up from the bottom of the river, the loose sediments will stay and not travel with the stream.

Siltation causes many disturbances in the water quality of the Kansas River. Not only does siltation limit the water in the waterway and cause changes to the flow of the river, but siltation also causes changes in the aquatic life of the water. The whole ecosystem of the river is

[24](American Public Works Association 2010)
[25](Kaw 2010)

disturbed by siltation. The changes that the sediment makes to the river changes the way the fish live in the water and all other living things in the river. This is why siltation and runoff are pollution issues that impair the water quantity and quality of the Kansas River basin.

URBAN ALTERNATIVES:

One way to decrease the effects urbanization has on the increased runoff is with the use of pervious or permeable concrete. Pervious concrete is a newer construction materials concept and is still being tested in regards to what situations it is more useful. Pervious concrete is similar to the commonly used material; however, the composition has larger aggregates and little to no sand, allowing for large voids within the material for water flow. Void can typically compose 15 to 25% of the concrete volume and allows for 480 in/hr. (0.34 cm/s, 5 gal/ft^2/min, 200 L/m^2/min) infiltration rates.[26] Materials used for the base underneath the concrete can also be adjusted to increase infiltration. The use of gravel of sand as opposed to clay will allow for water to more easily travel to the soil through air voids. Allowing the precipitation to infiltrate the concrete and then into the soil can recharge the groundwater table and decrease runoff. Although this type of concrete is much better for the environment than typical materials, it does not have the strength necessary to support many transportation corridors. It is currently being utilized mainly in the construction of sidewalks and parking lots.

Storm drains have been produced to help direct large amounts of runoff from nonporous surfaces to nearby waterways. With these storm drains come the various pollutants that stem from urban runoff and may include sediment loads from construction sites among others. Along with the contamination of the water, the gain in underground speed and the large volume of

[26](National Ready Mixed Concrete Association 2010)

runoff cause a higher rate of erosion on stream banks, damaging its vegetation and harming the aquatic habitat. Storm drains may also carry high water temperatures which can also affect the health and development of marine life. Such high river flows during times of flooding can result in a low enough stream flows in dryer months in that native fish are unable to survive.[27] Flood control programs have therefore been created and include "strategies to minimize peak flows and reduce channel velocities."[28] Some other applied techniques include holding ponds or detention basins that serve as a buffer for runoff and riverine peak flows. Additionally the use of energy dissipaters in channels has been used to reduce stream velocity. [29]

When managing urban runoff, the city and the general population should plan to use an effective mix of practices to control sources efficiently and still meet water quality goals.[30] Homeowners can do numerous things around the house to regulate the amount of pollutants entering water sources. For instance, they can use the natural vegetation and mulch when landscaping versus a higher maintenance lawn. When building driveways and sidewalks, households can use porous concrete options as mentioned above to maximize filtering of storm water. Homeowners should also use a sweeping method on their property, rather than using a hose to clean excess debris. Proper use, storage, and disposal of chemicals and picking up after pets are other easy ways to manage runoff. [31]

In new developments, city planners can use strategies such as low-impact development to conserve natural areas, provide structural controls, and publicize pollution prevention. By maximizing surface roughness on construction sites and increasing infiltration opportunities and

[27](United States Environmental Protection Agency 2008)
[28](Balch, Phill 2010)
[29](Balch, Phill 2010)
[30](Balch, Phill 2010)
[31](United States Environmental Protection Agency 2008)

flow paths surface runoff, can be reduced. With properly planned development runoff volume is not increased and stream channels do not undergo radical adjustments. [32]The most costly solution in controlling runoff is doing so with existing development. One way to manage runoff is through high efficiency street sweeping. Not only is it aesthetically pleasing, but it is also safer for road traffic and increases water quality. The city should recognize high priority pollutants and use various reduction opportunities to control the contamination of drinking water.[33]

There are numerous ways to reduce storm water runoff and costs through low-impact development practices. Storm water is a leading source of pollution in the United States for all water body types. "Most storm water runoff is the result of man-made hydrologic modification." [34]Some practices would include conservation designs like cluster development, reduced pavement widths on sidewalks and driveways, shared driveways and more. Infiltration practices as mentioned before include basins, trenches; porous pavement, rain gardens and other vegetation treatment reduce impacts of storm water runoff. A few other strategies include runoff storage practices (i.e. rain barrels, cisterns, green roofs), runoff conveyance practices, where examples of this are eliminating curbs and gutters and creating long flow paths over landscaped areas and filtration practices such as bioretention and vegetated filter buffers/strips. Low impact landscaping is another strategy that should be used frequently. Planting native, drought-tolerant plants and reforestation are great ways to reduce resulting storm water costs.[35]

Mitigation strategies on impacts of urbanization on water resources should be implemented and the local governments should raise awareness of impervious surfaces and their

[32](Balch, Phill 2010)
[33](United States Environmental Protection Agency 2008)
[34](United States Environmental Protection Agency 2007)
[35](United States Environmental Protection Agency 2007)

relationship to the water cycle, their impacts on waterways, and how the relationship can be used to better community planning and site design. Use of storm water impoundments also helps decrease water runoff and the movement of contamination. By placing regulations and controls and the location and amount of impervious surfaces an area can have can lessen damage that contaminants can do. [36]

One future goal would be to implement a cost effective program that is sustainable. The cities should enforce urban runoff water regulation and the municipal code. Also by providing the best management practices to communities, everyday activities will furthermore decrease the amount of pollution entering runoff. Local governments should outreach to develop community awareness and environmental stewardship and work with the public to protect and preserve water resources and provide continuous pollution prevention education.[37] And as mentioned before, it is more beneficial to try and understand and work with the river and stream's natural tendencies as opposed to attempting to control them.

AGRICULTURE AND BEST MANAGEMENT PRACTICES

The initial response addressing the water quality issue in the Kansas River bed is to understand what pollutants are being deposited into the system as well as, where the deposits take place. In many cases, the contaminations identified downstream can be from the agriculture community in the rural portions of the river's tributaries. Due to the contamination issues and the need for farmers and ranchers to support themselves, a middle ground needs to be met to alter the hazards yet not harm the farmers and ranchers. The Environmental Protection Agency has identified numerous contamination sources which come from the agriculture industry. Making

[36](United States Geological Survey 2009)
[37](United States Geological Survey 2009)

statements about issues and processing regulations without taking into account the negative results of the process will enviably harm people even more so then the pollutions at hand. In no way will the water quality issue of the Kansas River Basin be solved by simply regulating. It is without a doubt a problem, but one must understand there are two sides to every story. Instead of regulating and punishing farmers and ranchers who contribute to the contamination problem, take an attempt to propose ideas which will benefit them, as well as the environment. In all reality, regulations put on the farmers will eventually harm all beings since they are the proprietors of multiple food sources. One must look for compromises between the old-fashioned farming systems as well as the changing environment to successfully handle the issues at hand.

Establishing changes in the agriculture community becomes a difficult task for many reasons. With an average of 32.9 people living in Kansas per square mile[38], challenges arise when trying to control such rural areas of the state. When looking at the tributaries of the Kansas River, it is easy to see how pollutants can become hazardous due to the locations itself. In this case, farmers and ranchers alike need to work on developing new types of land use systems so the water quality can be better restored, while the government provides suggestive assistance ideas and examples. The following information has been collected and researched thoroughly. These new types of systems could help benefit the farmers by saving them money and enhancing the quality of water the citizens of Kansas rely on as means of survival. In an environment such as Kansas, drastic changes in the season's weather patterns can stimulate geomorphological evolution. This change impacts the cultivated areas that people depend on for crops. Whether it is from extensive exploitation of the earth or natural causes, humans need to better utilize the soils to promote longevity for the future. There are numerous methods to retard the natural

[38](U.S. Census Bureau 2010)

changes such as erosion or deposition; for example buffer strips, terracing, and grassed waterways. Practices such as these used to reduce erosion and depositions are referred to as Best Management Practices (BMP's)

BUFFER STRIPS:

More recently the agriculture systems of Kansas have been implementing buffer-strips in proximity between the water body and the cultivated lands. This practice should be used more throughout not only in the Kansas River Basin. As the surface of the earth changes either naturally or by human interaction with the environment the quality of water becomes jeopardized. It is common knowledge; the most fertile soils are those along bodies of water. This location yielding the most substantial crops comes at a price as the earth changes. Eventually the chemicals used to protect the crops seep into the water by leaching and can run off the field though erosion, affecting water quality in a negative matter. An approach has been

tested and put into use in the past to help slow the chances of the water being polluted by the herbicides. This idea is known as a buffer strip.

The Natural Resource Conservation Service defines buffers as "small areas or strips of land in permanent vegetation, designed to intercept pollutants and manage other environmental concerns."[39] In many cases, the buffer strip is constructed around the perimeter of the cultivated land to keep the contamination sources out of the water. More alterations have been made when dealing with buffer strips to better understand how contamination can decrease using various buffer methods. A study conducted at the University of Missouri shows different uses of native grasses yield higher results when dealing with buffer strips. In this study, research was conducted by developing riparian buffer zones using switch grasses and gamma grasses to reduce run-off enriched with Atrazine (a very common herbicide in corn production). This experiment measured the amount of atrazine which was infiltrated through each different type of plant or riparian buffer. The conclusion to the experiment shows the establishment of riparian buffers full of natural grasses slows, if not completely halts transportation of chemicals which have become water quality concerns.[40]

[39](NRCS n.d.)
[40](Lerch, Robert N. 2009)

TERRACES:

Another way to help stabilize the water quality issue is the instillation of terraces. In some cases, terraces occur in nature, but it is possible to create a man-made terrace as well. The natural terrace system occurs as river waters rise and sink over a substantial period of time. Eventually, the waters carve out portions of the land exposing new surfaces as points of erosion, but creating more of a barricade between tillable soils and the river. The distance between the river and cultivated land works well to slow, if not completely stop water contamination caused by agriculture. In all reality, the more terracing established, the greater the reduction of contamination.

Although terracing can occur naturally, the idea of installing manmade terraces helps cropland from not being naturally manipulated by the earth's rapid changes. Depending on the composition of the terracing, the landowner can benefit in various ways. In some terrace systems stones have been used. Generally, the stones of choice are those which are native to the

area of interest. In Kansas, majority of the natural stone is limestone or sandstone. When installing an artificial terrace, many constructors chose to use a rip rap method. Rips rap is a compilation of stones which are then held together by a concrete type mixture, creating very non-porous barricades on the slope of the riverbanks where waters can be most vulnerable to pollutions. The rock type and amount of concrete used to hold the stones together all determine how beneficial the terracing will be to the harvested lands nearby. For example, a stone which has a high porosity will take in more run-offs, but if it is too porous, the run-off from cultivated land (which is housing contaminations) will pass through leaking into the topsoil below. Eventually the run-off will transport to the water table if the correct composition of rip rap is not used.

Another popular way to terrace the land is to use the topsoil itself. In this system, terraces are installed along the river or water system; allowing enough distance between the each layer in the terrace for rows of crops. This system is pretty beneficial when the areas of high fertility are limited. The transportation of chemicals and other sediments into the river system becomes more risky due to the extent of the terracing and the effects nature can have on the land. In many cases, the terrace at the bottom will become the most exposed to the water nearby. With the chances of ten year floods, those establishing terraces need to plan ahead and make sure the slope they chose to install terraces on will not further expose the crops to flood waters which will ruin the crop yield and also spread pollutants into the river system.

Terraces are commonly used in Kansas not only on agricultural land directly by rivers and other water sources but on any agriculture fields with slopes. The terraces are usually built parallel to one another across the slope of the field. This reduces slope length while retaining runoff to conserve moisture. Stopping the runoff not only stops sediment erosion but it will stop

chemical and nutrient runoff as well. Installing these terrace systems in all sloped agricultural land will greatly reduce the amount of runoff into open water systems. Even if the field is not close to a water system it will still have an impact on the total watershed. That is why it is so important to promote a proper best management practice using terraces to farmers. It will not only increase their land use but help the overall health of the watershed they live in.

GRASSED WATERWAYS:

Grassed waterways are another proven BMP used to reduce erosion and sediment runoff. In agricultural fields grassed waterways can be established in areas where water naturally runs through the field. "A grassed waterway is a natural or constructed channel established to suitable vegetation for safer water disposal." [41] This helps stop the transport of sediment, nutrients, and chemicals from running off the field and eventually ending up in open water systems. Another benefit in using grassed waterways is they help establish a wildlife habitat in the crop ground.

[41](United States Department of Agriculture, Natural Resources Conservation Service n.d.)

Grassed waterways are generally inexpensive and easy to make but not all farmers like to use them as they take away acres from their field that could be used for a cash crop.

To fully utilize buffer strips, terracing, and grassed waterways in agricultural practices all three should be used together when needed. Using all three BMP's when needed will maximize efforts to minimize erosion and sediment loss on agricultural lands. Convincing farmers to use these practices will not only reduce their soil loss and increase their nutrient use but will help water quality by reducing their contribution to nonpoint source pollution. Eutrophication. The most common ways of convincing farmers to implement best management practices is through education, cost share and regulations. Education for farmers can begin as simple as an extension agent explaining the benefits of practice as well as government programs such as the National Resource Conservation Service, which hosts field days for producers. Cost share programs, such EQIP payments, can help to reduce cost to the produce creating incentive for implementing practice that help keep water clean. Regulations are used in order to make sure practices are being used that allow for fewer pollutants into waters. An example would be the regulations on confined animal feeding operations and there land application fields.

When proper BMP's are not used on farmland it will result in runoff and erosion that can have detrimental effects on the surrounding open water systems. One major problem experienced in the Kansas River watershed is Eutrophication. "Eutrophication is the over enrichment of aquatic ecosystems with nutrients leading to algal blooms and anoxic events."[42] In the Kansas River watershed nutrients play a major role in water quality. Eutrophication simply is when a water body receives too much of a nutrient in most freshwater cases phosphorus is the most limiting ingredient. Meaning when phosphorous (or the most limiting nutrient) is added to

[42](Carpenter 2005)

the water ecosystem it allows for aquatic plants and algae to grow rapidly. These plants and algae eventually die off and in deception use oxygen create water ecosystems which have low dissolved oxygen. Low dissolved oxygen will cause fish kills and decrease biodiversity of fish and plants in the ecosystem. "This research has led to understanding of Eutrophication, a significant environmental problem. Consequences of Eutrophication include excessive plant production, blooms of harmful algae, increased frequency of anoxic events, and fish kills. Economic losses attributed to Eutrophication include costs of water purification for human use, losses of fish and wildlife production, and losses of recreational amenities. Eutrophication has become a global problem that is likely to intensify in coming decades because of increases in human population, demand for food, land conversion, fertilizer use, and nitrogen deposition." [43]Eutrophication can be a cause for turbidity, foul odor and foul tasting water.

Sources of nutrients can enter water by two main sources, point and non-point. Point sources are source that directly discharge into water. An example of a point source would be a waste water treatment plant, or factory that uses and discharges used water. An example of a non-point source would be agriculture field runoff. The Clean Water Act began the National Pollutant Discharge Elimination System or NPDES program. This program creates a system that permits point sources of pollutants; these permits allow them to discharge only regulated amounts of pollutants. In the Environmental Protection Agency's Public Discussion Draft-August 2010 a statement is made about the current sources of needed control. "Sources of these stressors vary regionally, but the main national sources of water degradation are: agriculture, storm water runoff, habitat, hydrology and landscape modifications, municipal waste water, and

[43](Carpenter 2005)

depositions. EPA's strategy must meet these shifting needs and priorities." [44]In this portion of this paper will mostly cover agriculture's role in meeting water quality standards.

"The role of agriculture in the Eutrophication process has rarely been clearly defined, largely because anthropogenic sources are often the major and more easily controlled source of phosphorus. In addition, phosphorus losses in land runoff are difficult to quantify due to their diffuse nature. These losses of phosphorus emanate from a number of source areas within the landscape and their amount, form, and timing are very variable as a result of short-term and often unpredictable changes in hydrological conditions and farming practices, including crop rotations, the applications of fertilizers and manure, or the movement of animals from on field to another."[45]Nutrients are a very important part of farming and are necessary for proper crop growth; however when these nutrients leave the soil, they can end up in water and cause Eutrophication. Some farming practices, such as conventional till, plow or till the land continuously leaving exposed soil to environment. This exposed soil is more prone to runoff. Runoff from the soil can contain nutrients bound to the lost soil particles as well as the soil solution can contain nutrients that can enter the water. Other than just nutrients, pesticides and herbicides applied can also be lost into the water as well.

Increasing infiltration and increasing crop residue on the field will decrease runoff. Farming in a no till or conservation till, will allow for improved soil structure and increase water and nutrient holding capacity in the soil profile. Other ways to decrease runoff is to decrease the slope of the landscape. This can be accomplished by building terraces. Terraces allow for small, shallower slopes that will allow for water to decrease movement and infiltrate into the soil.

[44](United States Environmental Protection Agency 2010)
[45](Sharpley, Foy and Withers 2000)

Grass buffer strips at the edges of fields and the near water ways with in the field can increase infiltration of water and nutrients into the grass and slow water down allow for infiltration. Taking soil tests and properly applying nutrients based on crop needs will decrease losses to runoff. Split applications of nitrogen can help decrease nitrogen losses by applying when the crop needs it. Contour farming involves farming in curves, rather than straight up and down, this practice can slow water movement. Wetlands can help to contain water loss with runoff and allow for a decrease of nitrogen and phosphorus. On rangelands, keeping cattle away from water will decrease any nutrients from cattle getting into the water. Placing watering toughs, mineral block, wind beaks and feeding areas away from water will allow for cattle to not be encouraged to enter water.

Confined Animal Feeding Operations are point sources of pollutants and are permitted; CAFO's must contain all water and manure produced on the CAFO. This leaves CAFO's with wastewater and solid manure to manage. Most of CAFO's lands apply their nutrients to their own crop land. CAFO's are required to maintain a nutrient management plan. This plan says what will be applied to each field, and what is allowed to be applied to each field based on runoff equations, current soil tests and crop growth. These nutrient management plans are approved thorough the Kansas Department of Health and Environment. Many of these CAFO's have high phosphorus and nitrogen from application of wastewater and manure. Many of these fields are allowed to apply phosphorus up to 1.5 half times the crop recommendation, this creates an excess of phosphorous in the soil and can lead to increase of losses in runoff. "One of the main challenges to sustainable P management in agriculture is balancing P inputs in fertilizers and feed with P outputs in farm produce. In areas where large numbers of animal feeding operations are present, manure P, once considered a resource, is increasingly seen as a waste. Consequently,

farmers often underestimate the P content of manure in planning their fertilizer P requirements, leading to surplus P in the soil."[46]

FECAL MATTER:

Fecal matter has been showing up in the Kansas River systems and reservoirs affecting the water quality. Some of this has been due to small animal operation that are not monitored and rangeland grazing. Thus their contribution to the water systems would be considered non-point source pollution. Agriculture producers who have small animal feeding operations should be encouraged to implement some BMP's to reduce the runoff of fecal matter from their facilities. The easiest practice would be to move cattle or other animals away from open streams and other water sources to reduce direct fecal deposition in the water. If the animals are fed they should be fed on higher ground where there is a large grass buffer or catch pond to filter runoff before it joins a larger water system. Simple practices like these could help reduce fecal levels in water. Agriculture production is not the only non-point source to blame in these increasing levels as wildlife such as deer also contribute to this non-point source pollution.

CONCLUSION:

The Environmental Protection Agency's water quality draft shows the approach towards healthy watersheds and sustainable communities. The document was made to help broaden the general public's knowledge and understanding on the water quality aspects involved with the Kansas River. In both Agriculture and Urban communities the contamination issues that arise from water quality are fairly similar, as the source they are generated from differ. This requires

[46](Sharpley, Foy and Withers 2000)

extensive studies in both areas to reach an understanding of how to recognize and resolve these problems.

As you can see non-point source pollution from agriculture can be very broad and hard to define. It is clear that when BMP's are established the problems such as nutrient loads and fecal matter that currently plague or waters can be reduced. There is not a clear cut law that can be established and enforced as is the case with point source pollution. That is why a reduction in non-point source must be a collaborative effort between agricultural producers and government officials. The agriculture producers must be shown how BMP's can help their production while at the same time helping our water systems. "Research and education that increases our understanding and awareness of the agronomic, economic, and environmental issues related to nutrients will enable us to develop sound solutions to these problems that will achieve society's water quality goals and sustain productive and a profitable agricultural system. This is not a simple problem and the solutions will not be easy." [47]

As for the urban industry, future development should be built to minimize the increase of runoff, since runoff is the most common way to pollute the water. Permits for water treatment plants and other industrial companies should continually be updated and monitored frequently. And when standards aren't being met, punishment should be implemented accordingly. It's essential to recognize high priority contaminants and the government should take action to correct the problem before it becomes too immense to manage. Public education is important in order to make citizens aware of the impacts they have on water quality, as humans are the lead contributor to water pollution, and must be properly informed on ways to decrease abuse of natural resources.

[47](Sharpley, Foy and Withers 2000)

All levels of government should enforce the use of proper mitigation strategies for prospective expansion to avoid future expenses of restoration. Protection is too often overlooked, but should be the first strategy when dealing with natural resources, because it's the least expensive. Enhancement of our resources with additional practices can help prevent degradation to our water supply and should be carried out before resorting to restoration. Restoration should be the last means of operation as it is the most expensive and most demanding.

Implementing a cost-effective program that is sustainable to both Agriculture and Urban communities has become a necessary objective. The continual enforcement of the government on water regulations in both industries will help put into effect better management practices in the future. Water is the most valuable resource, so persistent research and rigorous studying over water quality and how to deal with various contamination issues is essential in order to protect the health of American citizens. Hopefully, the foundation that the EPA has built for the continuation of scientific growth will continue to educate America on protecting their delicate environment.

ADDITIONAL READINGS

"Coming together for clean water"

By: United States Environmental Protection Agency

"The River"

By Pare Loren

"Modeling urban growth effects on surface runoff with the integration of remote sensing and GIS"

By Q. Weng

"Research note: An approach to integrated assessment of reservoir siltation: The Joaquin costa reservoir as a case study"

By: Garces Valero and J. Machin

"Sediment management during reservoir depletion-experimental investigations of mud siltation and resuspention."

By C. Schweim, J.P. Welzel, V. Spork and J Kongeter

"Venturi anti-siltation system"

By W.G. Webb

"Teaching case studies in reservoir siltation and catchment erosion"

By H. Chanson and P. James

ADDITIONAL READINGS CONTINUED

"Management of eutrophication for lakes subjected to potentially irreversible change"

By: S.R. Carpenter, D. Ludwig, and W.A. Brock

"*The Overall Picture of Eutrophication"*

By: E. Gus Fruh

"Nutrient and Sediment Removal by a Restored Wetland Receiving Agricultural Runoff"

By: Thomas E. Jordan, Dennis Whigham, Kristen Hofmockel, and Mary Pittek

"The Transport of Bioavailable Phosphorus in Agricultural Runoff"

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