Strategic Analysis of Water Use and Risk in the Beverage Industry

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A project submitted
in partial fulfillment
of the requirements
for the degree of
Master of Science
(Natural Resources and Environment)
at the University of Michigan
April 2012

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Abstract

Water is an essential component in beverage industry products. As a result, companies face a material risk to their businesses from issues such as water quality, water scarcity, water pricing mechanisms, regulations for wastewater disposal, and community perception. However, at this time the nature and extent of the risk beverage companies face is not widely understood, particularly on a sub-national level. The objective of the project is to look at the role of water and risk within the value chain of the beverage industry, understand trends in water sourcing, treatment, and wastewater discharge, highlight risk mitigation and water use reduction opportunities and identify potential gaps where Dow Water & Process Solutions could leverage its existing product portfolio or develop new products to help address issues of water scarcity and quality.

To meet the project's objectives three specific analyses were conducted: calculation of the water footprint for a standard beverage, identification of business risks, and application of potential technological solutions. Additionally, the team visited two types of facilities in the beverage industry value chain, interviewed a number of agricultural experts and conducted a wealth of secondary research.

As a result of the above approach crop cultivation was identified as the largest contributor to the water footprint of sweetened carbonated beverages. Furthermore, by examining crop cultivation in a state with such highly diverse crop cultivation methods as Nebraska, the team was able to identify and assess a number of risks, which may be applied to other areas where crop cultivation provides agricultural inputs for the beverage industry.

Based on the research, analysis suggests that beverage companies should examine the water risks posed and faced by the crop cultivation segment of their value chain. To this point, though the specific risks are likely to vary by company, companies can utilize the analytical approaches used in this report to assess their risk and identify opportunities to mitigate risk and reduce water use.

Acknowledgements

The completion of this project would not have been possible without significant support from a number of individuals and organizations. Our team greatly appreciates the time and effort you have devoted to the project and we would like to acknowledge your support. A special thanks to:

- Chris Sacksteder and Gregg Poppe with Dow Water and Process Solutions
- Scott Noesen, our faculty advisor with the University of Michigan School of Natural Resources and Environment
- Thomas Strasser with Coca Cola Bottling in Detroit, Michigan
- Tate & Lyle corn wet milling in Lafayette, Indiana
- Marcie Mirgon with Dow Water and Process Solutions, our contact for Tate & Lyle

Table of Contents

Executive Summary

The research goal for this project was to examine water consumption, disposal, and risk, and to provide insights on how to reduce the water footprint and identify and mitigate risks for the beverage industry. To achieve these objectives, our team utilized two primary analytical tools, a water footprint and water risk assessment.

In order to understand water usage throughout the value chain blue, green, and grey-water footprints were calculated for each stage of the value chain examined in the project. Based on preliminary interviews and secondary research our team determined to bound our scope to examining the three stages of the value chain of a caloric (corn-sweetened) carbonated beverage, which were generally believed to account for the most water usage in the beverage industry. These areas are: crop cultivation, sweetener production (wet milling), and beverage manufacturing (bottling).

The combined water footprint for a 20 ounce bottle of sweetened carbonated soda is 57.5 bottles of water. Of this 22.7 bottles came from green water, 27.5 from blue water and 7.3 from grey water. Crop cultivation accounted for 55.4 bottles, sweetener production for 0.2 bottles, and beverage manufacturing for 1.7.

To understand the beverage industry's exposure to risk in these stages of the value chain our team used a physical, regulatory, and reputational risk assessment framework. Using this lens our team examined three specific risk exposures: scarcity, quality, and price. For scarcity we examined two risks: first, that water sources would be depleted, and second that climate change may contribute to physical scarcity. With regard to quality our team focused on the risk effluent and run-off posed to ground-water quality and downstream bodies of water. Finally, our team also examined the risk that water prices will increase and the potential implications for the beverage industry.

From our analysis, we determined beverage companies face significant risks of physical scarcity due to over-withdrawal from ground-water sources and the potential effects of climate change on crop cultivation. Moreover, our research revealed that water quality issues may further exacerbate scarcity. In addition to these issues, our research also demonstrated that water prices have generally been trending upwards, exposing the beverage industry to financial risk.

In the course of our research our team was able to identify a number of opportunities for beverage companies to reduce their water use. Additionally, based on our research, our team has formulated three recommendations which we believe will better enable Dow to help the beverage industry address water use and risk.

Specifically, Dow can leverage its developing product portfolio to provide innovative technological solutions that directly address the need for drought-tolerant seeds, water-efficient irrigation equipment, and water-filtration and re-use equipment. Through partnerships (e.g. public-private), Dow may also be able to play a key role in pairing technological solutions with market incentives to increase the adoption rate of water-efficient or conservative technologies. Furthermore, by increasing inter-organization and cross-business unit collaboration Dow can better communicate with beverage industry related customers throughout the value chain in an ongoing effort to identify water challenges and solutions for the beverage industry.

Introduction

Dow Water & Process Solutions approached the student team requesting to gain an in-depth understanding of water consumption, water disposal, and water risk (physical, regulatory, and reputational) specific to the beverage industry. Water plays a critical role in both the operations process and product of the beverage industry. As a result, water quality, water scarcity, water pricing mechanisms, regulations for wastewater disposal, and community perception all pose a material risk to the business model and growth prospects of companies in the beverage sector. Insight into these risks will enable Dow Water & Process Solutions to form strategic partnerships with targeted customers in the beverage industry with a focus on reducing water consumption, enhancing operational efficiency, and improving the quality of process/ingredient water and wastewater discharge.

The objective of the project is to look at the role of water within the value chain of the beverage industry, understand trends in water sourcing, treatment, and wastewater discharge, and highlight potential gaps where Dow Water & Process Solutions could leverage its existing product portfolio or develop new products to help address issues of water scarcity and quality.

The objective is achieved by focusing on three specific analyses: calculation of water footprint of a standard beverage, identification of business risks, and application of potential technological solutions. The water footprint calculations are done for a typical carbonated caloric soft drink produced in the United States and include the embedded water associated with bottling, producing corn syrup, and growing corn. Embedded water associated with packaging, use and disposal are not considered in this study. The comprehensive water risk assessment includes research on three key dimensions of water risk: physical water scarcity, regulatory risk, and reputational risk. Water pricing and the social dimension of water as a basic human right is also considered.

Beverage Industry and Water

Global concern of water as a critical natural resource has been increasing over the past decade. The beverage industry has a distinct physical and reputational reliance on water for two key reasons. First, the beverage industry's ultimate product is a liquid of which water is the single largest ingredient. Second, most of the non-water ingredients used by the beverage industry (such as sugar, oranges, wheat, barley, or tea) are products of the agricultural industry, which as an industrial sector is the single largest consumer of water. (Gardiner, 2011) To address issues such as these, a number of beverage companies have joined forces and established the Beverage Industry Environmental Roundtable (BIER), which defines itself as a partnership of global beverage companies who are working together on environmental stewardship issues. (Beverage Industry Environmental Roundtable) In addition to BIER some beverage companies have made extensive efforts to assess, minimize, and manage their water use. The Coca-Cola Company has even begun publishing an annual Replenishment Report to document their efforts in partnership with local organizations and larger groups like the World Wildlife Fund. (Replenish)

Overview of Water Footprinting

The concept of a water footprint is relatively nascent compared to that of a carbon footprint. The Water Footprint Network, a non-profit organization based in the Netherlands, defines a water footprint as the total volume of freshwater that is used to produce goods and services. A water footprint accounts for both direct and indirect water use, similar to how a carbon footprint may include both Scope 1 (direct) and Scope 2 and 3 (indirect) emissions.

A water footprint differs from a carbon footprint in several ways. First, a water footprint must be geographically explicit. Whereas emissions are often simply summed across different geographical locations, it is important to know where freshwater was withdrawn from in order to understand the relative water stress of the groundwater or surface water source. For example, a withdrawal from the Great Lakes, home to a large proportion of the world's freshwater supply, is not the same as a withdrawal from the Rio Grande, which has seen its water flow decrease steadily throughout the years.

Second, there is also a temporal component. For instance, a water withdrawal in Texas during the summer months, when water is extremely scarce, is not the same as a water withdrawal in the same region during the wetter winter months. These spatial and temporal dimensions make it difficult to simply compare amounts of water withdrawn without understanding when and where the withdrawals took place.

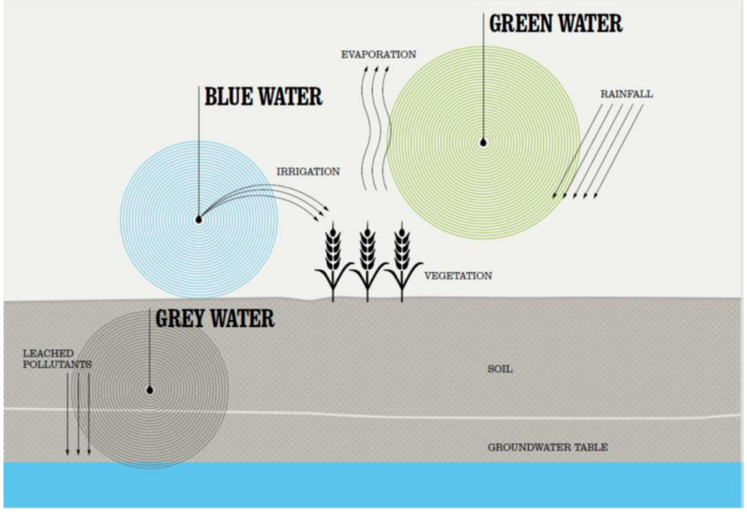
However, a water footprint ultimately comes down to a number that represents the volume of freshwater necessary to produce the good or service in question. In order to identify the type of water being consumed there are different categories of water as defined by the Water Footprint Network – green, blue and grey.

Green water is rainfall that is absorbed by vegetation that is then harvested as an end product (for example, bananas) or used as an intermediate product in the manufacturing process (for example, corn). The green water footprint is typically calculated by determining the area of land covered by the vegetation, understanding how much water is required for the vegetation to reach a state where it can be harvested, and then comparing those numbers to the actual amount of rainfall in the geographic region where the vegetation is being grown.

Blue water is water withdrawn from a groundwater or surface water (lake, river, stream, etc.) source. The blue water footprint is typically the easiest to calculate from an industrial standpoint because there are generally a finite number of freshwater withdrawal points within any manufacturing supply chain and these typically have an associated water flow rate that can be extrapolated across the total hours of operation to arrive at a total volume of water withdrawn. However, blue water calculations can be more difficult to estimate when considering a commodity crop. Withdrawals differ per crop based on location, seasonal fluctuation, and application and use of technology, and legislation does not require farmers to report blue water withdrawals.

Grey water is usually the most difficult component of a water footprint to calculate. Grey water is defined as the amount of clean freshwater required to absorb pollutants that are leached to a surface water source or groundwater aquifer through wastewater discharge. In order to calculate the grey water footprint, one must first determine what pollutants are being discharged (and in what quantities) and then understand what concentration of pollutants is deemed acceptable in the water source where the wastewater is being discharged. The diagram below illustrates the three different categories of water that comprise a water footprint.

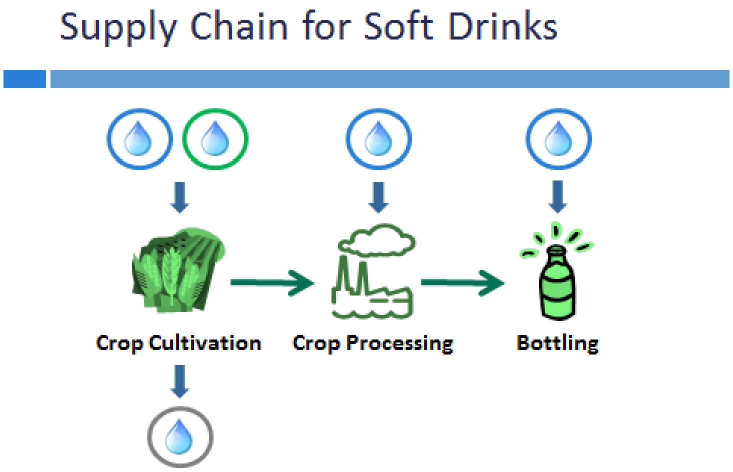
Figure 1: Water Footprint Classification



(Water Footprint Network, 2012)

For our project, we conducted a water footprinting study of the carbonated beverage supply chain, which is illustrated below. It is important to note that packaging manufacturing (i.e., bottles, cans, labels, pallets, cartons, etc.), transportation, and the use/recycle phase were outside the scope of our project.

Figure 2: Soft Drink Value Chain.
Note the green and blue circles indicating inputs of green and blue water at various steps in the value chain, and the grey circle indicting consumption of grey water in association with waste products



(Figure created by the student team for the purpose of this project)

The crop cultivation phase has both green and blue water as inputs because we studied corn grown to make High Fructose Corn Syrup (HFCS), which is used to sweeten carbonated beverages. Specifically, we looked at corn grown in Nebraska, where crops are both rain fed and irrigated from the Ogallala Aquifer. Part of the crop cultivation process involves the use of fertilizer, pesticides and herbicides. As a result, pollutants (mainly nitrogen and phosphorous) and leached into the groundwater and surface water. This accounts for the grey water component of the crop cultivation water footprint.

The crop processing and bottling phases both only have a blue water input because sweetener manufacturing plants and bottling plants typically get their water from either the city or from groundwater wells. We also assumed that these plants discharge their wastewater to the city sewer system, where it is treated and then pumped back out. In essence, this process does not require any additional water (unless you consider the water required to cool the wastewater treatment plant). This means that, for our purposes, these phases did not have a grey water footprint. As discussed earlier, grey water is often the trickiest portion of the water footprint to calculate, and we made certain assumptions in order to be able to proceed with our calculations.

Case Study Methodology

During our team's initial discussions with Dow on researching water risk in the beverage industry, we quickly realized it would be necessary to focus our efforts in terms of both the type of beverages and companies to be covered, as well as to the factors most relevant to water risk.

After conducting a review of the literature on water risks and the beverage industry, our team decided that it would be prudent to focus our project on corn-sweetened carbonated beverages, which comprise approximately three-quarters of the soft drink industry (USDA/Economic Research Services, 2011). Our rationale behind this decision was to ensure our project addressed the water-risks introduced by agricultural inputs, as well as in the bottling process. Consequently, we decided to our scope should include examining water risks at the agricultural input level, sweetener-processing plants, and bottling-facilities.

Project Scope

In specifying project scope we also specifically excluded several factors from our research: the production of the beverage containers, container labeling, and the beverages' consumer-use and end-of-life phases. These factors we considered to be immaterial based on preliminary research of how much water is consumed by each of these factors.

Having determined the bounds of our scope, we chose to narrow our geographical focus in order to examine the influence specific local conditions are likely to bear on water risk. In doing so, our team chose to focus on the state-level, Nebraska, specifically. Nebraska was chosen for two primary reasons. First, it produces nearly 12% of the nation's corn annually (Exhibit I – U.S. Corn Production by State), which is the principal ingredient in carbonated-beverage sweeteners. Secondly, 53% of Nebraska's farmlands are irrigated, while 47% are rain-fed (Exhibit J - % of Corn Crop Irrigated by State) and we decided this mix would allow us to examine the water-risk posed by each method. Additionally, Nebraska also happens to be home one of the nation's twenty-seven wet-milling facilities (Exhibit B: Wet Milling Plants by Company and State (1994 EPA data)).

With our team's focus on water risks faced by the sweetened-carbonated beverage industry at the agricultural, sweetener, and bottling levels at the state-level in mind, we set about creating a methodology to guide our research. In order to gather the information we needed we chose to focus both our primary and secondary research around the following areas: agricultural input of corn (crop cultivation), corn syrup sweetener facilities (crop processing, or wet-milling), and bottling plants.

Primary Research

In examining the use of water for agricultural inputs, our team conducted interviews with a number of experts. To learn more about how the choice of corn variety and genetics affects water consumption we spoke with Yoon-Sup So, a former PhD in Agronomy at Iowa State. Then to examine the effects climate change may have on corn yields we spoke with Jon Eischeid, Senior Professional Research Assistant at the National Oceanic and Atmospheric Administration, in regards to a presentation on climate change and agriculture at Iowa State University. We also spoke with an irrigation equipment supplier regarding corn farmers' irrigation needs.

In addition to interviewing experts on beverage industry agricultural inputs, we also conducted site visits and interviews at two commercial facilities. During the course of our research, our team visited a Tate &

Lyle wet-milling (i.e. sweetener processing) plant in Lafayette, Indiana and a Coca-Cola bottling plant in Detroit, Michigan.

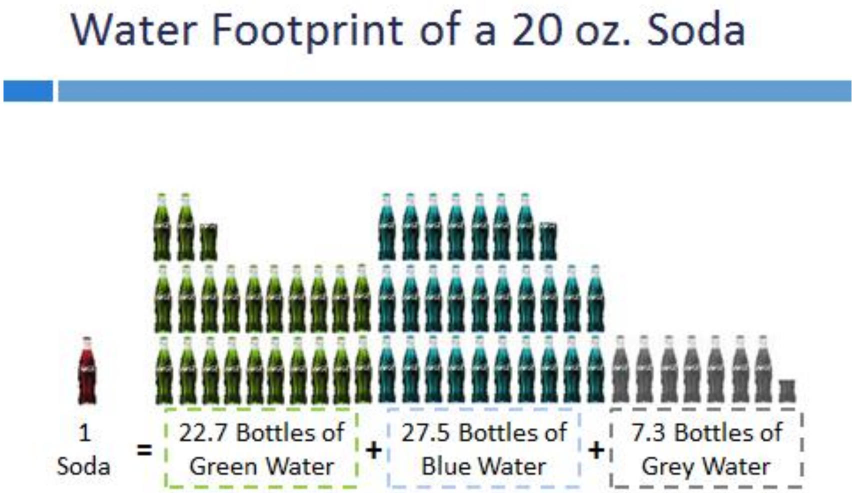
Secondary Research

To gain an understanding of what research had already been conducted and to supplement our primary research, our team also carried out an extensive amount of secondary research. As with the primary research, our team focused on three major areas: agricultural inputs, sweetener processing, and bottling. We utilized a variety of academic resources, industry and company reports, and scientific papers. In sum, we sourced information from 29 resources, which are documented in Works Cited.

Water Footprint Calculations

Based on our analysis and calculations, we arrived at a water footprint of 57.5 units of water required to manufacture 1 unit of soda. This can be further broken down into green, blue and grey water as illustrated in the diagram below. While corn syrup represents a relatively small amount of each unit of soda by volume, the bulk of the embedded water (over 96%) comes from growing the corn. Our findings are consistent with industry research: a 2011 study conducted by researchers at the Water Footprint Network found that over 99% of the total water footprint of a sweetened carbonated beverage is embedded in the supply chain (Ercin, Aldaya, & Hoekstra, 2010). The following sections of the report go into detail regarding how each component of the water footprint was calculated.

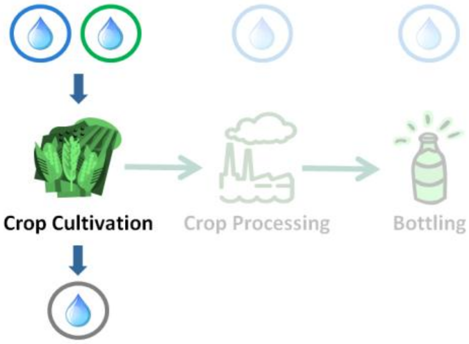
Figure 3: Water Footprint of a 20oz. Caloric Soft Drink



(Figure created by the student team for the purpose of this project)

Corn Growing *(Cultivation)*

Overview



In order to explore the risks surrounding water usage in agriculture, it is important to understand the full context of issues by selecting a cultivation area that appropriately depicts the wide facet of issues. While the corn growing states east of the Mississippi are primarily rain-fed, as we move west the abundance of precipitation diminishes dramatically. As a consequence, these states need additional sources of water to grow their supply of corn. Nebraska, one of these prairie states, relies on the Ogallala aquifer (Exhibit K - Total Withdrawal of Ground Water in the United States), in addition to rain, to grow corn. Moreover, Nebraska is the third biggest corn growing state after Illinois and Iowa (Exhibit I – U.S. Corn Production by State), accounting for ~12% of the total corn grown in the United States.

"The Plains States of Nebraska, Kansas, and Texas account for almost 70 percent of the corn area under irrigation nationally. Nebraska alone accounts for 47 percent of this area (USDA, 1999a). Moreover, Nebraska is the 3rd largest corn-producing state in the U.S. accounting for 12% of the corn produced (Exhibit I – U.S. Corn Production by State). 53% of the freshwater used for growing corn in Nebraska comes from surface and ground water while the remaining 47% is rain-fed (Exhibit J - % of Corn Crop Irrigated by State). In contrast, Ohio, for instance, another major corn-producing state, uses little to no surface and ground water for corn production as the climate's precipitation amount is sufficient for growing corn. Of the surface and ground water, 96% of the water is ground water from the Ogallala aquifer. Nonetheless, according to the USDA, "Irrigated farms had more than twice the acreage of non-irrigated farms and had a higher proportion of their total acreage in corn. The gross cash sales of farms with irrigation were almost double those of non-irrigated farms, reflecting larger acreage and higher yields".

Corn Production Process

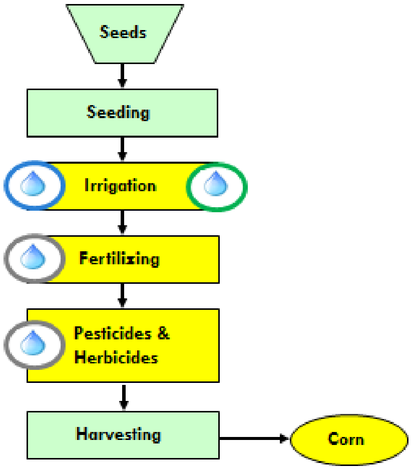


Figure 4 - Corn Production Process Map

(Figure created by the student team for the purpose of this project)

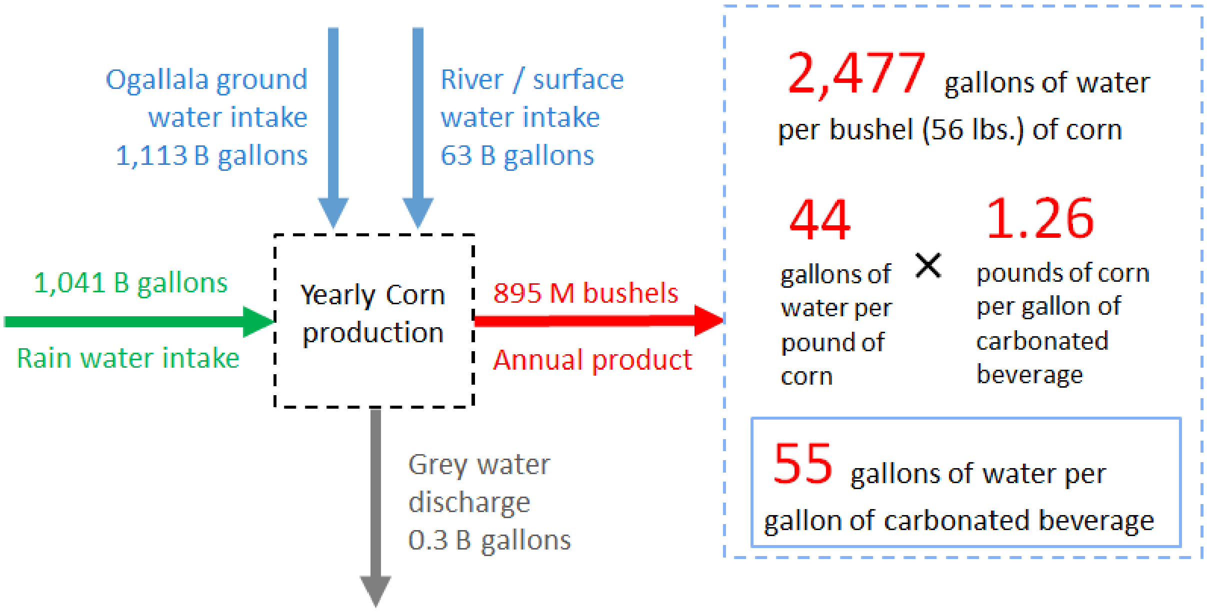
“Typical corn plants develop 20 to 21 total leaves, silk about 65 days after emergence, and mature around 125 days after emergence (**Error! Reference source not found.**). The specific time interval, however, can vary among hybrids, environments, planting date, and location” (Elmore & Abendroth, 2011).

To irrigate the crops evenly throughout the growing season, Nebraska receives approximately half of its water from groundwater (95%) and surface water (5%), and the other half from rain. This compares to regions further east, such as Indiana or Ohio, who are almost solely rain-fed, hence green water exclusive. In terms of grey water, the application of fertilizers, pesticides, and herbicides, which are applied at the preference of the given farmer, mixes with the irrigated and rain-fed waters that seep into the soil eventually leaching back into the groundwater source (estimated at around 15% in Nebraska – (Nolan, 2002)).

To further understand some of the water risks associated with the production of corn in Nebraska as it relates to the fabrication of corn syrup for soda, the team calculated the water footprint for the production of corn for an average soda bottle.

Water Footprint

Introduction of Footprint



(Figure created by the student team for the purpose of this project)

To estimate the water footprint, our team used data provided and compiled from the USDA's Agriculture Resource Management Survey with additional research that was conducted by the University of Twente in the Netherlands.

Green Water Calculations and Assumptions

The Eastern half of Nebraska receives approximately 25.89 inches of rain per year (The Weather Channel, 2012), which is approximately 50% less than the precipitation in Columbus, Ohio. Over an area spanning 9.1M acres of corn fields, 1,041 billion gallons of rain-fed water are supplied. Additionally high rates of evapotranspiration range from 60 to 105 inches per year requiring further blue water needs (Massachusetts Institute of Technology, 2011).

Blue Water Calculations and Assumptions

In order to fulfill the water gap needs to grow certain crops, Nebraska relies on groundwater and surface/river water for irrigation. The Ogallala aquifer supplies 95% (1,113 billion gallons) of the blue water with a small additional amount (5% or 63 billion gallons) coming from surface/river water. On average, farmers applied about 8.9 inches of water per irrigated acre (see Exhibit Q - Nebraska Data of Corn Production). The total blue water accounts for approximately 53% of the total water used to grow corn in Nebraska.

Grey Water Calculations and Assumptions

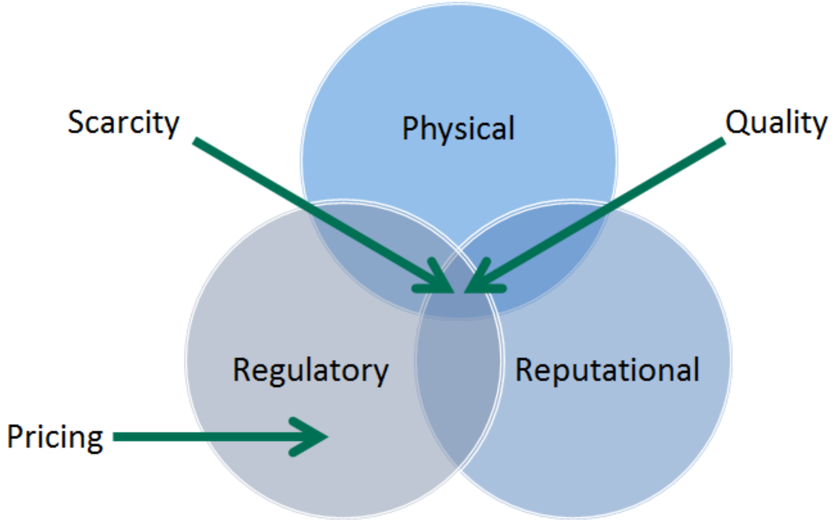
The combination of fertilizers, pesticides, herbicides, and fungicides used in the corn agricultural process with the Green and Blue water can create grey water if the combination enters the watershed system. Currently, there are 128 million pounds of chemicals being used to enhance the growth and yield of corn in Nebraska(See Exhibit R – Chemical Use in Corn Production). Approximately 15% of the green and blue water leaches into the groundwater supply after attaining the crops bringing with them some of the applied chemicals (Massachusetts Institute of Technology, 2011) – at a 2.31mg/L. Moreover, the groundwater system is linked to the area watershed streams and rivers that feed the Mississippi river.

Water Footprint Risk to the Beverage Industry

The annual production of corn in Nebraska is approximately 895 Million bushels (56lbs each) consuming 2,477 gallons of water each. Given that each gallon of carbonated beverage contains 1.26 pounds of corn (See Exhibit Q - Nebraska Data of Corn Production), there are 55 gallons of water per gallon of carbonated beverage for the production of corn only. This staggering amount of water can bring many risks to a corporation as they deal with operational and financial efficiency, regulatory compliance, and reputation/image maintenance.

Risks

Taxonomy of Risks



There are three main areas of risks, in which, we have identified three areas of focus retaining to the beverage industry:

- Physical - Water quantity (scarcity) and water quality that is unfit for use (pollution)
- Regulatory - Restrictions on water use by government – pricing, licenses to operate, quality standards, etc.
- Reputational - Impact on a company's brand and image

Areas of Focus:

- Scarcity - In the case study of Nebraska, the depletion of the Ogallala aquifer and consequences of climate change attribute to scarcity risk.
- Quality – Contamination of the groundwater and watersheds from the use of fertilizers and other chemicals during the corn production process.
- Pricing – the cost of water is heavily dependent on local, state, and national regulations.

Scarcity

Ground water depletion

Ground water is commonly used throughout the United States although in the plain states region, ground water is used heavily for agricultural purposes to accommodate for the reduction in precipitation found east of the Mississippi.

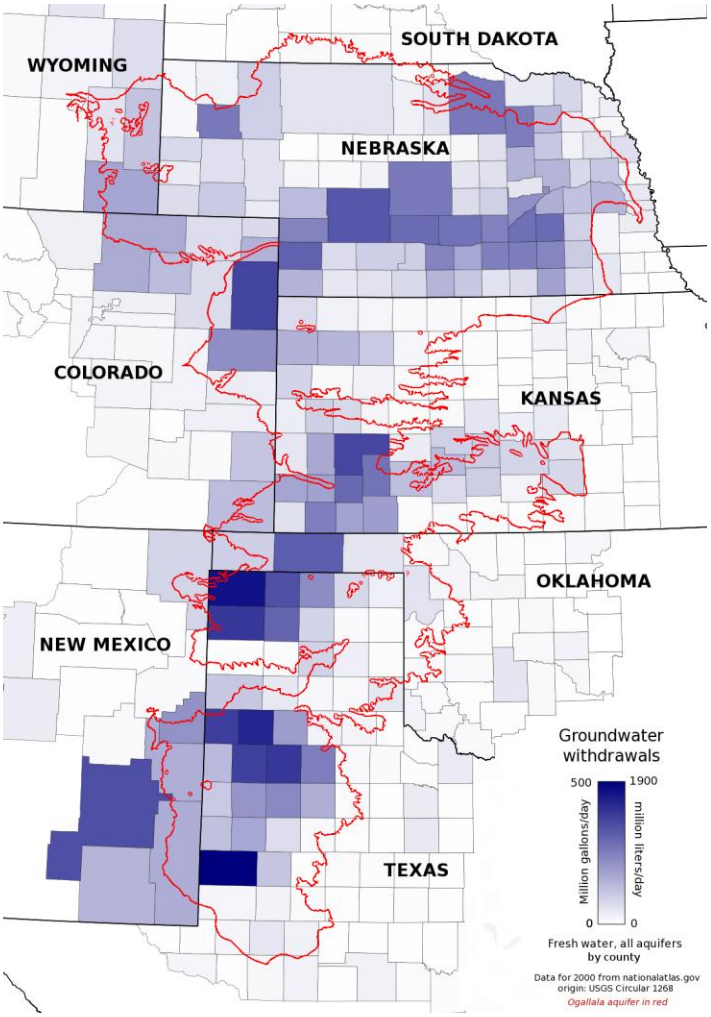


Figure 5 - Groundwater Withdrawals

Ogallala Aquifer Background

- 81% of water used in the high plains area
- 54% of land is used for farming
- Represents 15% of U.S. Corn grown
- Recharge rate = .85/in/year
- Net Overdraft = 54.9mm / year

Depletion rate

94% of the total groundwater usage from the Ogallala is for irrigation, which is roughly 15,745 millions of gallons per day of water. This represents 30% of all groundwater used for irrigation in the United States. Figuratively, this depletion represents around 24,000 Olympic-sized swimming pools a day or 0.2% of Lake Michigan. In some parts, since pre-development, the water table has dropped 45m (~150ft) (Massachusetts Institute of Technology, 2011). The depletion rate also affects natural ecosystems. For instance, riparian ecosystems are very sensitive to the depletion of aquifer. Small changes in the water table can have dramatic effects on this ecosystem, which helps prevent fertilizers and other chemicals from entering riparian bodies of water. Another risk faced by the depletion of the Ogallala aquifer is the dependence on this source of water by a majority of the population in Nebraska. Moreover, by 2020, it is predicted that Nebraska will incur a 15% population increase (Exhibit O - Table of Population projections for Nebraska), furthering its dependence on the Ogallala aquifer for its source of drinking water.

State rights

In Nebraska, one has the right to use "a reasonable amount of the ground water under their land for beneficial use on that land" (Massachusetts Institute of Technology, 2011). There are 23 natural resource districts in Nebraska who manage groundwater use individually. A ground water management plan detailing depletion and quality management is required for each district (including the distribution of well permits). In areas where there is limited governance, residents follow the Nebraska correlative rights doctrine that states that residents must share when groundwater supplies are limiting (Massachusetts Institute of Technology, 2011). Additionally, since the Ogallala aquifer expands multiple states, there is a current lack of vision and cohesion between state laws on groundwater usage.

Modifying the current laws can be tricky as more stringent laws would create higher water prices (certainly a risk to beverage industry), but a lack of regulation will lead to complete depletion, an indirect long-term risk to beverage industry).

Climate Change Risks

It is predicted that Climate Change will have some effects on agriculture in the Midwest and Great Plains: A temperature increase will be stabilized by a precipitation increase, effectively changing the current environment to grow corn. According to a study done at the University of Wisconsin (Kucharik &

Serbin, 2008), an increase in temperature will lead to a lower corn crop yield (~17%) due to more sporadic weather with heavier rains and longer droughts. These heavier rains have caused mass-flooding in the Great Plains region as seen with the late-spring flooding of North Dakota in 2011; More frequent floods lead to more grey water runoff into the watersheds due to poorly constructed water drainage systems, levee heights, the channelization of the Mississippi, and loss of wetlands. Moreover, temperature and precipitation increases will subject corn to more invasive species and disease requiring additional fertilizers/chemicals to protect the crops and yield. Lastly, the increase in temperature will increase the levels of evapotranspiration particularly in the spring and summer months when most precipitation occurs, so only a small percentage of this rainfall actually reaches the aquifer. Most of the recharge due to precipitation occurs during snowfall and rainstorms (Kucharik & Serbin, 2008).

All of these risks due to scarcity need to be taken into account for a beverage manufacturer since they affect the price of corn and their manufacturers' operations directly reducing their overall financial profits.

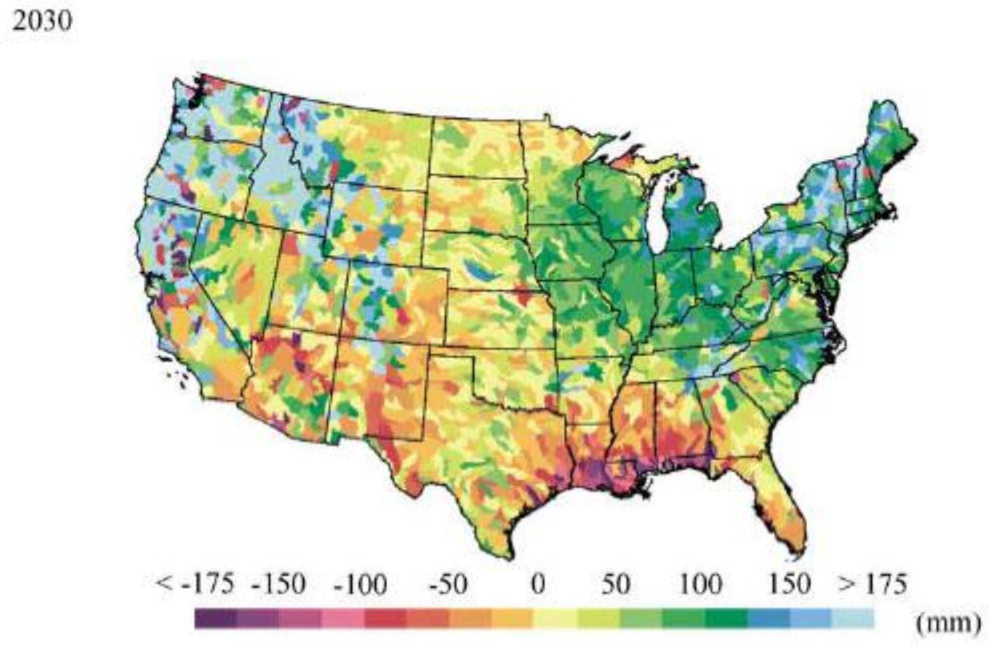


Figure 6 - U.S. Precipitation change in 2030

Climate change in higher latitudes causes more rainfall and less snowfall, increasing the possibility of overland flow and flooding, allowing soil erosion, and bringing more contaminants into the river (Massachusetts Institute of Technology, 2011). The vast flooding that occurred in North Dakota and Iowa in 2011 are illustrative examples. “It is reported that 68% of the 548 outbreaks of waterborne diseases between 1948 and 1994 were associated with the 80% increase in precipitation intensity, which substantially washed pollutants into the surface waters used by people” (Massachusetts Institute of Technology, 2011). Not only wetter climates but also drier climates can exacerbate water quality. Increased droughts reduce the water penetration in the soil (due to a lower absorption rate), reducing the replenishment of the ground water ecosystem. Furthermore, chemicals, nutrients and microorganisms in the aquifer can accumulate over a long periods of time, and become concentrated to an undrinkable/toxic level due to the lack of water replenishment in the aquifer.

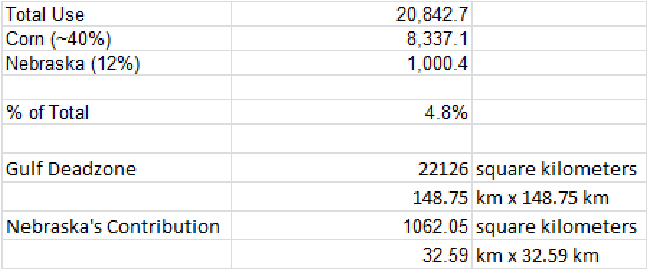
Water Quality and Community risks

Groundwater & Downstream Contamination

An increase in temperature, together with an increase in nutrient levels increases in water storage, exacerbates biological activities in water and stimulates an excessive growth of microorganisms (Massachusetts Institute of Technology, 2011). Consequently, Algae may build up on the water's surface, preventing water from exchanging gas and getting the necessary sunlight subsequently leading plants to die off creating an environmental unsuitable for life.

Moreover, any pollutants entering the water sources for human consumption can have severe effects on the local population such as a rise in health issues, which indirectly causes a decrease in economic productivity. These type of negative health and economic effects have been seen in West Virginia with the coal industry (Epstein & Buonocore, 2011). In the case of the Ogallala aquifer, the current nitrate levels entering the groundwater in Nebraska (based on the amount of fertilizers/chemicals used) averages an alarming 2.4mg/Liter. “A study of cancer incidence in Iowa women 55-69 years old found that the risk of bladder cancer was 2.83 times higher and the risk of ovarian cancer was 1.84 times higher when nitrate concentration in municipal water supplies exceeded 2.46 mg/L. In another study, nitrate concentrations of 4 mg/L or more in water from community wells in Nebraska increased the risk of non-Hodgkin's lymphoma. Shallow groundwater unaffected by human activities commonly contains less than 2 mg/L of nitrate (Nolan, 2002).”

Moreover the Gulf of Mexico dead zone is a 22,126 square kilometer (8,543 mi^2) region. Based on calculations of fertilizers use, Nebraska’s corn production contribution to the dead zone is ~5% of the total deadzone:



Total Use	20,842.7	
Corn (~40%)	8,337.1	
Nebraska (12%)	1,000.4	
% of Total	4.8%	
Gulf Deadzone	22126	square kilometers
	148.75	km x 148.75 km
Nebraska's Contribution	1062.05	square kilometers
	32.59	km x 32.59 km

The destruction of the natural ecosystems around the rivers that fed the Mississippi is a major reason for the alarming growth of the Gulf of Mexico deadzone:

- Ground water leaks into surface water sheds continue to increase with the removal of riparian ecosystem
- Removal of wetlands buffer for new development leading to increased amounts of agricultural run-off that is high in nutrient content

- As much as 15% of irrigation water can permeate into the Ogallala Aquifer. Additional sources of recharge include industrial wastewater, treated sewage, and storm water. All three of these water sources flow into the Ogallala Aquifer through a series of ditches (Massachusetts Institute of Technology, 2011).

Additionally, natural ecosystems act as a natural water filter for aquifers. Groundwater provides a natural buffer against periods of drought which estuaries, wetlands, and riparian ecosystems (at the banks of rivers) depend on. The grey water entering an aquifer ecosystem kills microbes and bacteria that disintegrate contaminants into nutrient and energy, abolishing the natural process of water purification.

Opportunities

To address the risks of water scarcity and quality related to the corn production in Nebraska, there are several technological and organizational opportunities to consider. Since this report covers the entire value chain for the development of a soda beverage, the organizational opportunities will be discussed in the overall recommendations sections at the end of the report.

Overall opportunity themes to improve Agricultural Water Practices by water type include (Water Footprint Network, 2012):

- Green Water – Improve water productivity, increase rain-fed production
- Blue Water – Increase irrigation efficiency, more crop per drop of water
- Gray Water – Lower use of fertilizers and pesticides

Several technological solutions can be used to address these opportunities: the development of disease resistant and water efficient seeds, accurate irrigation technology, and membrane technology to filter gray water.

To address the water scarcity risks such as the reduced availability of water, the rise of droughts and floods, and the increase in invasive species, the modification of seeds using bio-engineering can become crucial. Developing seeds that are more water efficient would help cope with unpredictable weather patterns. Moreover to address the increase in invasive species and to prevent the use of additional chemicals/fertilizers, the development of disease resistant seeds will become necessary to prevent a reduction in corn yields and subsequently price fluctuations. Lastly, creating genetically modified corn that reduces the need for soil tillage will help limit the loss of soil during the planting period.

Farmers producing irrigated corn operated an average of 5.5 wells per farm. Among irrigated farms, 64 percent of wells (serving 77 percent of the area irrigated) used backflow prevention devices to protect the water quality of aquifers, and 23 percent of wells had meters. Seventeen percent of irrigated corn acres received chemical fertilizer through the irrigation system. Pesticides were applied through irrigation systems to 8 percent of the irrigated area (Exhibit Q - Nebraska Data of Corn Production) (Massachusetts Institute of Technology, 2011). Further improvements to irrigation technology such as smart readers and moisture readers are important measures to optimize water needs by crops and reduce ground water withdrawals. Water run-off capturing technology could also prove beneficial to mitigating some of the scarcity and price water risks. Since irrigated water brings a higher yield which means a more lucrative agricultural production system, the adoption of rain water capture technology for irrigation is a desirable option. Moreover, the adoption of sprinkler irrigation technology and the use of irrigation information sources are identified as critical water conservation strategies. (Christensen, 2002)

Lastly, the use of membrane technology to filter gray water from agricultural irrigation would be an important step to limiting the discharge of grey water into the Ogallala aquifer and the watersheds that drain into the Mississippi river. To stimulate the adoption of such technology, a partnership, with the EPA for instance, could prove beneficial to advocate for legislation for the reuse/cleaning of grey water in agriculture.

Corn Processing *(Wet Milling)*

The form of sweetener, or corn syrup, most widely used in soft drinks is a variety called high-fructose corn syrup 55 (HFCS 55). Raw corn is converted into a base corn starch through the wet milling process and further modified to create sweetener.

Corn Wet Milling Industry Overview

Corn wet milling is a $6.6B[1] industry (NAICS) and produces a trio of head products using #2 yellow dent corn: corn starch, corn sweeteners and fuel ethanol (Schenck F. , 2001). Both sweeteners and fuel ethanols use corn starch as a raw material (Vuilleumier, 1993) and further modify the base starch; therefore, all three head products require the same corn starch processing, or wet milling.

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[1] 2008 numbers

The wet milling industry is fairly sophisticated and existing technology is mature (IBISWorld, Syrup and Flavoring Production in the US, 2012). Nearly all food-related waste is diverted into revenue-generating co-products: corn gluten feed, corn gluten meal, corn oil and, when fermenting ethanol, carbon dioxide (Schenck F. , 2001). Figure 7 and Table 1 illustrates the composition of a corn kernel and the relevant products and co-products.

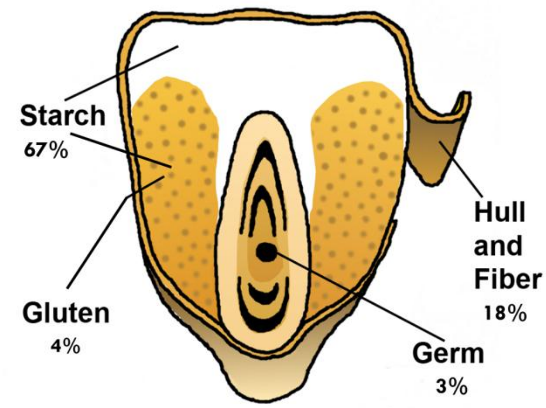


Figure 7: Anatomy of a Corn Kernel and Breakdown by Percentage (Association, Corn Refiners)

Component of Corn Kernel	Products and Co-Products
Starch	Modified starches, syrups and ethanol
Gluten	Feed products
Hull and Fiber	Feed products
Germ	Corn oil

Table 1: Co-Products from Corn

Plants are highly capital intensive, are designed for efficiencies of scale, (Blanchard, 1999) and typically operate 24-hour shifts year round. Most U.S. plants are fairly old and many date back to the advent of the food industry. Production capacity for corn starch processing in the United States experienced two major expansions: one in the 1970s to handle demand for HFCS from the beverage industry, and second in the early 2000s to accommodate demand for fuel ethanol (Rausch, 2002). Plants are typically located in geographic proximity to areas where corn is grown and harvested (Exhibits A, B, and C) in order to minimize transportation costs of the low-value, perishable product.

Water Footprint

Corn wet milling is highly water intensive. Researchers in the 1980s estimated that corn wet milling plants used 1.5 cubic meters of water per ton of corn. (Cicuttini, Kollacks, Brussels, Rekers, & Hardenberg, 1983)

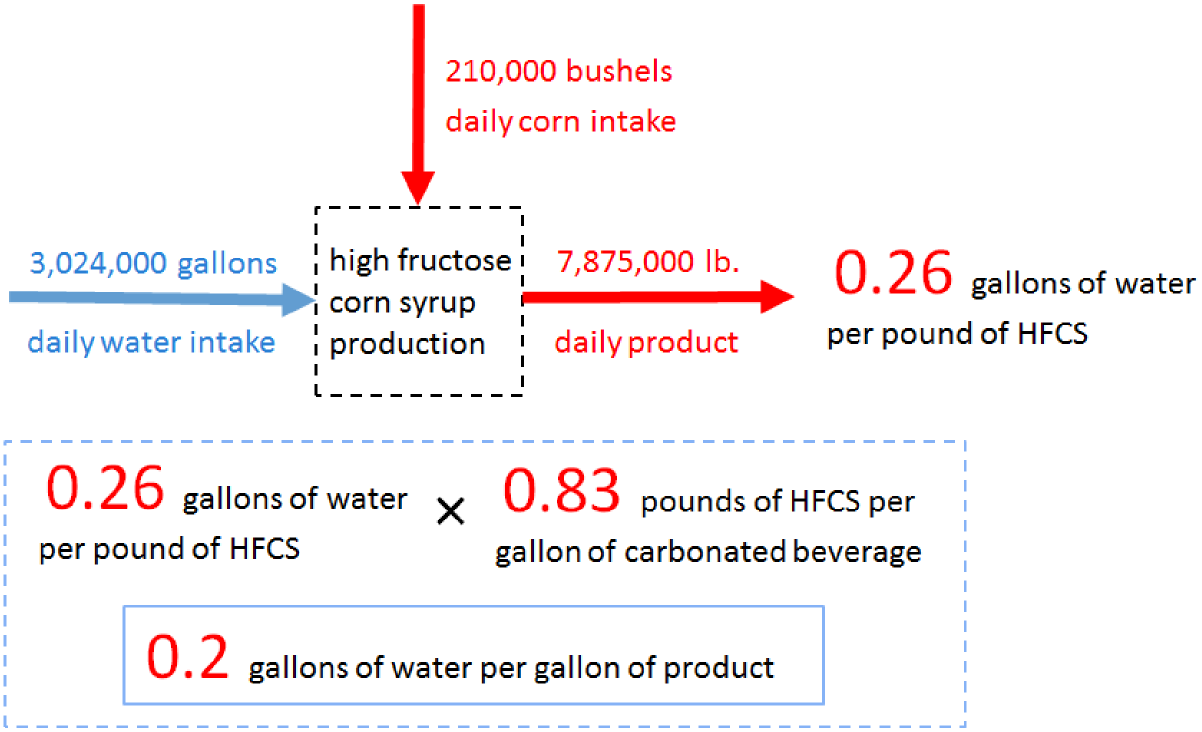
The corn industry claims that for every bushel, or 56lbs, of raw corn, approximately 37.5lbs are converted into starches and on into corn syrups. (The Gallitsky, Ruth and Worrell (2003) report for the EPA indicates only 33lbs of corn syrup per bushel of corn.) To determine the amount of corn syrup in a 20oz bottle of cola, we first assume that all calories in a caloric soft drink come from the HFCS-55. Since other flavorings are used in smaller volumes and are often present in diet sodas, which are calorie free, we believe this is a fair, albeit not perfect, approximation.

$$\frac{240\ cal}{1\ 20oz\ bottle\ nondiet\ cola} \times \frac{0.25 gram}{cal\ HFCS} \times \frac{lb\ HFCS}{453.5924\ grams\ HFCS} \times \frac{56\ lb\ raw\ corn}{37.5\ lb\ HFCS} = \frac{0.197534\ lbs\ raw\ corn}{1\ 20\ oz\ bottle\ nondiet\ cola}$$

Combining with the amount of water consumed per unit of product at a typical corn syrup wet milling facility yields a rough approximation for the footprint.

Figure 8: Water Footprint for Manufacturing High Fructose Corn Syrup

Numbers based on data obtained at Tate & Lyle corn wet milling facility in Lafayette, IN



Corn Starch Processing

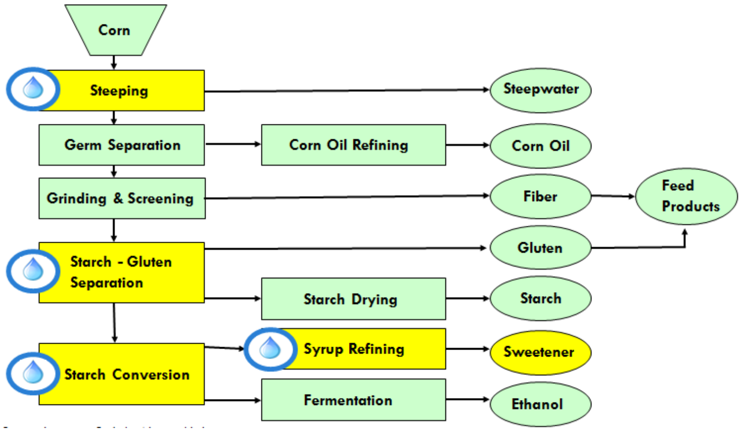


Figure 9: Corn Wet Milling Process Flow (Galitsky, Ruth, & Worrell, 2003)

Step 1: Steeping

The first step in the wet milling process is steeping. Corn kernels soak continuously in a weak solution of sulfurous acid[2], typically for 24-48 hours (Rausch, 2002). As the kernels absorb water they expand and soften; the gluten bonds weaken, allowing the release of corn starch and loosening the germ (Association, Corn Refiners).

The steep tanks typically hold 2,000-13,000 of corn at 52°C. Water entering the steeping system is typically reused water from other mill operations. The water flows first through the batch of corn that is furthest along in the steeping process and flows on to finish with the newest batch of corn. The steepwater is then discharged to multiple-effect evaporators to separate suspended solids, while some steepwater can be added to animal feed or used in the ethanol fermentation. (Standards, 1994)

The corn mixture leaving the steep tanks is referred to as slurry.

Step 2: Germ and Gluten Separation

Cyclone separators, similar to centrifuges, physically separate low density corn germ from the slurry. Remaining starch is washed off of the germs. The germs undergo a process of mechanical and chemical extractions to separate the oil from the germ. Oil is refined before being packaged as corn oil, while germ residue is used as a component of animal feed. (Corn Refiners Association)

Step 3: Grinding and Screening

Grinding and screening processes separate starch and gluten from more fibrous material, which is used as a component of animal feed (Standards, 1994).

Step 4: Starch Separation

Centrifuges separate the gluten from the starch, which is then “dewatered, dried, and added to the animal feed.” The slurry undergoes additional washing to remove any residual gluten. (Standards, 1994)

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[22] Sulfurous acid and/or sulfur dioxide prevent bacterial growth

The slurry is now pure base starch and can be further modified to corn starches, sweeteners, or ethanols.

Step 5: Syrup Conversion

Partial hydrolysis hydrolyzes the starch resulting in corn syrup (complete hydrolysis produces a corn sugar). Hydrolysis can be performed either with mineral acids, enzymes, or a combination of both (Standards, 1994); the tradeoff between cost of catalytic materials and efficiency of process is determined at the plant level.

Hydrolyzed corn syrups are decolorized with activated carbon and stripped of inorganic salt impurities via ion exchange resins in the refining process. Refined syrup passes through evaporators to achieve the desired level of concentration before being cooled, packed, stored, packed and shipped. (Standards, 1994)

Water Flow in Wet Milling

Corn wet milling is highly energy and water intensive (Ray, Kucera-Giener, & Retzlaff, 1986). The industry has spent years developing ways to reduce water inputs (Cicuttini, Kollacks, Brussels, Rekers, & Hardenberg, 1983). Minimizing water consumption reduces the energy load and helps improve product yields by reducing the amount of dewatering and evaporation needed (Galitsky, Ruth, & Worrell, 2003). To minimize water consumption, the industry uses what is known as the “countercurrent concept” (Galitsky, Ruth, & Worrell, 2003).

> “In this approach fresh water is introduced to the system at only one place, i.e. the last step, starch washing. The water recovered from starch washing is used in the previous step, and so on, so that the water in which corn steeps is the same water that was introduced during starch washing. In this way, the plants minimize water usage and energy required for evaporation and drying. The countercurrent concept is used with the various process steps as well.” (Galitsky, Ruth, & Worrell, 2003)

Wastewater Management in Wet Milling

While corn wet milling plants consume large amounts of water thereby generating waste-water, much of the process water is removed either in steepwater evaporators or dryers for the co-products from germ and gluten (Rausch, 2002). “Typically, 2.1 to 2.5 kg water per dry starch is used to remove residual protein from starch using multistage hydroclone systems. Since water introduced into the process is removed by evaporation, the amount of water used to wash starch is linked to evaporative capacity of the plant”. (Rausch, 2002) The waste load of steepwater has been cited to have a chemical oxygen demand (COD) as high as 200,000 mg/L (Ray, Kucera-Giener, & Retzlaff, 1986), a figure that far exceeds EPA permissible COD discharge (Exhibit E: Environmental Protection Act 2002: Standards for Effluent Discharge Regulations) of 120 mg/L, implying that wet milling plants have to treat waste steepwater.

Risks

Cost of raw materials

Production “is highly dependent on local… economics of agricultural raw materials” (Vuilleumier, 1993), and the price of commodity corn is the largest cost driver in the wet milling industry (Schenck F. , 2001). Therefore, any price spike in corn as a result of water risk can translate to dangerously thin margins for the corn wet milling industry. Competition with population growth and water consumption

Many sweetener facilities are located in the vicinity of urban areas and use the local municipal water source.

Regulation and Competition with Population Growth

The U.S. government currently has no limits on the volume of water a wet milling plant can consume. However, many corn wet milling plants are located near urban areas, some of which may experience increased water stress as population growth combines with increased consumption per capita and drought. This may result in either quantity limits or higher water prices.

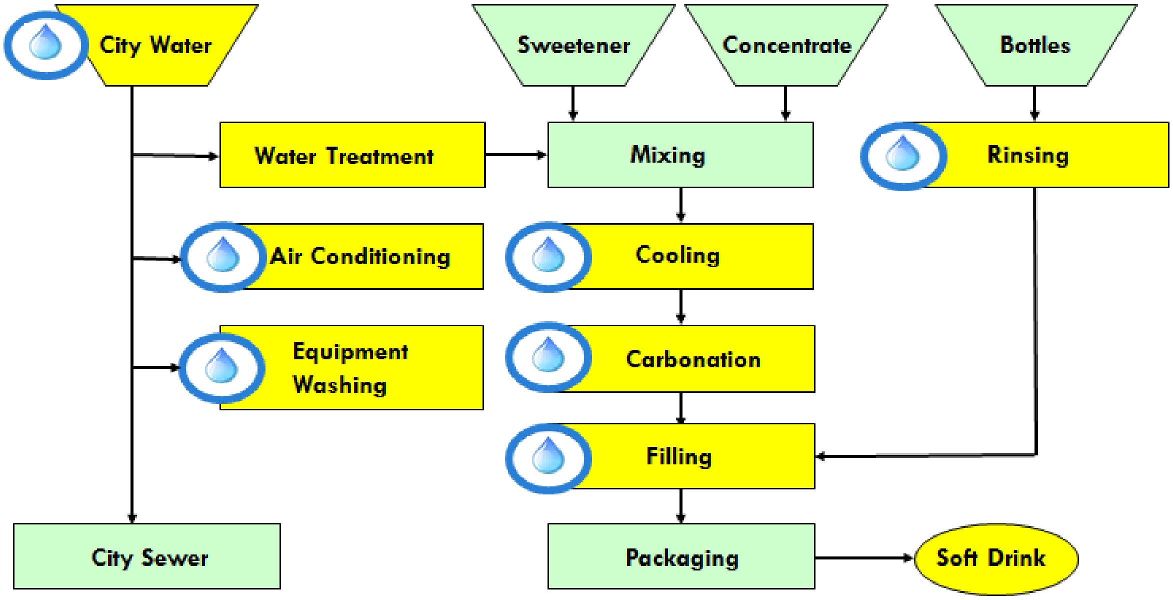
Discharge limits are set by the EPA and have been amended twice since enactment in the 1970s.

Opportunities

Opportunity exists for extant plants to be retrofitted with technological solutions to reduce the water footprint of corn sweeteners. Two such technological solutions include the application of membranes at various stages in the process and the addition of enzymes in the steeping phase in order to reduce steep time (and therefore water consumption). While retrofitting older corn sweetener plants to maximize efficiencies can be beneficial, greater opportunity for application of water-minimizing technologies exists when designing and building new facilities. Furthermore, new facilities can be located to optimize the tradeoffs of transportation (from farm to corn sweetener plant and corn sweetener plant to bottling plant) and contributing to water stress in certain geographical locations.

Additionally, using certain types of corn, specifically hybrids or GMOs, can result in more efficient processing.

Beverage Manufacturing *(Bottling)*



Industry Overview

The carbonated beverage industry is a $16 billion industry with 959 facilities located across the US. (IBISWorld, Soda Production In The US, 2012) Companies in this industry combine water with sweeteners and concentrates through a variety of processes before containerizing and distributing the beverages for consumer use. Though beverage companies use a variety of processes for creating beverages, the bottling process for a sweetened carbonated beverage is generally the same and illustrated in the figure above.

In this process water plays an essential, non-substitutable role. First, it is the primary ingredient for the beverage itself. Second, it is also utilized for introducing and mixing in additives, cleansing equipment, and facility-use.

Water Footprint

A typical bottling plant relies on the city where it is located for input water. This water comes into the plant and is used primarily for three different types of tasks – process, cooling and washing. Process water is water that is used as an ingredient in the beverage product. A regular carbonated beverage is comprised mostly of water, thus it stands to reason that process or ingredient water makes up the bulk of the water used within a bottling plant. In fact, based on our research and site visit, this number is close to 70%.

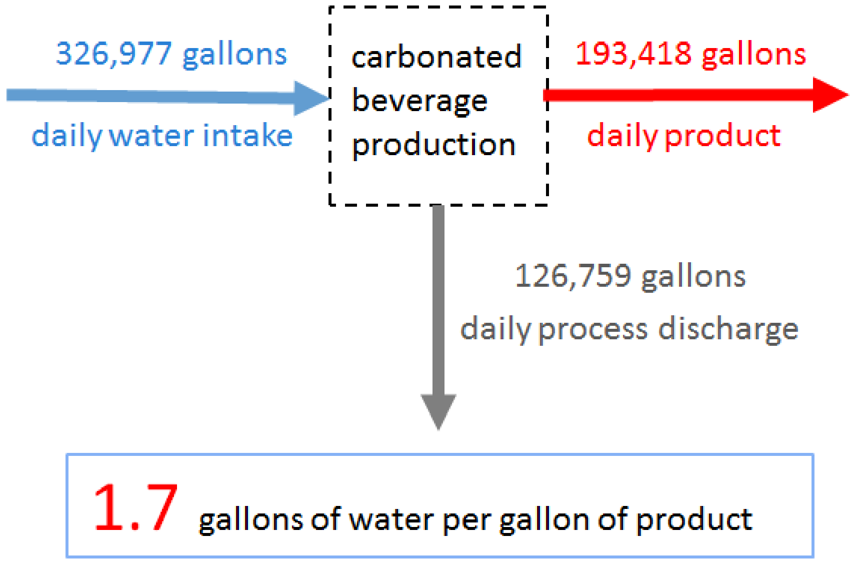
Water that is not used as an ingredient is either used for cooling or for washing plant equipment. Cooling is necessary for the ammonia refrigerant used to cool the mixed beverage prior to carbonation as well as to keep the entire plant at a reasonable temperature (depending on its location). Large-scale cooling is usually accomplished through the use of a recirculating cooling tower, which must occasionally blow down water into the city sewer and replace it with fresh make up water from the city. Cooling can account for anywhere between 10 – 20% of the total water use at a bottling plant.

The remainder of the water footprint comes from water required for washing plant equipment. Many bottling plants only have a single assembly line and therefore can only make one product at a time. Whenever there is a product change, the pipes need to be rinsed to ensure that there is no mixing of flavors. The intensity of the rinse can vary from 30 minutes for a simple change from Coca Cola to Cherry Coke to as much as 2 hours for a change from Dr. Pepper (which has a stronger flavor and odor) to another product. This means that the amount of water consumed for rinsing pipes can vary greatly depending on the setup of the particular bottling plant and the inventory philosophy being used. The plant we visited was required to use a Just-In-Time (JIT) approach, which meant frequent product changes and a lot of water consumed for rinsing.

In order to calculate the water footprint for the bottling plant, we looked at how much water the plant took in from the city compared to the volume of carbonated beverage that the plant produced on a monthly basis. We ignored water used for Dasani bottled water, which was also made at this particular plant but was not part of our scope. In order to account for seasonal variation with respect to cooling requirements and plant production levels, we looked at the plant data for a 12 month period and averaged the monthly totals to arrive at our input and output numbers.

Figure 10: Water Footprint of Beverage Manufacturing

Data obtained from Coca-Cola Bottling facility in Detroit, MI



The diagram above illustrates our results. We found that the plant required approximately 1.7 gallons of blue water for every gallon of product. In fact, Coca Cola has mandated a target ration of 1.7 for many of its plants, and has been working to steadily decrease this water use ratio over the past several years.

Risks

Bottling facilities face a variety of water risks across all three risk categories. In terms of physical risks, bottling facilities face two threats: having a constant and sufficient supply of water, and being able to prevent water-quality issues with its beverages or process effluent. As per-capita water consumption continues to rise in tandem with population this risk of physical scarcity is only likely to increase. Fortunately, however, as water treatment technologies and our understanding to the effects of contaminants in water continue to improve along with regulatory oversight, the likelihood of water-quality risks increasing is unlikely.

Aside from the physical risks beverage manufacturers face, they often face regulatory risk as well. Local governments or regulations may limit or prohibit water withdrawals. Additionally, local regulators may impose water usage or withdrawal fees, which would increase the price of water that companies would be required to pay – potentially forcing some beverage company locations to shut-down their operations.

In addition to the aforementioned risks, it‘s worth noting that water usage can expose a company to significant reputational risks. For example, in 2004, the Coca-Cola Company faced allegations that one of its facilities in India had played a role in depleting local water supplies. Regardless of the veracity of the allegations, Coca-Cola’s brand was tarnished and the company’s multi-million dollar facility was temporarily shut-down until the issue was resolved. In yet another instance, Nestle encountered significant negative press after seeking to open a water bottling facility near the Great Lakes in Michigan. The company was challenged by opponents claiming opening the bottling facility would promote the redistribution of Great Lake' waters outside its natural water basin, thereby damaging the Great Lakes' ecosystems and the lands its waters support over the long term.

Opportunities

To identify and examine where opportunities may exist to further reduce water consumption at beverage manufacturing facilities it is useful to break down water use into the aforementioned categories of process, cooling, and washing.

Since water is the primary ingredient in sweetened carbonated beverages, reducing process water requirements is extremely challenging for beverage manufacturers. The reduction opportunities that exist at this stage fall into one of two categories: optimizing the amount of water used to process other ingredients during the production process or adjusting the formula of the beverage to require less water input per container, which could be done by substituting or adding ingredients to the beverage that have a lower water footprint than the amount of process water the ingredients would displace.

In regards to cooling water, in cases where facilities are using large-scale cooling towers opportunities may exist to reduce water consumption further by analyzing how the cooling towers and process are configured. Minimizing blow-down by optimizing concentration ratio or obtaining water for the cooling-towers from alternative sources, such as effluent from other facility processes that meet the cooling towers' treatment requirements (Federal Energy Management Best Practices: Cooling Tower Management).

Potential opportunities to reduce water consumption also exist for the washing process. Here there are two principal opportunities. First, adjusting a facility's inventory policy or production-line change schedule may have substantial affects. Inventory policies have a direct effect on the frequency of line-change requirements, and while increasing inventory levels for products are likely to affect beverage manufacturers in other ways, the change would reduce the number of washings facilities needed to conduct. Similarly, depending on a facility's operations it may be possible to optimize the production-line change schedule to reduce the number of required washings. Secondly, beverage manufacturers can seek out non-water based equipment cleaning methods. While these methods may be more expensive, they would reduce a beverage manufacturing facility's water footprint.

Water Pricing Risk

One of the greatest water risks in any manufacturing supply chain is the risk of an increase in water tariffs. A water tariff is a price assigned to water supplied by a public utility through a piped network to its customers. The term is also often applied to wastewater tariffs. Water and wastewater tariffs are not charged for water itself, but to recover the costs of water treatment, water storage, transporting it to customers, collecting and treating wastewater, as well as billing and collection. Water tariffs vary widely in their structure and level between countries, cities and sometimes between user categories (residential, commercial, industrial or public buildings). In many developing countries tariffs are set below the level of cost recovery. In developed countries water and, to a lesser degree, wastewater tariffs are typically set close to or at the level of cost recovery, sometimes including an allowance for profit.

Tariff Structures

The four most common water tariff structures are:

- Flat rate – In a non-metered environment, customers pay a flat rate regardless of their consumption. This can be uniform or differentiated based on customer characteristics, season, etc.

- Single volumetric rate – In a metered environment, a single rate per cubic meter is applied regardless of volume consumed. This can be uniform or vary according to customer characteristics.
- Increasing block tariff (IBT) - The volumetric charge changes in steps with increasing volumes consumed.
- Decreasing block tariff - Volumetric rates decline with successive higher consumption blocks.

The International Benchmarking Network for Water and Sanitation Utilities (IBNET) collects water tariff data worldwide. Sample water tariff data for 20 major cities collected by IBNET is summarized below. Most of this data is for residential rates, but we can use it as an approximation for industrial rates.

Country	City	Utility	Water ($US/m^3)	Wastewater ($US/m^3)	Total Tariff ($US/m^3)
Canada	Vancouver	City of Vancouver Engineering Services	4.17	1.64	5.81
Canada	Calgary	City of Calgary Water Services	2.29	1.47	3.76
United States	Los Angeles	Los Angeles Dept of Water and Power	0.77	1.24	2.00
United States	Houston	Dept of Public Works and Engineering	2.86	3.54	6.39
United States	Detroit	Detroit Water and Sewerage Dept	0.92	2.21	3.13
Mexico	Mexico City	Sistema de Aguas de la Ciudad de Mexico	2.97	0.26	3.23
Chile	Santiago	Ministerio de Econom’a, Fomento y Reconstrucci-n, Aguas Andinas S.A.	0.67	0.73	1.39
South Africa	Cape Town	City of Cape Town Water Dept	0.58	0.95	1.53
Israel	Jerusalem	Hagihon	2.91	1.89	4.80
United Kingdom	London	Thames Water	2.45	1.20	3.65
Spain	Madrid	Canal de Isabel II	1.43	1.13	2.56
France	Paris	Compagnie des Eaux de Paris	2.40	1.47	3.88
Russia	Moscow	Mosvodokanal Moscow Public Utility Enterprise	0.82	0.59	1.41
Australia	Sydney	Sydney Water	2.88	3.05	5.93
Australia	Brisbane	Queensland Urban Utilities	3.61	2.81	6.41

India	Mumbai	Municipal Corporation of Greater Mumbai	0.08	0.05	0.12
Philippines	Manila	Manila Water	0.25	0.07	0.32
Japan	Tokyo	Bureau of Waterworks	0.72	4.29	5.00
South Korea	Seoul	Arisu	1.09	0.15	1.24
China	Shanghai	Shanghai Chentou Corp	0.31	0.20	0.51

(IBNET International Benchmarking Network for Water and Sanitation Facilities)

Most people rarely pay attention to their water bill because water tariffs pale in comparison to those on electricity. However, many industrial users of water use an incredible amount of water daily. In fact, nearly every single industry in the world requires water for its operations. Both sweetener manufacturing plants and bottling plants are amongst the largest industrial consumers of water. Based on our site visits, a mid-size sweetener plant requires approximately 3 million gallons of water per day and a mid-size bottling plant requires approximately 300,000 gallons of water daily. If we use the water tariff rates for Los Angeles above (\$2.00 per cubic meter = \$0.0075 per gallon) and assume that the plants operate 365 days per year, the annual water bill comes out to around \$8 million dollars for the sweetener manufacturing plant and more than \$800,000 for the bottling plant. Even a relatively small increase in the water tariff on the order of 10% would result in a noticeable cost increase.

Global Water Intelligence conducts an annual survey of water tariffs across the world. The data includes water tariffs, wastewater tariffs, combined tariffs, and change in combined tariffs for numerous countries and over 250 cities worldwide going back to 2007. The 2008 GWI survey data indicated that approximately 150 of the 261 cities surveyed increased their combined water and wastewater tariffs from 2007. Many water-scarce cities are starting to pass the additional costs on to customers. Examples of large cities with significant increases in tariffs can be seen in the table below.

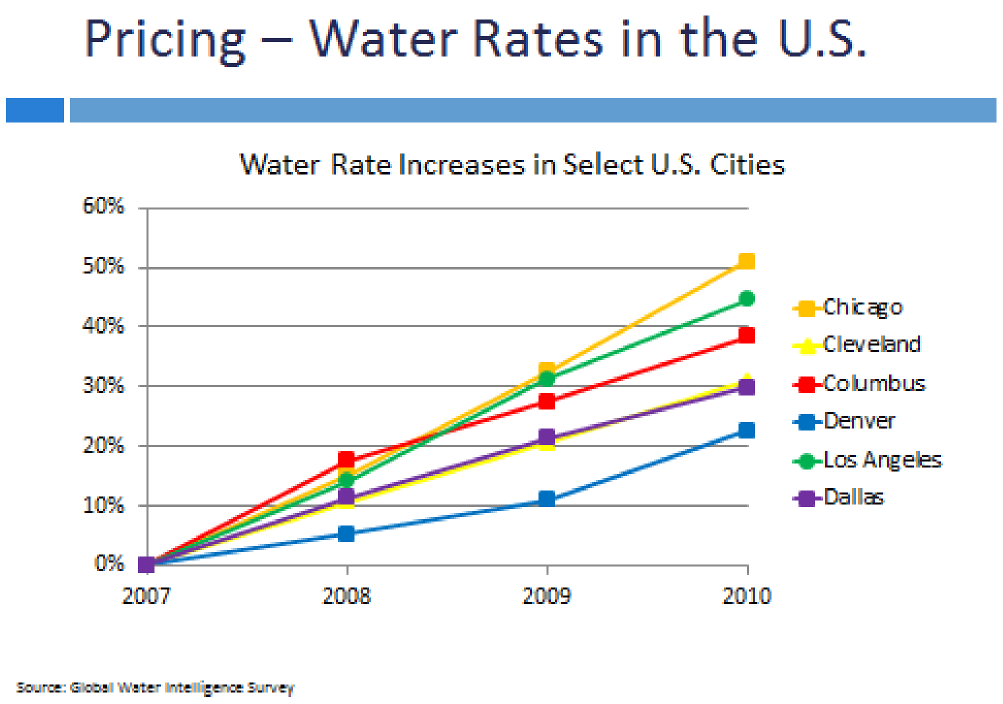
City	**Country**	**% change**	**US\$/m^3**

Ankara	Turkey	+19.5%	$1.87
Brisbane	Australia	+12.6%	$3.75
Chongqing	China	+26.7%	$0.51
Istanbul	Turkey	+46.4%	$2.44
Krakow	Poland	+10.2%	$2.32
Melbourne	Australia	+20.1%	$3.17
Monterrey	Mexico	+14.8%	$0.42
Moscow	Russia	+19.1%	$0.82
New Delhi	India	+14.4%	$0.09
Odessa	Ukraine	+20.0%	$0.56
Santiago de Chile	Chile	+12.7%	$1.15
Stockholm	Sweden	+19.3%	$1.87
Tel Aviv	Israel	+11.1%	$1.62
Toronto	Canada	+10.2%	$1.64
Warsaw	Poland	+33.3%	$3.14

(Global Water Intelligence)

In fact, water tariffs in most cities across the United States are expected to continue to rise over the coming years as the country struggles to find funding to replace its aging water infrastructure. The Environmental Protection Agency estimated that the United States has a water infrastructure gap in the hundreds of billions of dollars. That is not a problem that can be solved overnight. Whereas other countries may face rising water tariffs as a result of water scarcity and rapid population growth, the United States is set to face rising water tariffs regardless of what happens with its climate or population.

The graph below illustrates the disconcerting trends in water tariffs across six major cities in the United States between 2007 and 2010. Each of these cities is either near a sweetener manufacturing plant or the site of a major carbonated beverage bottling plant.



Pricing – Water Rates in the U.S.

Water Rate Increases in Select U.S. Cities

Source: Global Water Intelligence Survey

Recommendations and Conclusion

Based on the research and analysis conducted on water usage and risk throughout the beverage industry value chain, several recommendations can be made.

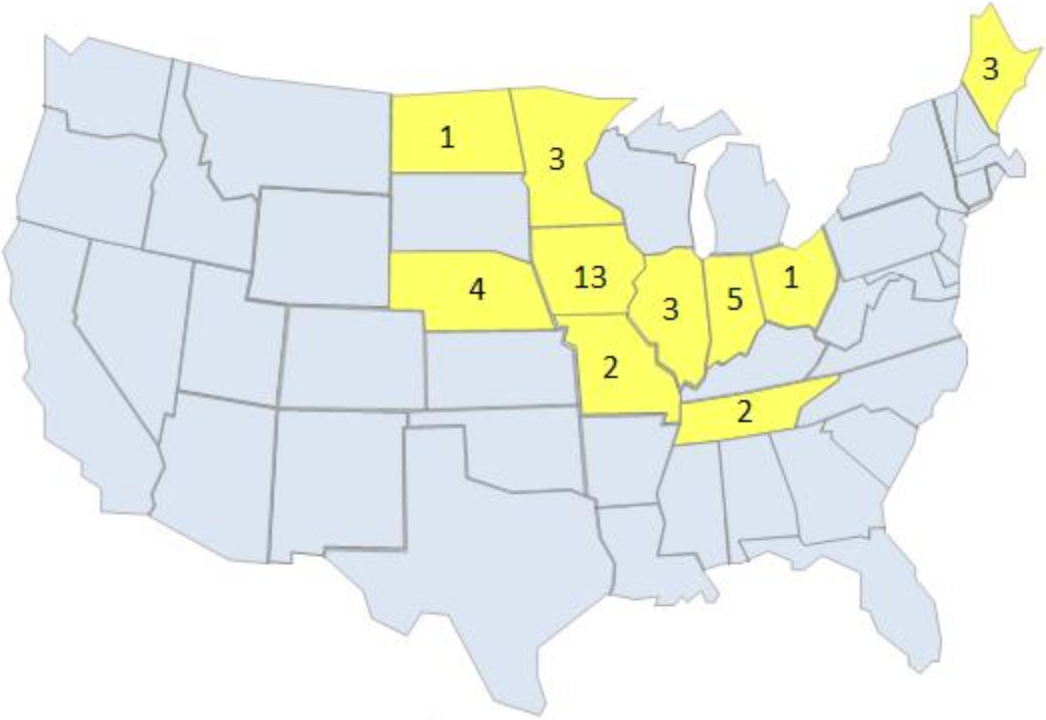
First, technological solutions can be developed and applied to mitigate the risk of water scarcity and poor water quality. Specifically, technologies such as drought-tolerant or water efficient seeds, higher efficiency irrigation equipment, and equipment for water treatment and re-use would address these risks.

Second, to accelerate the development and adoption of these technological solutions, it is recommended an emphasis be placed on partnerships. While business to business partnerships may be potentially beneficial in this regard, it is recommended a focus be placed on establishing and leveraging public-private partnerships, in addition to business to business partnerships. In with other forms of partnership, public-private partnerships offer companies the unique opportunity to influence environmental policy and align technologies with market incentives and policy initiatives such as incentivizing responsible water withdrawal or adopting agricultural effluent standards. In addition to mitigating scarcity and quality risks, it should be noted that forging public-private partnerships also presents the opportunity to mitigate regulatory and reputational risks through proactive engagement.

Third, to improve the abilities of organizations to recognize and seize opportunities and address challenges it is recommended stakeholders focus on improving collaboration across their organizations and value chain. This holds true for all stakeholders. Doing so will contribute to accelerating the development and adoption of technological solutions as well as the formation of key partnerships to address water-related issues between stakeholders. For these reasons collaboration is a key enabler for beverage industry stakeholders and their partners.

In addition to the aforementioned recommendations, this research project was intended to be structured and conducted in a way that its approach could be adapted and applied to analyzing water usage and risk in non-beverage industries. To that end, it is recommended interested parties adopt, improve and apply our research to improve the understanding of water usage and risk, and opportunities for use reduction and risk mitigation in other industries. By doing so, our team hopes our efforts will contribute to reduced water foot prints and risks.

Exhibit A: Wet Milling Locations (2007 census data)[3]



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[3] http://www.census.gov/econ/industry/geo/g311221.htm,

Exhibit B: Wet Milling Plants by Company and State (1994 EPA data)

In 1994, the EPA used a written communication from a contact at the US Corn Refiners Association to identify corn wet milling facilities in the US by state and by company. Note that the industry has undergone major consolidation since 1994, with four companies (ADM, Cargill, Tate & Lyle, and Ingredion (formerly Corn Products) controlling the market.

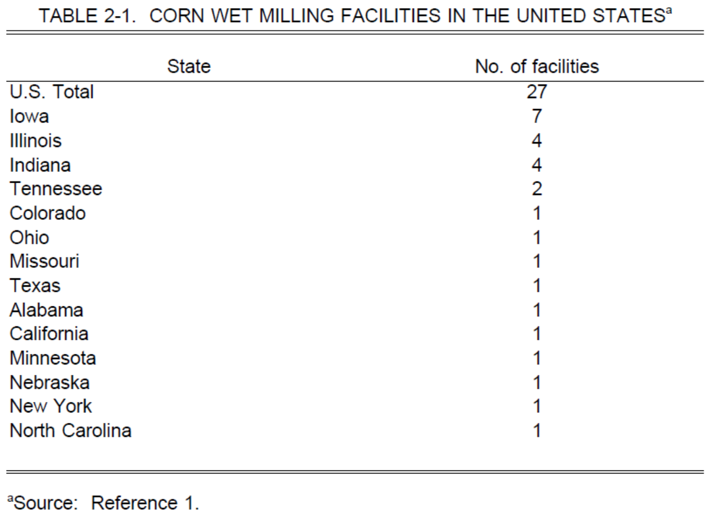


TABLE 2-1. CORN WET MILLING FACILITIES IN THE UNITED STATES[a]

State	No. of facilities
U.S. Total	27
Iowa	7
Illinois	4
Indiana	4
Tennessee	2
Colorado	1
Ohio	1
Missouri	1
Texas	1
Alabama	1
California	1
Minnesota	1
Nebraska	1
New York	1
North Carolina	1

[a] Source: Reference 1.

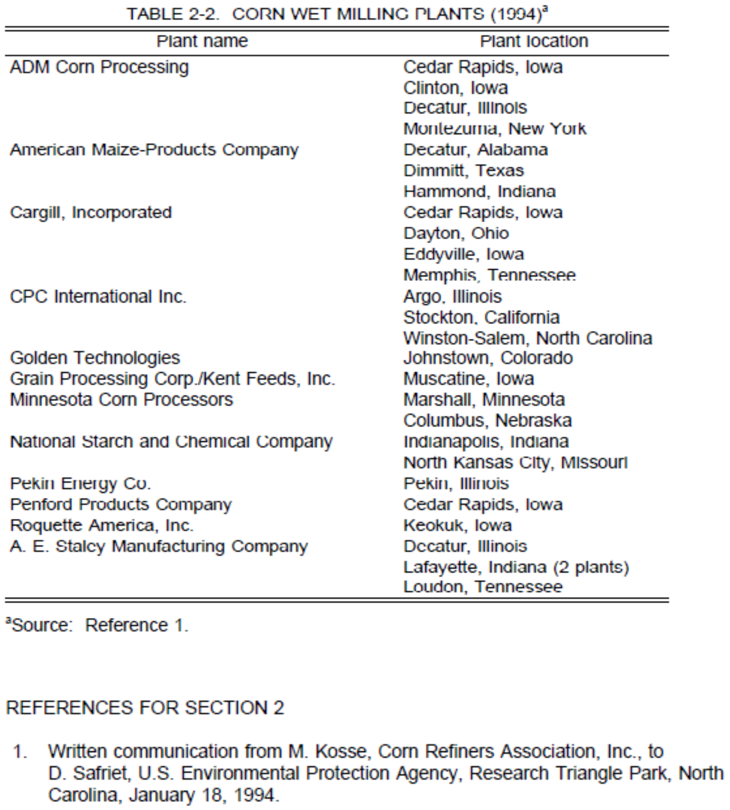


TABLE 2-2. CORN WET MILLING PLANTS (1994)[a]

Plant name	Plant location
ADM Corn Processing	Cedar Rapids, Iowa Clinton, Iowa Decatur, Illinois Montezuma, New York
American Maize-Products Company	Decatur, Alabama Dimmitt, Texas Hammond, Indiana
Cargill, Incorporated	Cedar Rapids, Iowa Dayton, Ohio Eddyville, Iowa Memphis, Tennessee
CPC International Inc.	Argo, Illinois Stockton, California Winston-Salem, North Carolina
Golden Technologies	Johnstown, Colorado
Grain Processing Corp./Kent Feeds, Inc.	Muscatine, Iowa
Minnesota Corn Processors	Marshall, Minnesota Columbus, Nebraska
National Starch and Chemical Company	Indianapolis, Indiana North Kansas City, Missouri
Pekin Energy Co.	Pekin, Illinois
Penford Products Company	Cedar Rapids, Iowa
Roquette America, Inc.	Keokuk, Iowa
A. E. Staley Manufacturing Company	Decatur, Illinois Lafayette, Indiana (2 plants) Loudon, Tennessee

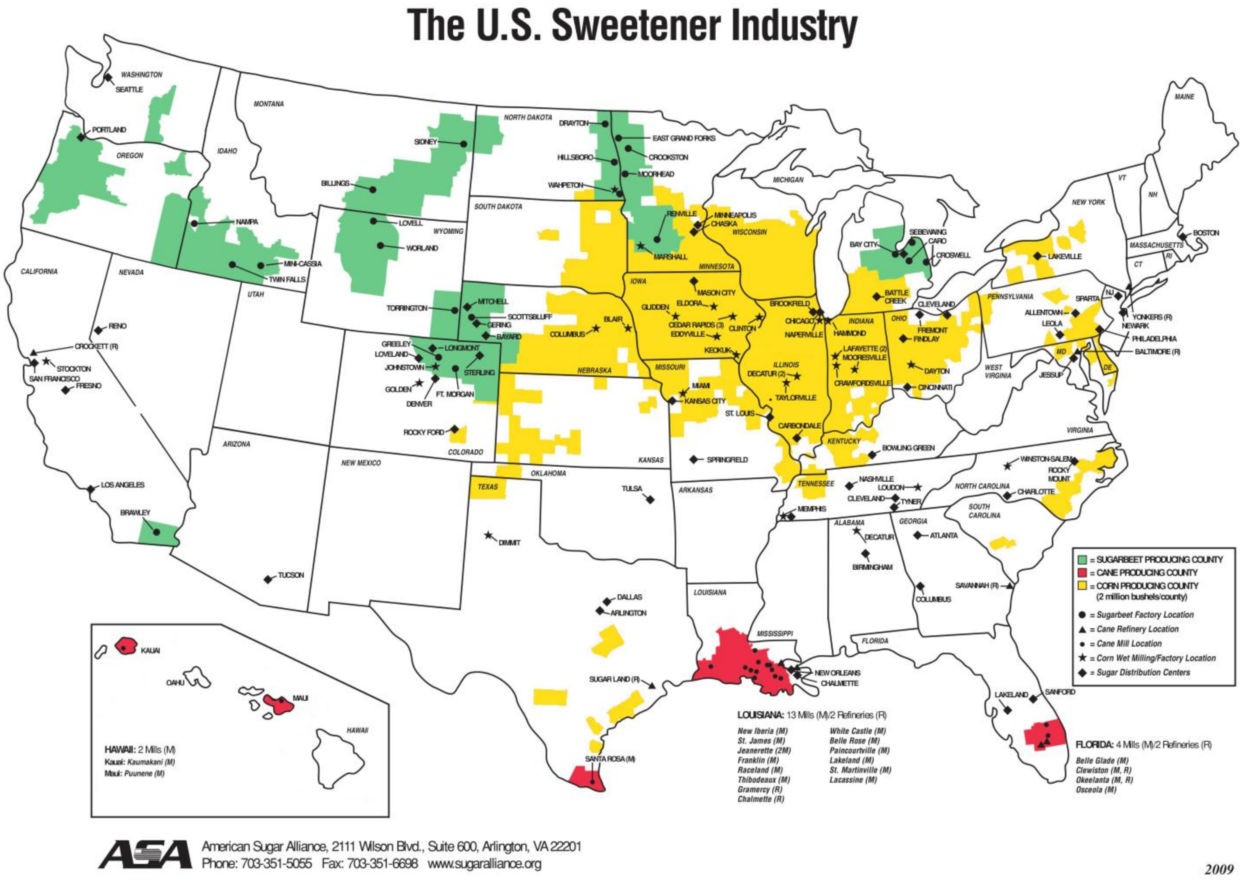
[a] Source: Reference 1.

REFERENCES FOR SECTION 2

1. Written communication from M. Kosse, Corn Refiners Association, Inc., to D. Safriet, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, January 18, 1994.

Exhibit C: Sweetener Industry Map, 2009[4]

Corn wet milling facilities are denoted with stars.



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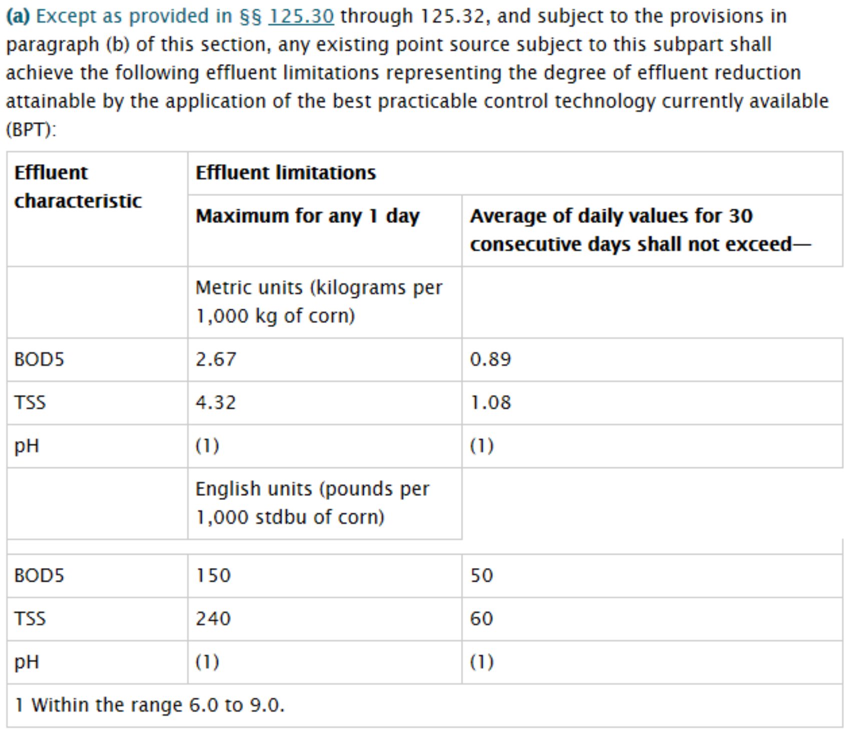
[4] http://www.sugaralliance.org/images/stories/AmericanSugar/asa.industry.map.2009.jpg

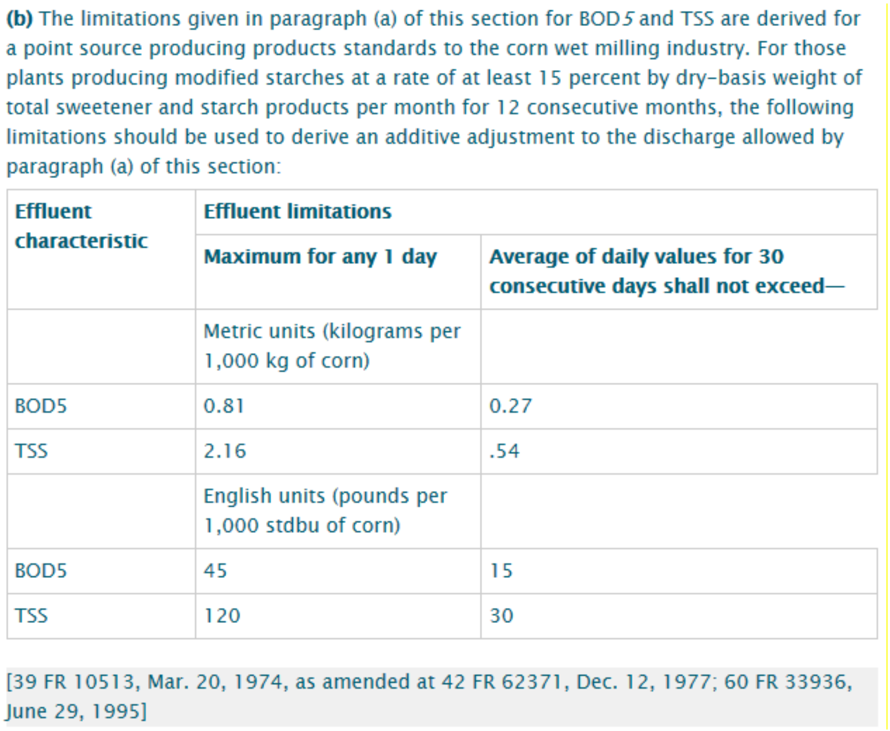
Exhibit D: EPA Wet Milling Effluent Limits[5]

Effluent limits for corn wet milling manufacturing facilities, as defined by the EPA in 40 CFR 406.12, were set in 1974 and amended in 1977 and 1995.



(a) Except as provided in §§ 125.30 through 125.32, and subject to the provisions in paragraph (b) of this section, any existing point source subject to this subpart shall achieve the following effluent limitations representing the degree of effluent reduction attainable by the application of the best practicable control technology currently available (BPT):

Effluent characteristic	**Effluent limitations**	
	Maximum for any 1 day	**Average of daily values for 30 consecutive days shall not exceed—**
	Metric units (kilograms per 1,000 kg of corn)	
BOD5	2.67	0.89
TSS	4.32	1.08
pH	(1)	(1)
	English units (pounds per 1,000 stdbu of corn)	
BOD5	150	50
TSS	240	60
pH	(1)	(1)
1 Within the range 6.0 to 9.0.		



(b) The limitations given in paragraph (a) of this section for BOD*5* and TSS are derived for a point source producing products standards to the corn wet milling industry. For those plants producing modified starches at a rate of at least 15 percent by dry-basis weight of total sweetener and starch products per month for 12 consecutive months, the following limitations should be used to derive an additive adjustment to the discharge allowed by paragraph (a) of this section:

Effluent characteristic	**Effluent limitations**	
	Maximum for any 1 day	**Average of daily values for 30 consecutive days shall not exceed—**
	Metric units (kilograms per 1,000 kg of corn)	
BOD5	0.81	0.27
TSS	2.16	.54
	English units (pounds per 1,000 stdbu of corn)	
BOD5	45	15
TSS	120	30

[39 FR 10513, Mar. 20, 1974, as amended at 42 FR 62371, Dec. 12, 1977; 60 FR 33936, June 29, 1995]

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[5] http://www.law.cornell.edu/cfr/text/40/406/12

Exhibit E: Environmental Protection Act 2002: Standards for Effluent Discharge Regulations

Standards for Effluent Discharge Regulations

General Notice No.44.of 2003

THE ENVIRONMENT PROTECTION ACT 2002

Regulations made by the Minister under sections 39 and 96 of the Environment Protection Act 2002

1. These regulations may be cited as the Environment Protection (Standards for effluent discharge) Regulations
2003.

2. In these regulations -

(b)"effluent" means water sullied or contaminated by any matter, in solution or suspension and derived from the use of the water in connection with domestic, industrial or other activities;

"HWM" means the High Water Mark at spring tide;

"influent" means water diverted from a river, stream, spring, canal, underground or water supply network used in connection with any activity listed in the First Column of the First Schedule;

"parameter" means, in relation to an effluent, the characteristics or constituent elements set out in the Second Column of the First Schedule in respect of the corresponding activity set out in the First Column of the First Schedule;

"Wastewater system" –

(a) means a sewer, conduit, pump, engine or other appliance used or intended to be used for the reception, conveyance, removal, treatment and disposal of effluent; and

(b) does not include house sewers;

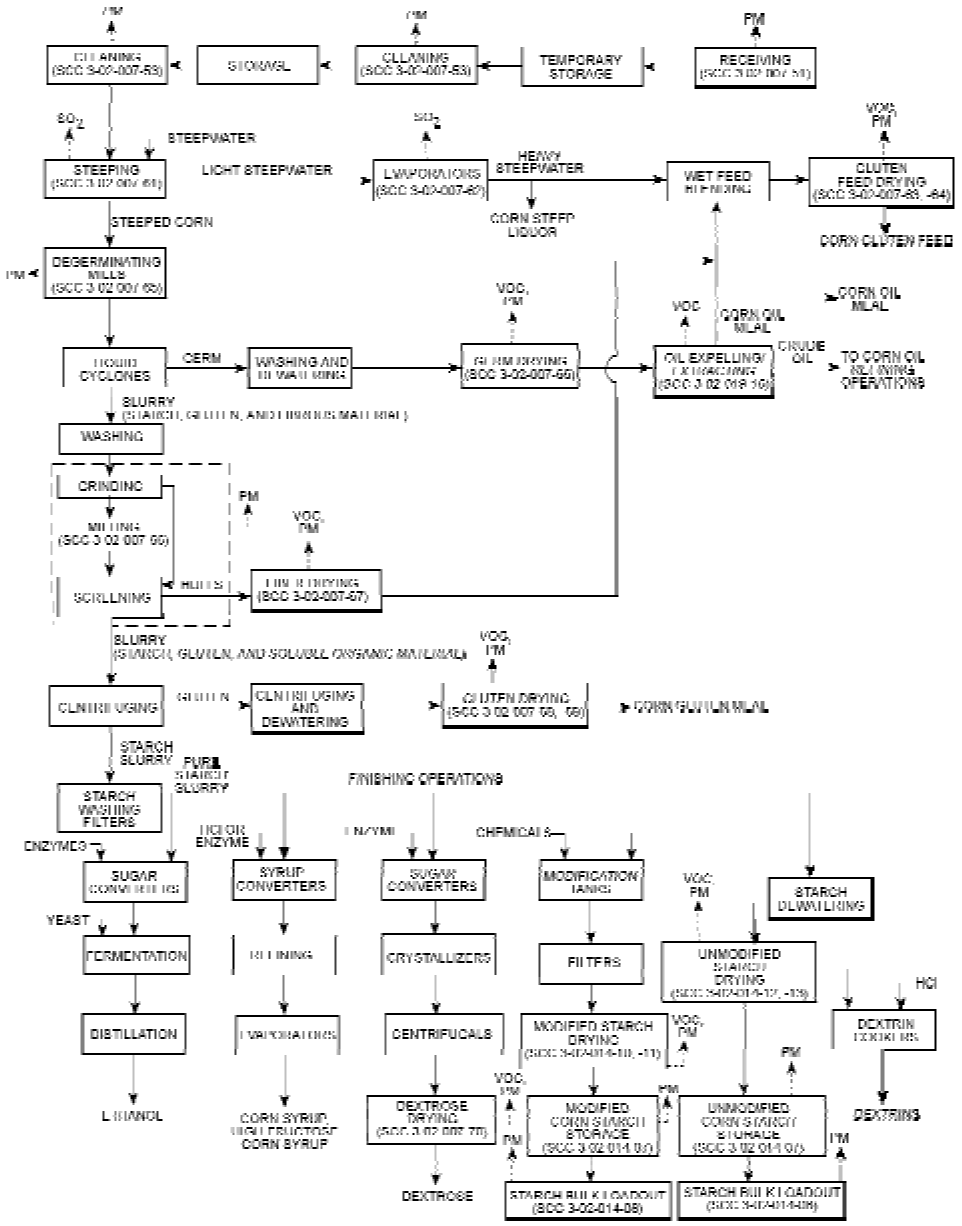


Figure 9.9.7-2. Corn wet milling process flow diagram.[1-4]
(Source Classification Codes in parentheses.)

“waterbody” includes a stream, a river, a canal, a lake, a pond, a reservoir, an estuary, a wetland and underground water;

“watercourse” means any natural or artificial channel, pipe or conduit, excluding the sewerage system, carrying, or that may carry, and discharging water directly or indirectly into a water body;

3.No person shall discharge effluent onto land, into a watercourse or into a waterbody unless he ensures that the parameters of the effluent do not exceed the permissible limits set out in the Second Schedule.

4.Notwithstanding regulation 3 or any other enactment, no person shall discharge or cause to be discharged any effluent into a waterbody or watercourse used or earmarked to be used for potable water supply.

5.Notwithstanding regulation 3, any person using an influent, the limits concentration or value of the any parameters of which exceeds the permissible limit for that parameter set out in the Second Schedule, shall ensure that the concentration or value of the parameters of in the effluent does not exceed those that of the influent.

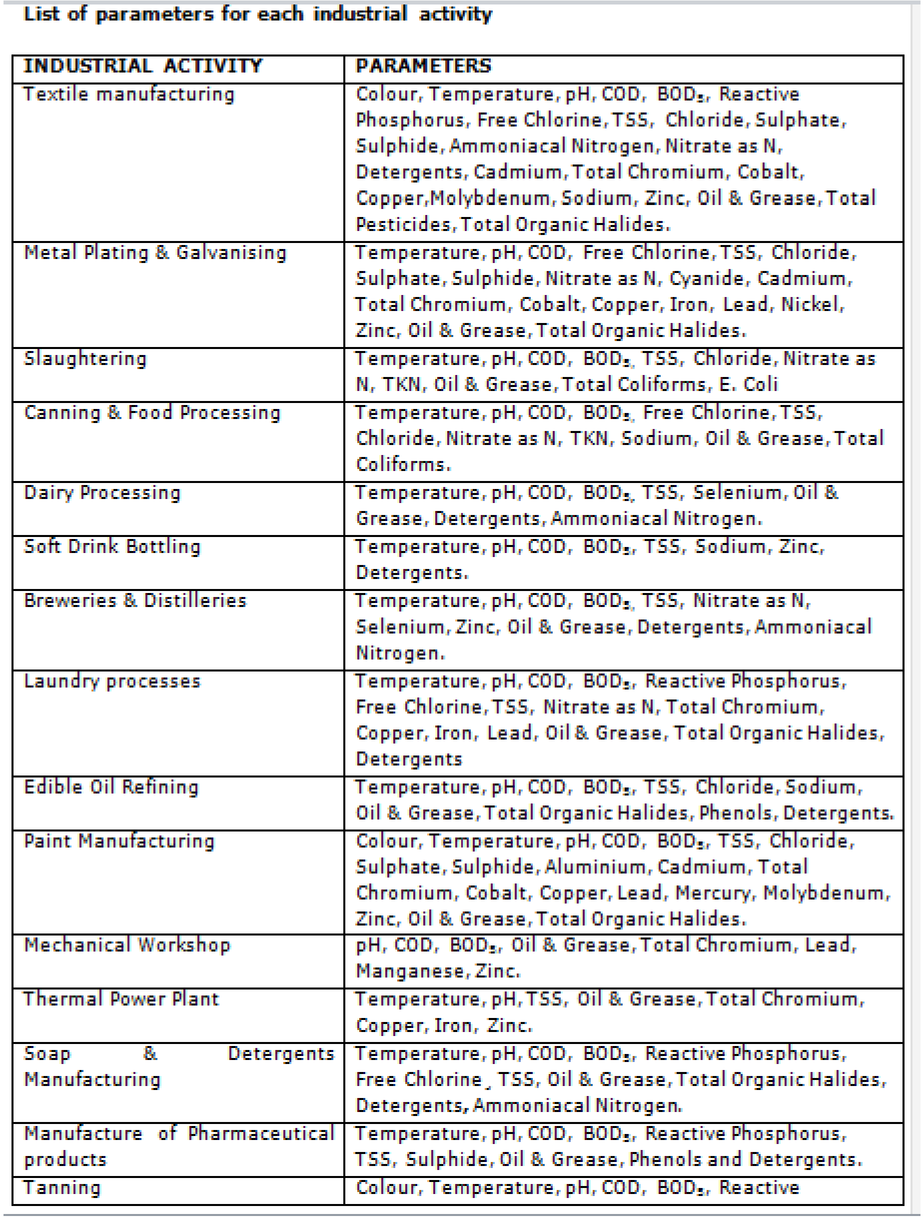
6.Any industry existing prior to the promulgation of these regulations and which is within a distance of 200 metres from the HWM shall comply with the permissible limits set out in the Third Schedule.

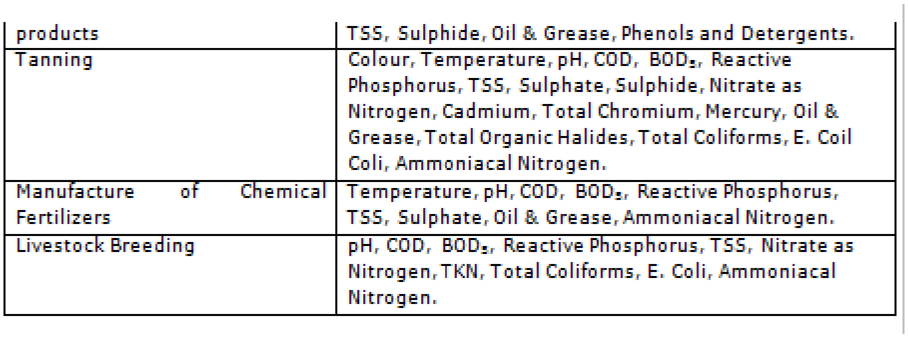
7.These regulations shall come into operation on 01 September 2003.

Made by the Minister on 05 February 2003

FIRST SCHEDULE

(regulation 2)





List of parameters for each industrial activity

INDUSTRIAL ACTIVITY	PARAMETERS
Textile manufacturing	Colour, Temperature, pH, COD, BOD_5, Reactive Phosphorus, Free Chlorine, TSS, Chloride, Sulphate, Sulphide, Ammoniacal Nitrogen, Nitrate as N, Detergents, Cadmium, Total Chromium, Cobalt, Copper,Molybdenum, Sodium, Zinc, Oil & Grease, Total Pesticides, Total Organic Halides.
Metal Plating & Galvanising	Temperature, pH, COD, Free Chlorine, TSS, Chloride, Sulphate, Sulphide, Nitrate as N, Cyanide, Cadmium, Total Chromium, Cobalt, Copper, Iron, Lead, Nickel, Zinc, Oil & Grease, Total Organic Halides.
Slaughtering	Temperature, pH, COD, BOD_5, TSS, Chloride, Nitrate as N, TKN, Oil & Grease, Total Coliforms, E. Coli
Canning & Food Processing	Temperature, pH, COD, BOD_5, Free Chlorine, TSS, Chloride, Nitrate as N, TKN, Sodium, Oil & Grease, Total Coliforms.
Dairy Processing	Temperature, pH, COD, BOD_5, TSS, Selenium, Oil & Grease, Detergents, Ammoniacal Nitrogen.
Soft Drink Bottling	Temperature, pH, COD, BOD_5, TSS, Sodium, Zinc, Detergents.
Breweries & Distilleries	Temperature, pH, COD, BOD_5, TSS, Nitrate as N, Selenium, Zinc, Oil & Grease, Detergents, Ammoniacal Nitrogen.
Laundry processes	Temperature, pH, COD, BOD_5, Reactive Phosphorus, Free Chlorine, TSS, Nitrate as N, Total Chromium, Copper, Iron, Lead, Oil & Grease, Total Organic Halides, Detergents
Edible Oil Refining	Temperature, pH, COD, BOD_5, TSS, Chloride, Sodium, Oil & Grease, Total Organic Halides, Phenols, Detergents.
Paint Manufacturing	Colour, Temperature, pH, COD, BOD_5, TSS, Chloride, Sulphate, Sulphide, Aluminium, Cadmium, Total Chromium, Cobalt, Copper, Lead, Mercury, Molybdenum, Zinc, Oil & Grease, Total Organic Halides.
Mechanical Workshop	pH, COD, BOD_5, Oil & Grease, Total Chromium, Lead, Manganese, Zinc.
Thermal Power Plant	Temperature, pH, TSS, Oil & Grease, Total Chromium, Copper, Iron, Zinc.
Soap & Detergents Manufacturing	Temperature, pH, COD, BOD_5, Reactive Phosphorus, Free Chlorine, TSS, Oil & Grease, Total Organic Halides, Detergents, Ammoniacal Nitrogen.
Manufacture of Pharmaceutical products	Temperature, pH, COD, BOD_5, Reactive Phosphorus, TSS, Sulphide, Oil & Grease, Phenols and Detergents.
Tanning	Colour, Temperature, pH, COD, BOD_5, Reactive Phosphorus, TSS, Sulphate, Sulphide, Nitrate as Nitrogen, Cadmium, Total Chromium, Mercury, Oil & Grease, Total Organic Halides, Total Coliforms, E. Coil Coli, Ammoniacal Nitrogen.
Manufacture of Chemical Fertilizers	Temperature, pH, COD, BOD_5, Reactive Phosphorus, TSS, Sulphate, Oil & Grease, Ammoniacal Nitrogen.
Livestock Breeding	pH, COD, BOD_5, Reactive Phosphorus, TSS, Nitrate as Nitrogen, TKN, Total Coliforms, E. Coli, Ammoniacal Nitrogen.

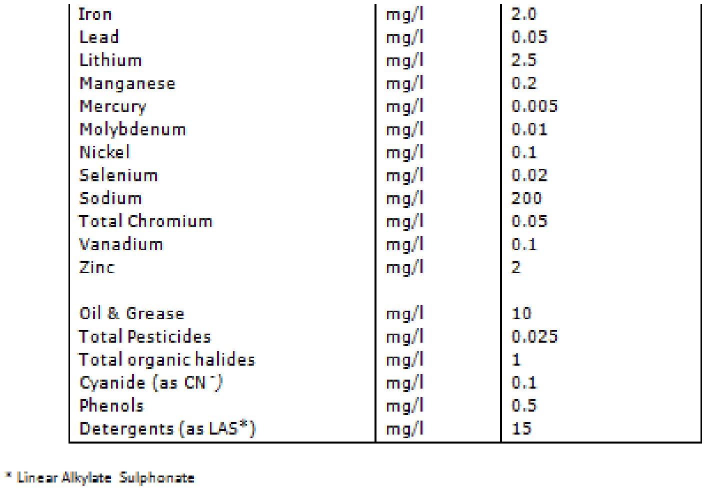
SECOND SCHEDULE

(regulation 4)

Effluent discharge Standards

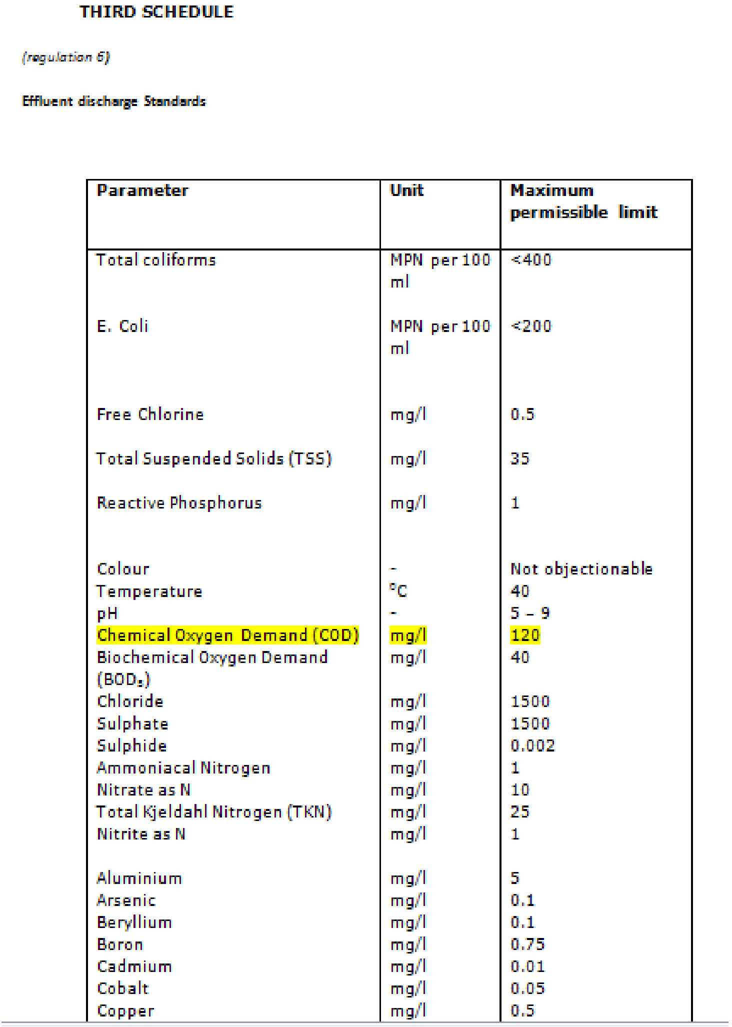
Parameter	**Unit**	**Maximum permissible limit**	
		Land/ Underground	**Surface water courses**
Total coliforms	MPN per 100 ml	-	<400
E. Coli	MPN per 100 ml	<1000	<200
Free Chlorine	mg/l	-	0.5
Total Suspended Solids (TSS)	l	45	35
Reactive Phosphorus	mg/l	10	1
	mg/l		
Colour	-	Not objectionable	
Temperature	°C	40	
pH	-	5 – 9	
Chemical Oxygen Demand (COD)	mg/l	120	
Biochemical Oxygen Demand (BOD_5)	mg/l	40	
Chloride	mg/l	750	
Sulphate	mg/l	750	
Sulphide	mg/l	0.002	
Ammoniacal Nitrogen	mg/l	1	
Nitrate as N	mg/l	10	
Total Kjeldahl Nitrogen (TKN)	mg/l	25	
Nitrite as N	mg/l	1	
Aluminium	mg/l	5	
Arsenic	mg/l	0.1	
Beryllium	mg/l	0.1	
Boron	mg/l	0.75	
Cadmium	mg/l	0.01	
Cobalt	mg/l	0.05	
Copper	mg/l	0.5	
Iron	mg/l	2.0	
Lead	mg/l	0.05	
Lithium	mg/l	2.5	
Manganese	mg/l	0.2	
Mercury	mg/l	0.005	
Molybdenum	mg/l	0.01	
Nickel	mg/l	0.1	
Selenium	mg/l	0.02	
Sodium	mg/l	200	
Total Chromium	mg/l	0.05	
Vanadium	mg/l	0.1	
Zinc	mg/l	2	
Oil & Grease	mg/l	10	
Total Pesticides	mg/l	0.025	
Total organic halides	mg/l	1	
Cyanide (as CN^-) *or Free cyanide*	mg/l	0.1	
Phenols	mg/l	0.5	
Detergents (as LAS*)	mg/l	15	

* Linear Alkylate Sulphonate



Iron	mg/l	2.0
Lead	mg/l	0.05
Lithium	mg/l	2.5
Manganese	mg/l	0.2
Mercury	mg/l	0.005
Molybdenum	mg/l	0.01
Nickel	mg/l	0.1
Selenium	mg/l	0.02
Sodium	mg/l	200
Total Chromium	mg/l	0.05
Vanadium	mg/l	0.1
Zinc	mg/l	2
Oil & Grease	mg/l	10
Total Pesticides	mg/l	0.025
Total organic halides	mg/l	1
Cyanide (as CN^-)	mg/l	0.1
Phenols	mg/l	0.5
Detergents (as LAS*)	mg/l	15

* Linear Alkylate Sulphonate



THIRD SCHEDULE

(regulation 6)

Effluent discharge Standards

Parameter	Unit	Maximum permissible limit
Total coliforms	MPN per 100 ml	<400
E. Coli	MPN per 100 ml	<200
Free Chlorine	mg/l	0.5
Total Suspended Solids (TSS)	mg/l	35
Reactive Phosphorus	mg/l	1
Colour	-	Not objectionable
Temperature	°C	40
pH	-	5 – 9
Chemical Oxygen Demand (COD)	mg/l	120
Biochemical Oxygen Demand (BOD$_5$)	mg/l	40
Chloride	mg/l	1500
Sulphate	mg/l	1500
Sulphide	mg/l	0.002
Ammoniacal Nitrogen	mg/l	1
Nitrate as N	mg/l	10
Total Kjeldahl Nitrogen (TKN)	mg/l	25
Nitrite as N	mg/l	1
Aluminium	mg/l	5
Arsenic	mg/l	0.1
Beryllium	mg/l	0.1
Boron	mg/l	0.75
Cadmium	mg/l	0.01
Cobalt	mg/l	0.05
Copper	mg/l	0.5

(Standards, 1994)

Exhibit G – Primary and Co-Product Yields per Bushel of Corn

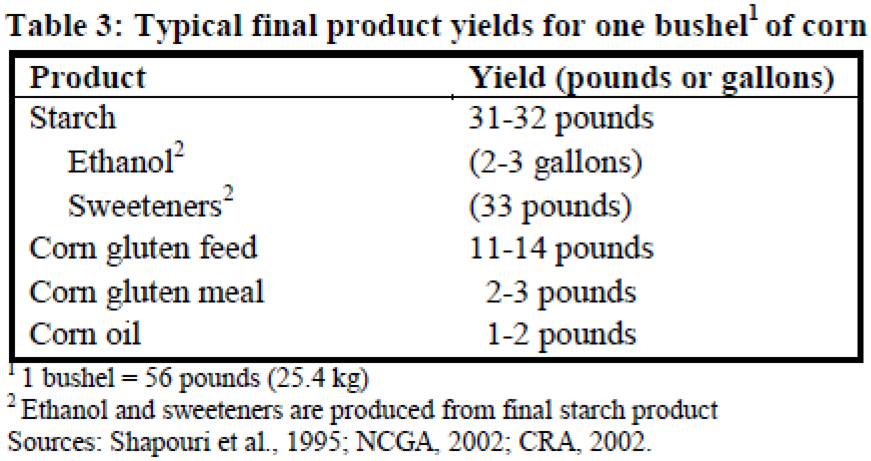


Table 3: Typical final product yields for one bushel[1] of corn

Product	Yield (pounds or gallons)
Starch	31-32 pounds
Ethanol[2]	(2-3 gallons)
Sweeteners[2]	(33 pounds)
Corn gluten feed	11-14 pounds
Corn gluten meal	2-3 pounds
Corn oil	1-2 pounds

[1] 1 bushel = 56 pounds (25.4 kg)

[2] Ethanol and sweeteners are produced from final starch product

Sources: Shapouri et al., 1995; NCGA, 2002; CRA, 2002.

(Galitsky, Ruth, & Worrell, 2003)

Figure 6: Typical final product % yields

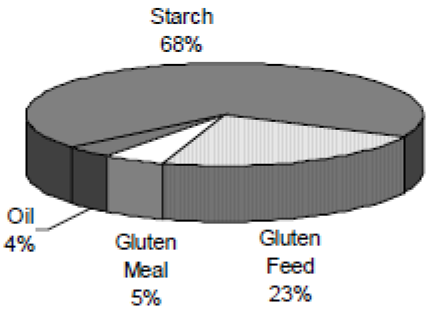
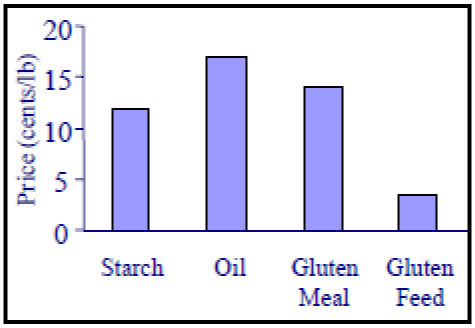


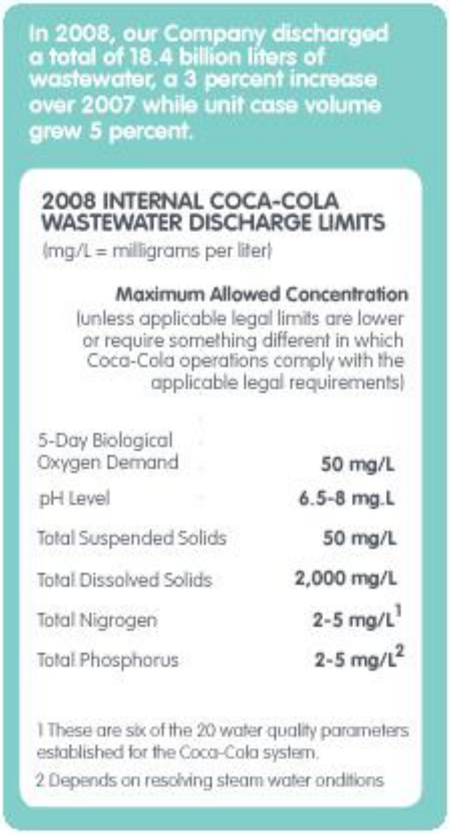
Figure 7: Corresponding current prices of products



Source: Eckhoff, 2002b

(Galitsky, Ruth, & Worrell, 2003)

Exhibit H – Select Coca Cola Internal Wastewater Discharge Limits



In 2008, our Company discharged a total of 18.4 billion liters of wastewater, a 3 percent increase over 2007 while unit case volume grew 5 percent.

2008 INTERNAL COCA-COLA WASTEWATER DISCHARGE LIMITS

(mg/L = milligrams per liter)

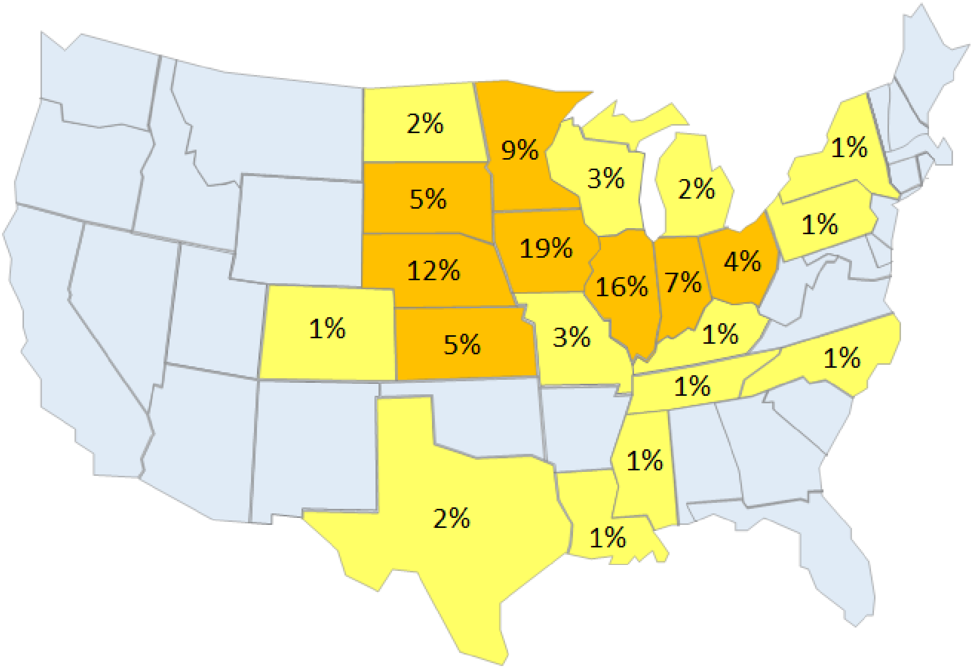
	Maximum Allowed Concentration (unless applicable legal limits are lower or require something different in which Coca-Cola operations comply with the applicable legal requirements)
5-Day Biological Oxygen Demand	**50 mg/L**
pH Level	**6.5-8 mg.L**
Total Suspended Solids	**50 mg/L**
Total Dissolved Solids	**2,000 mg/L**
Total Nigrogen	**2-5 mg/L**[1]
Total Phosphorus	**2-5 mg/L**[2]

1 These are six of the 20 water quality parameters established for the Coca-Cola system.

2 Depends on resolving steam water onditions

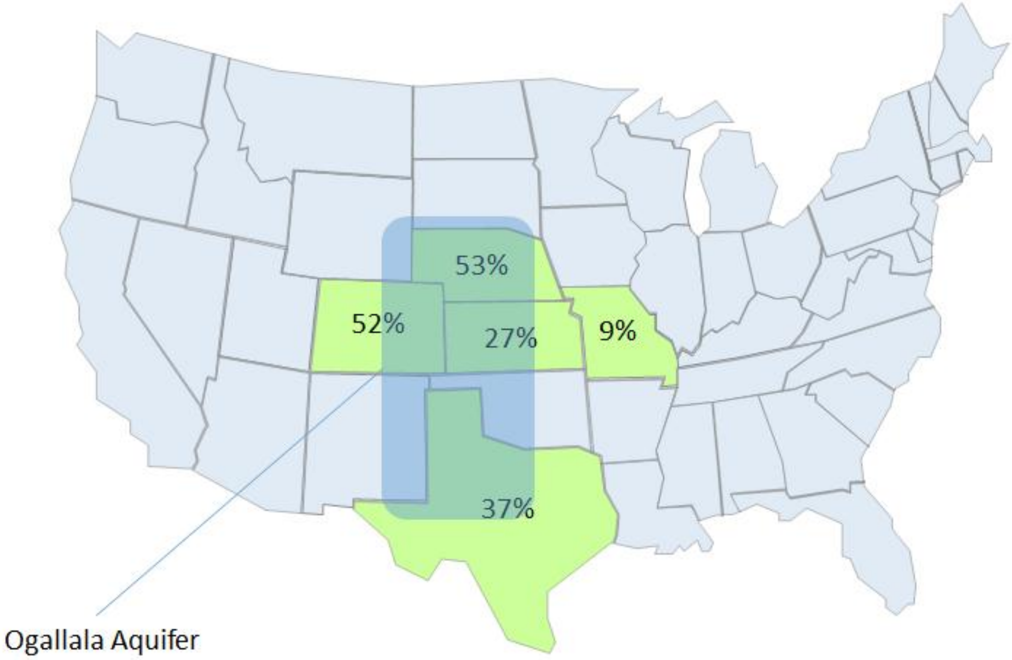
http://www.thecoca-colacompany.com/citizenship/global_awareness_action.html

Exhibit I – U.S. Corn Production by State



Data Source: USDA – ARMS, 2011.

Exhibit J - % of Corn Crop Irrigated by State



Data Source: USDA – ARMS, 2011.

Exhibit K - Total Withdrawal of Ground Water in the United States

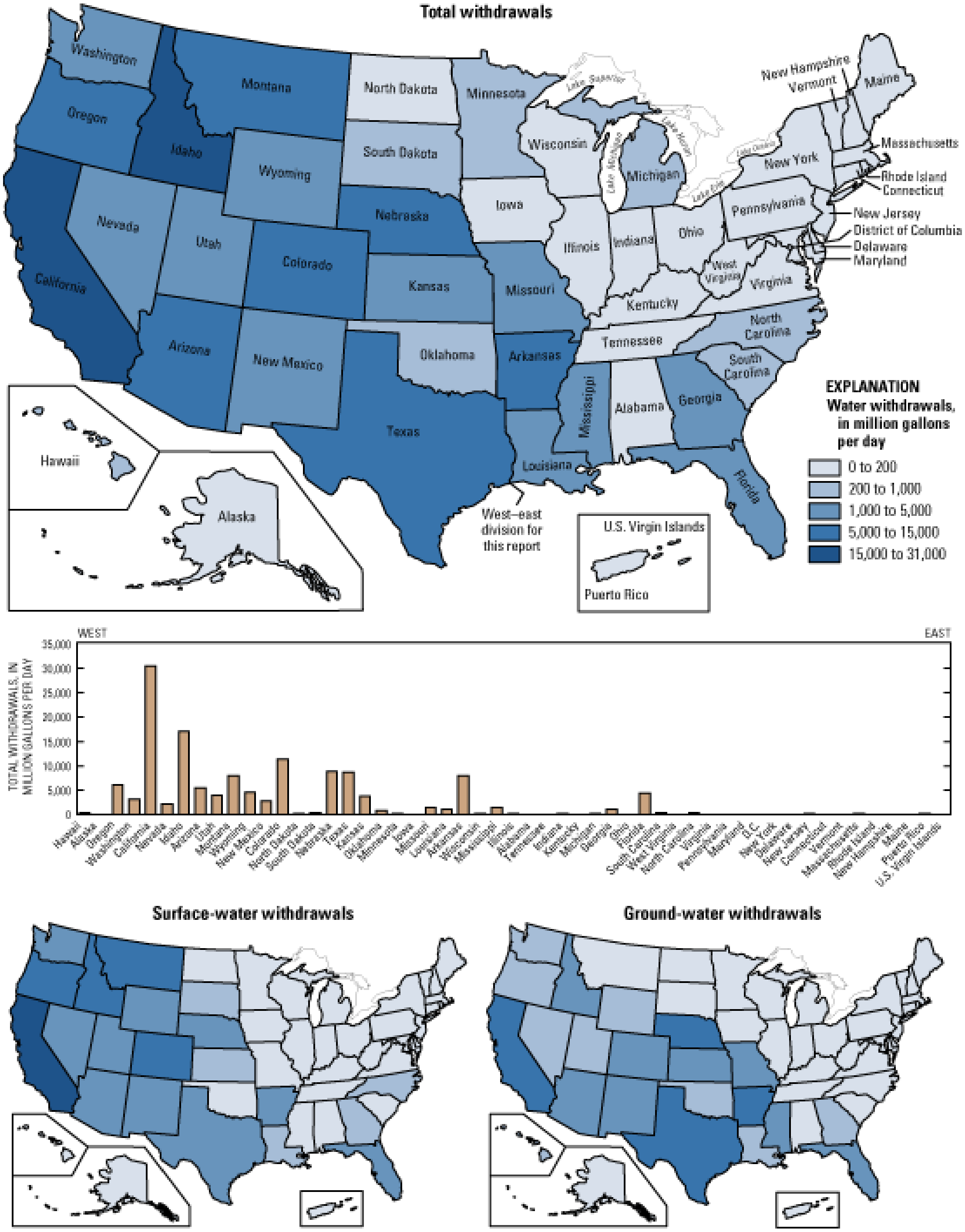


Exhibit L: Precipitation Changes over the Past Century

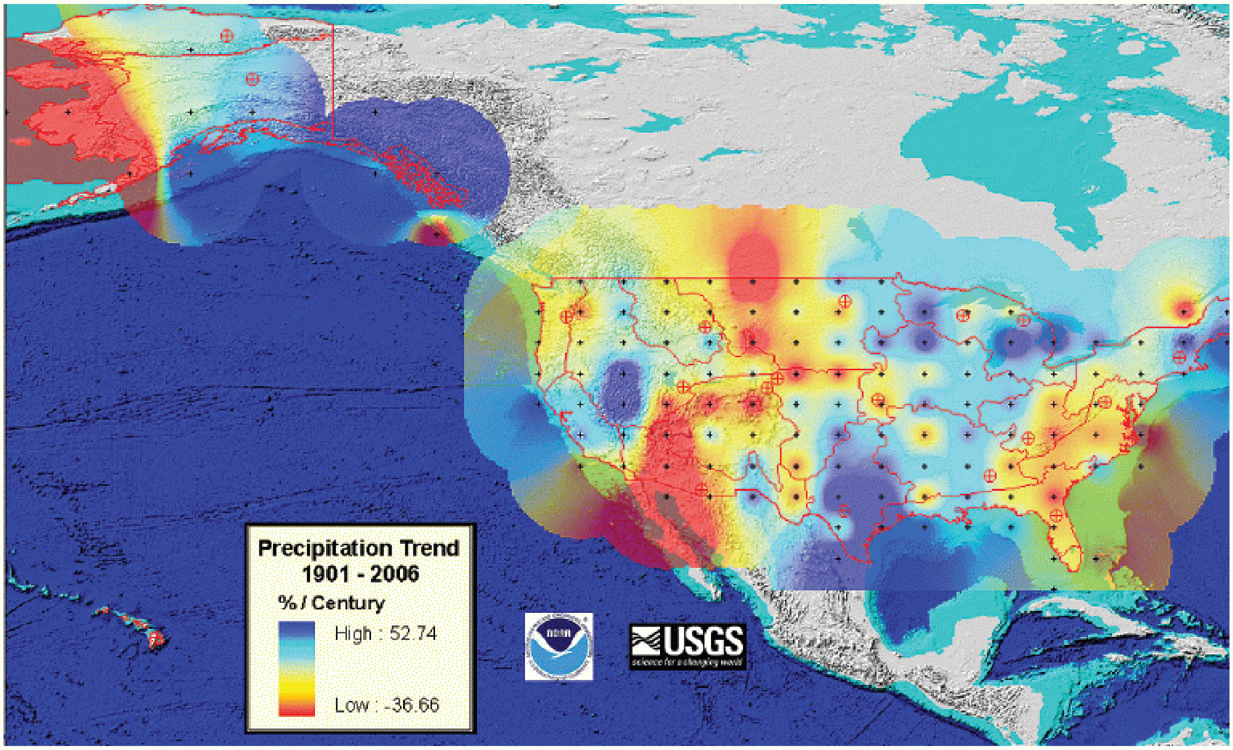


Figure 1.4 Precipitation changes over the past century from the same weather stations as for temperature. The changes are shown as percentage changes from the long-term average. Courtesy of NOAA's National Climate Data Center and the U.S. Geological Survey.

Backlund, Janetos and Schimel. The effects of climate change on agriculture, land resources, water resources, and biodiversity in the United States. Introduction, 16.

Exhibit M – Total Water Footprint of a 0.5 Liter PET- Bottle by Country

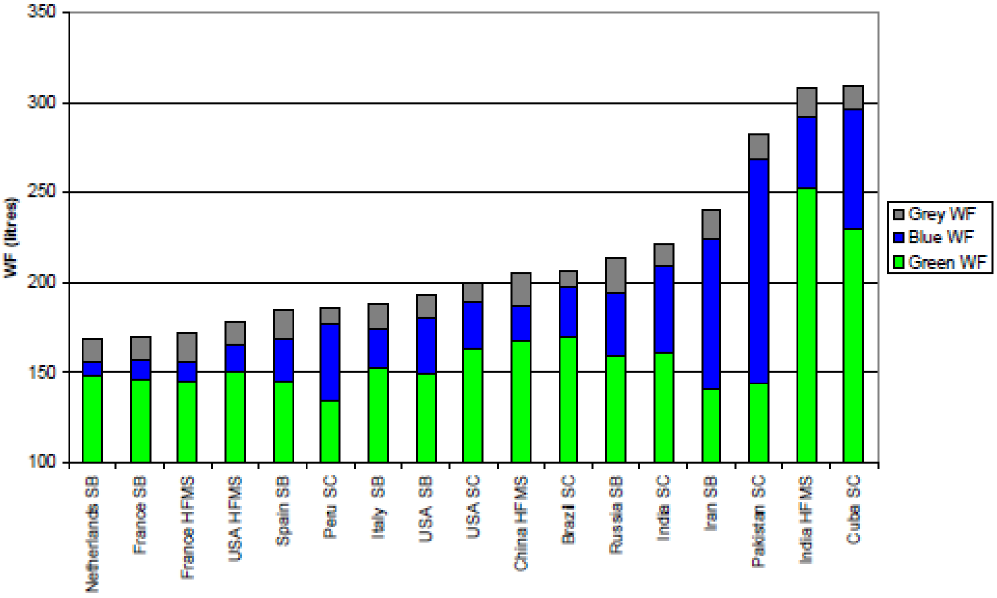
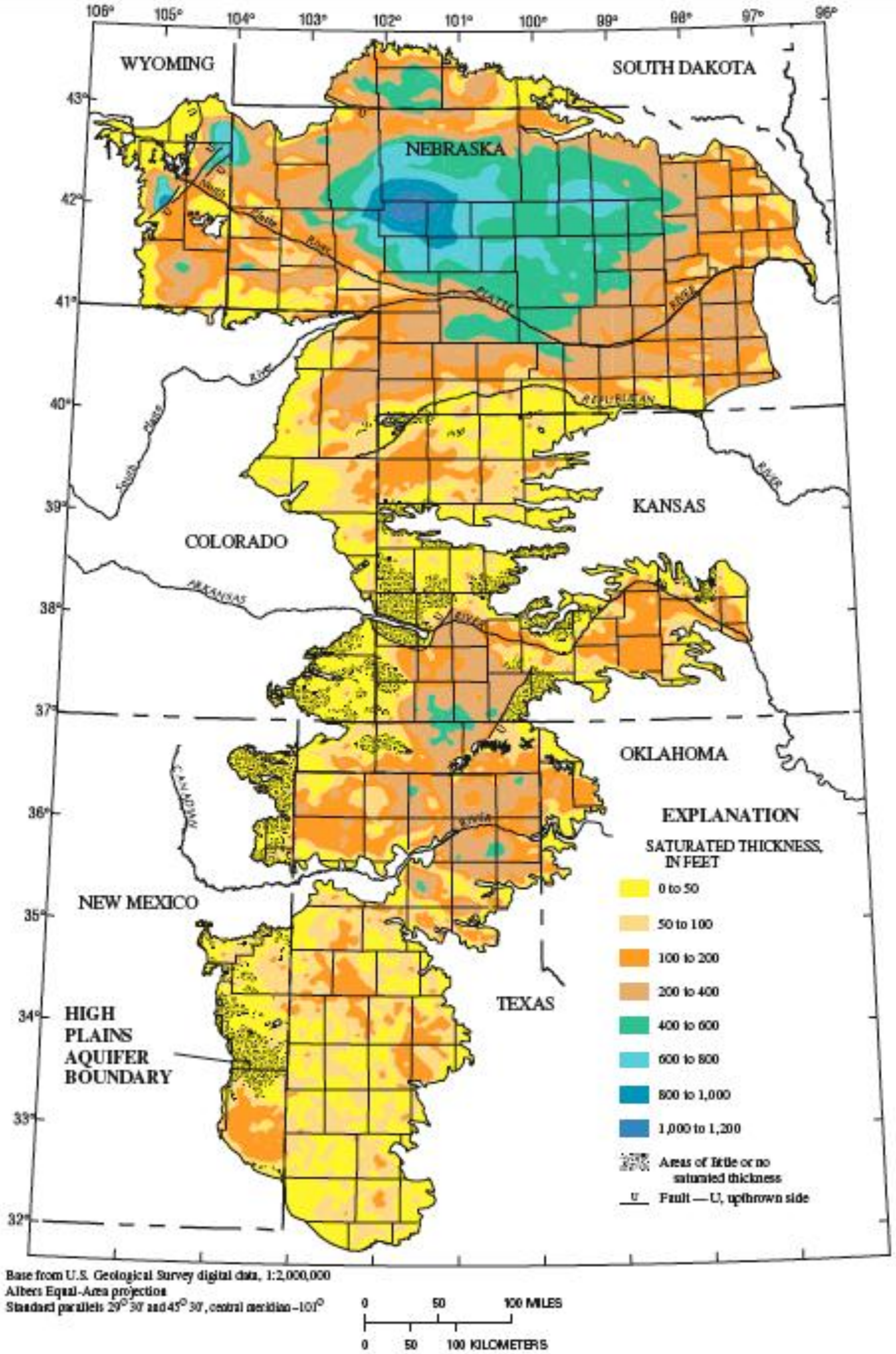


Figure 3. The total water footprint of 0.5 litre PET-bottle sugar-containing carbonated beverage according to the type and origin of the sugar (SB=Sugar Beet, SC=Sugar Cane, HFMS= High Fructose Maize Syrup)

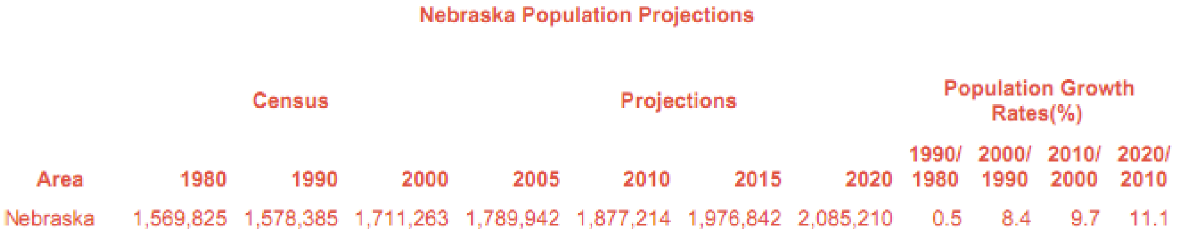
Exhibit N – Saturated Thickness of the Ogallala Aquifer



Base from U.S. Geological Survey digital data, 1:2,000,000
Albers Equal-Area projection
Standard parallels 29° 30' and 45° 30', central meridian –101°

Figure 14. Saturated thickness of the High Plains aquifer, 2000. (Modified from Weeks and Gutentag, 1981.)

Exhibit O - Table of Population projections for Nebraska



Nebraska Population Projections

	Census			Projections				Population Growth Rates(%)			
Area	1980	1990	2000	2005	2010	2015	2020	1990/ 1980	2000/ 1990	2010/ 2000	2020/ 2010
Nebraska	1,569,825	1,578,385	1,711,263	1,789,942	1,877,214	1,976,842	2,085,210	0.5	8.4	9.7	11.1

Exhibit P – Yields and Irrigation Information of Corn Producers

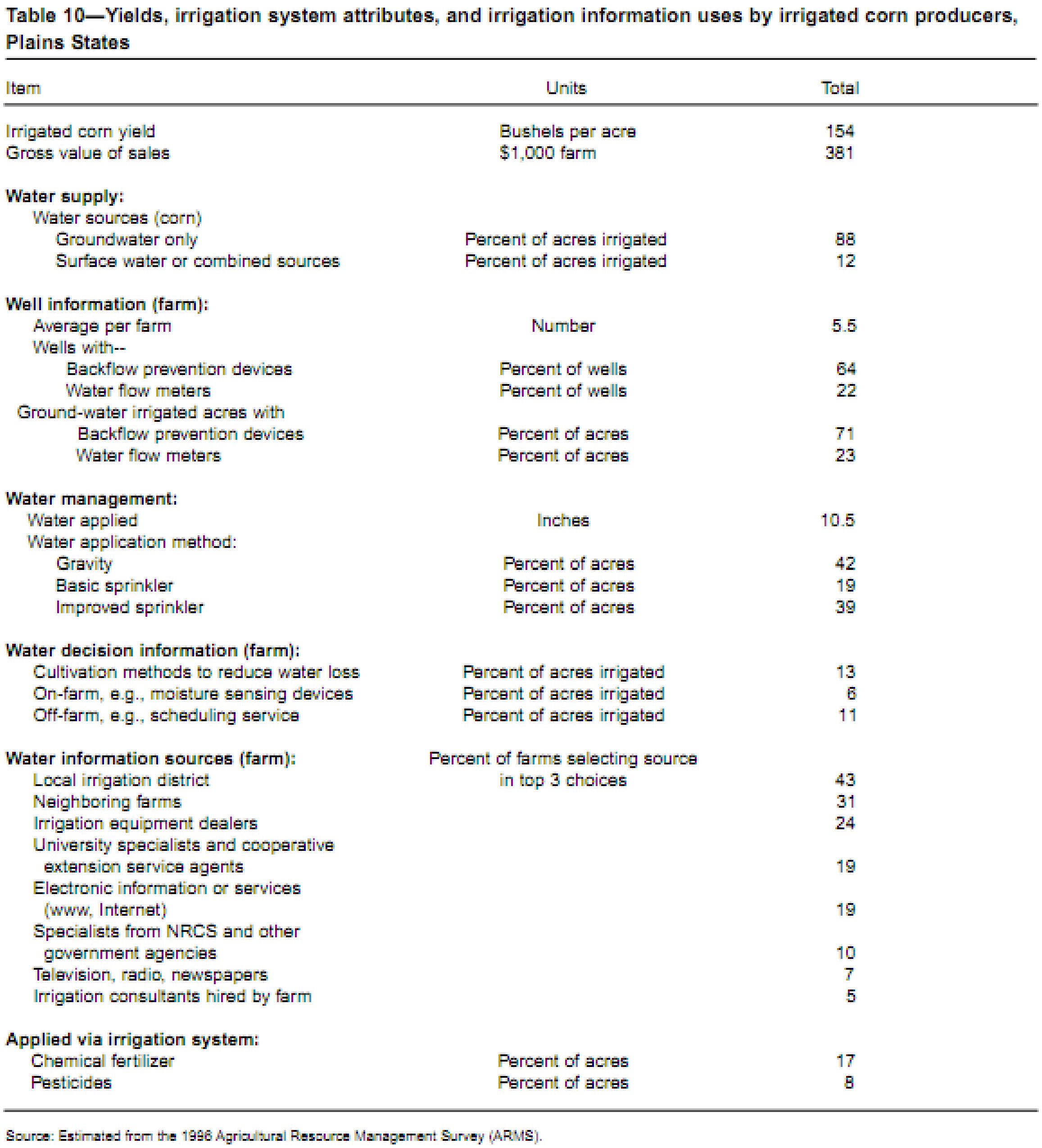
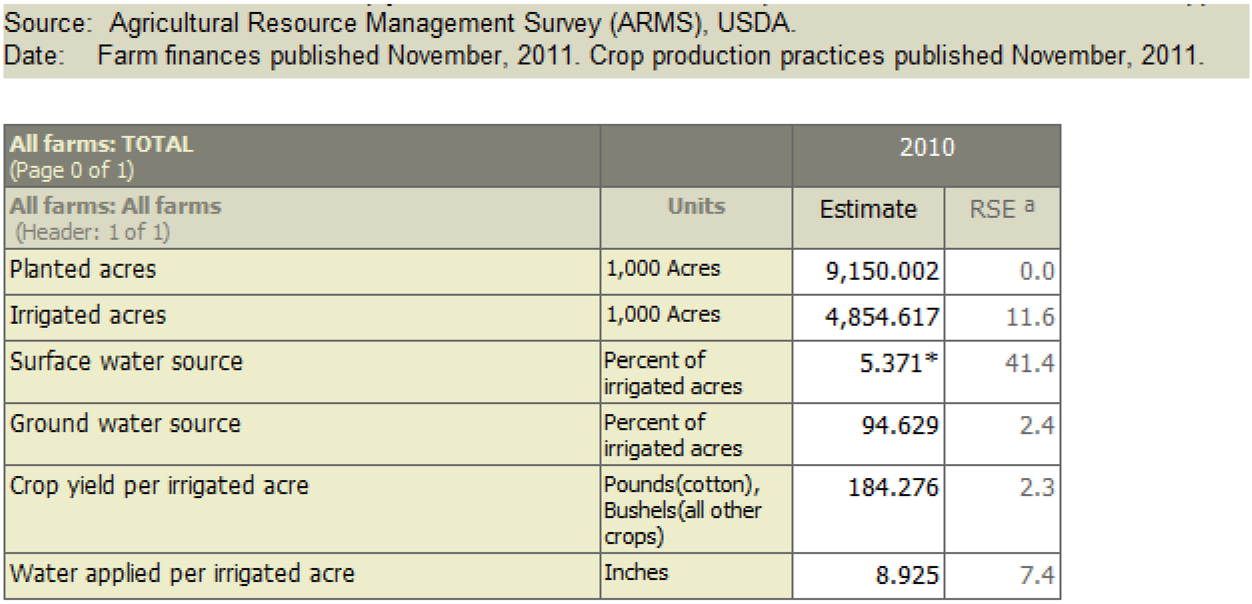


Table 10—Yields, irrigation system attributes, and irrigation information uses by irrigated corn producers, Plains States

Item	Units	Total
Irrigated corn yield	Bushels per acre	154
Gross value of sales	$1,000 farm	381
Water supply:		
Water sources (corn)		
Groundwater only	Percent of acres irrigated	88
Surface water or combined sources	Percent of acres irrigated	12
Well information (farm):		
Average per farm	Number	5.5
Wells with--		
Backflow prevention devices	Percent of wells	64
Water flow meters	Percent of wells	22
Ground-water irrigated acres with		
Backflow prevention devices	Percent of acres	71
Water flow meters	Percent of acres	23
Water management:		
Water applied	Inches	10.5
Water application method:		
Gravity	Percent of acres	42
Basic sprinkler	Percent of acres	19
Improved sprinkler	Percent of acres	39
Water decision information (farm):		
Cultivation methods to reduce water loss	Percent of acres irrigated	13
On-farm, e.g., moisture sensing devices	Percent of acres irrigated	6
Off-farm, e.g., scheduling service	Percent of acres irrigated	11
Water information sources (farm):	Percent of farms selecting source	
Local irrigation district	in top 3 choices	43
Neighboring farms		31
Irrigation equipment dealers		24
University specialists and cooperative extension service agents		19
Electronic information or services (www, Internet)		19
Specialists from NRCS and other government agencies		10
Television, radio, newspapers		7
Irrigation consultants hired by farm		5
Applied via irrigation system:		
Chemical fertilizer	Percent of acres	17
Pesticides	Percent of acres	8

Source: Estimated from the 1998 Agricultural Resource Management Survey (ARMS).

Exhibit Q - Nebraska Data of Corn Production



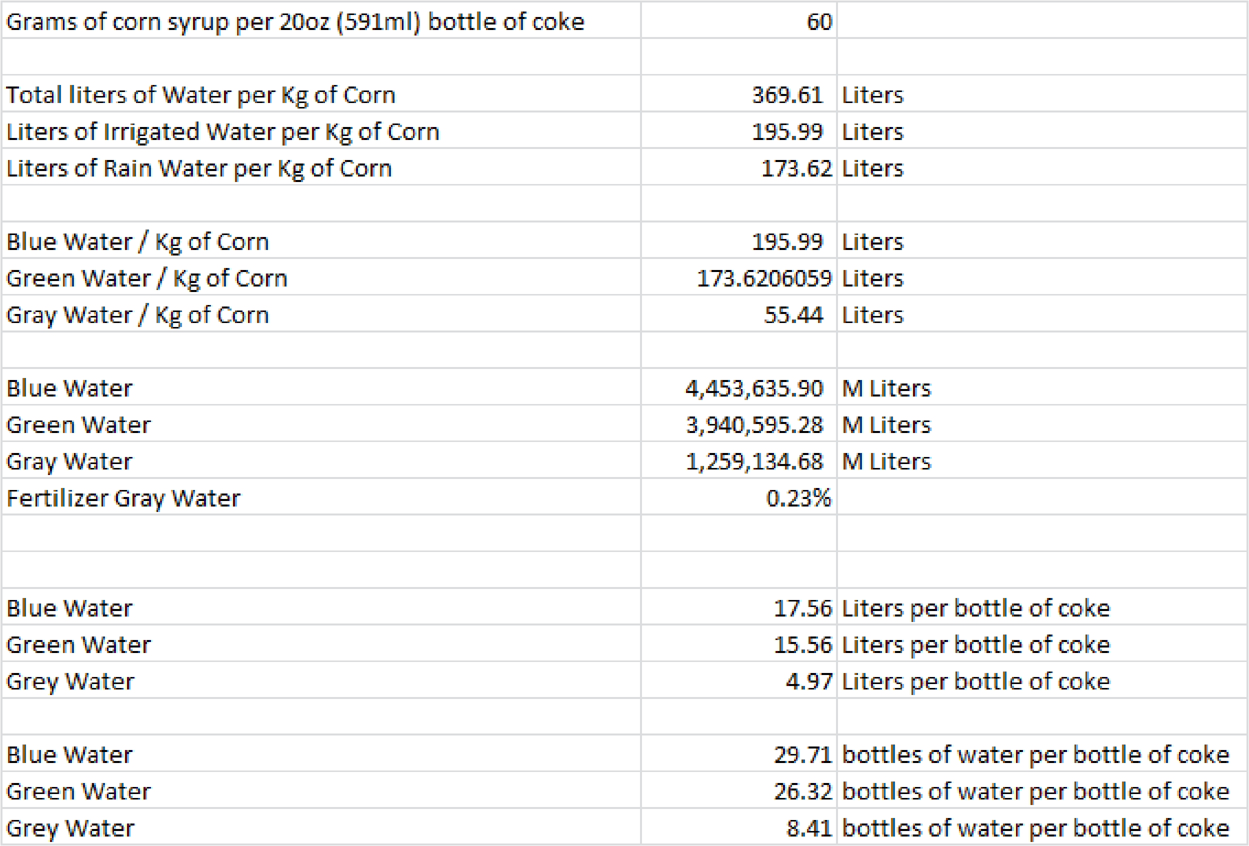
Source: Agricultural Resource Management Survey (ARMS), USDA.
Date: Farm finances published November, 2011. Crop production practices published November, 2011.

All farms: TOTAL (Page 0 of 1)		2010	
All farms: All farms (Header: 1 of 1)	Units	Estimate	RSE a
Planted acres	1,000 Acres	9,150.002	0.0
Irrigated acres	1,000 Acres	4,854.617	11.6
Surface water source	Percent of irrigated acres	5.371*	41.4
Ground water source	Percent of irrigated acres	94.629	2.4
Crop yield per irrigated acre	Pounds(cotton), Bushels(all other crops)	184.276	2.3
Water applied per irrigated acre	Inches	8.925	7.4

Corn production	56.03594032
wet milling	0.22
bottling	1.69
TOTAL	57.94594032
lbs of corn per gallon of coke	1.265225362
lbs of corn per 20oz of coke	0.197534174
g of Corn per 20oz of coke	89.6
volume of sweetner produced per volume of raw corn	0.669642857

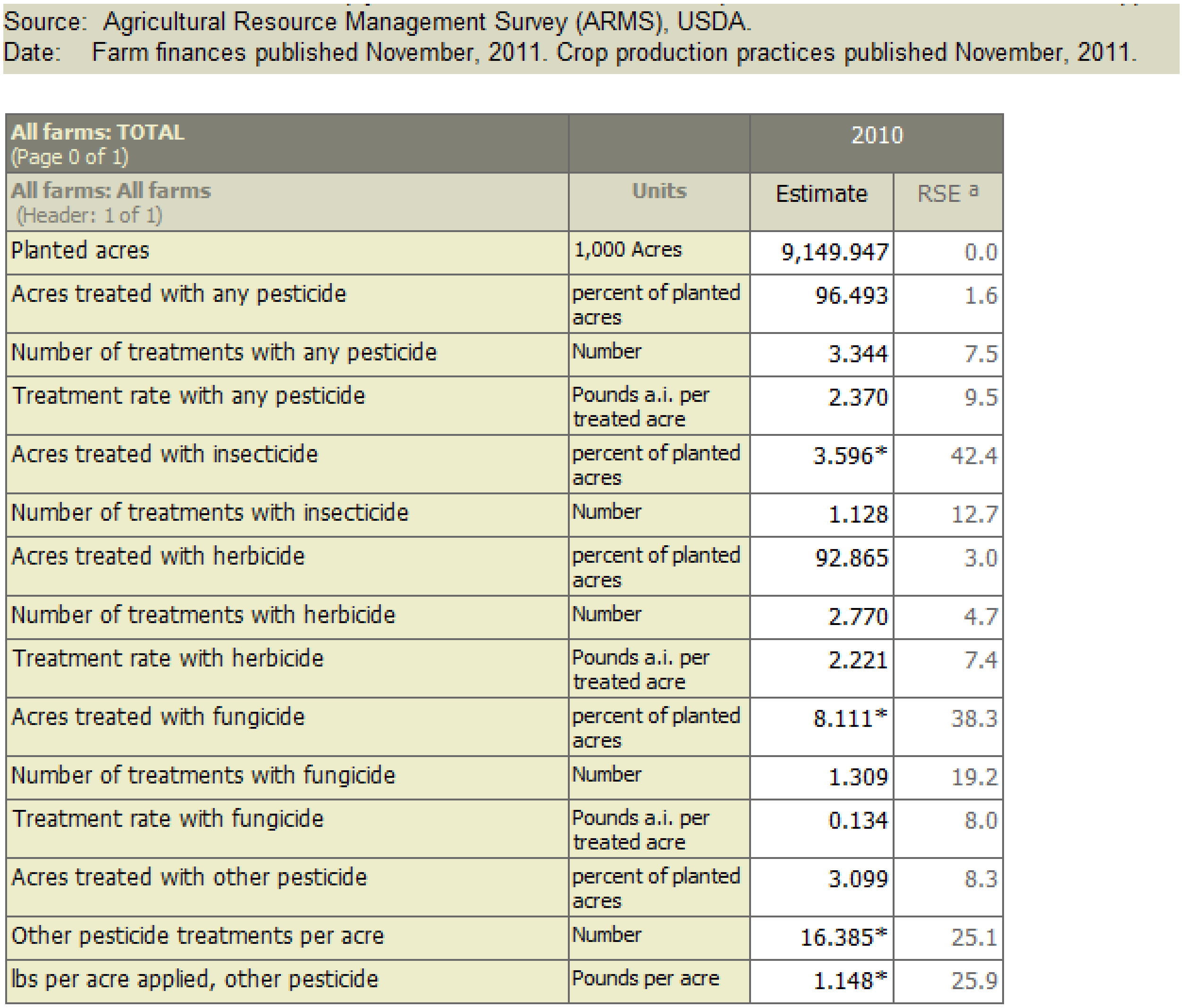
Lake Michigan	1.19939E+12	CU MI
	1.41528E+15	gallons per CU MI
Ogallala Aquifer use for irrigation	15,745,000,000	gallons per day
	2.36175E+12	gallons per year (150 days of use)
	0.2%	of lake michigan a year
Olympic Swimming Pool	660,000	gallons
	23856	pools of water per day

	Figures	%
Total Corn cultivated acres	9,150,002	100%
Acres Irrigated	4,854,617	53%
River / Surface water	260,741	5%
Ground Water	4,593,876	95%
Acres Not Irrigated	4,295,385	47%
bushels yield per irrigated acre	184.276	
bushels in nebraska	894,589,402	
bushels from Surface Water	48,048,396.80	
Bushels from Ground Water	846,541,005.49	
Pounds per Bushel	56	
Inches of Water applied per irrigated acre	8.925	
1 inch acre in US Gallons	27154.2857	
Liters to US Gallon	3.78541178	
Gallons of Water per acre	242351.9999	
M Gallons of Water from Surface Water	63,191	
M Gallons of Water from Ground Water	1,113,335	
Gallons of Surface Water per bushel	1,315.16	
Gallon of Ground Water per bushel	1,315.16	
Gallons of ground water per pound of corn	23.48	
Liters per US Gallon	3.78541178	
Pounds per Kg	2.204622622	
	88.90	
Liters of Water per Kg of Corn	195.99	
Gallons of blue water per 20oz bottle of coke	**4.64**	
Liters of Water	17.56	
# of 20oz bottles of water	**29.7137656**	



Grams of corn syrup per 20oz (591ml) bottle of coke	60	
Total liters of Water per Kg of Corn	369.61	Liters
Liters of Irrigated Water per Kg of Corn	195.99	Liters
Liters of Rain Water per Kg of Corn	173.62	Liters
Blue Water / Kg of Corn	195.99	Liters
Green Water / Kg of Corn	173.6206059	Liters
Gray Water / Kg of Corn	55.44	Liters
Blue Water	4,453,635.90	M Liters
Green Water	3,940,595.28	M Liters
Gray Water	1,259,134.68	M Liters
Fertilizer Gray Water	0.23%	
Blue Water	17.56	Liters per bottle of coke
Green Water	15.56	Liters per bottle of coke
Grey Water	4.97	Liters per bottle of coke
Blue Water	29.71	bottles of water per bottle of coke
Green Water	26.32	bottles of water per bottle of coke
Grey Water	8.41	bottles of water per bottle of coke

Exhibit R – Chemical Use in Corn Production



Source: Agricultural Resource Management Survey (ARMS), USDA.
Date: Farm finances published November, 2011. Crop production practices published November, 2011.

All farms: TOTAL (Page 0 of 1)		2010	
All farms: All farms (Header: 1 of 1)	**Units**	Estimate	RSE [a]
Planted acres	1,000 Acres	9,149.947	0.0
Acres treated with any pesticide	percent of planted acres	96.493	1.6
Number of treatments with any pesticide	Number	3.344	7.5
Treatment rate with any pesticide	Pounds a.i. per treated acre	2.370	9.5
Acres treated with insecticide	percent of planted acres	3.596*	42.4
Number of treatments with insecticide	Number	1.128	12.7
Acres treated with herbicide	percent of planted acres	92.865	3.0
Number of treatments with herbicide	Number	2.770	4.7
Treatment rate with herbicide	Pounds a.i. per treated acre	2.221	7.4
Acres treated with fungicide	percent of planted acres	8.111*	38.3
Number of treatments with fungicide	Number	1.309	19.2
Treatment rate with fungicide	Pounds a.i. per treated acre	0.134	8.0
Acres treated with other pesticide	percent of planted acres	3.099	8.3
Other pesticide treatments per acre	Number	16.385*	25.1
lbs per acre applied, other pesticide	Pounds per acre	1.148*	25.9

Agriculture Chemical Usage on Corn Production			
	69,972,759.63	fertilizer (lbs)	
	371,148.20	insecticide (lbs)	
	52,275,593.13	herbicide (lbs)	
	130177.949	fungicide (lbs)	
	5,333,698.82	other fertilizers (lbs)	
	128,083,377.73	Total (lbs)	
	50%	absorption rate of fertilizers (http://www.grasshopperfertilizer.com/grasshopper-fertilizer-delivers-consistent-growth)	
	64,041,688.87	pounds of Fertilizers entering soil to watershed	
	6,404,168,886.70	100:1 Injection (http://pubs.ext.vt.edu/430/430-100/430-100.html)	
	2,910,985,857.59	liters	
	0.14	pounds of fertilizer per bushel	
	1.159702882	grams of fertilizer per kg of corn	
	0.069582173	grams of fertilizer per bottle of coke	
	15%	Leaching into Groundwater / runoff	
Dead Zone Contribution			
	Total Use	20,842.7	
	Corn (~40%)	8,337.1	
	Nebraska (12%)	1,000.4	
	% of Total	4.8%	
	Gulf Deadzone	22126	square kilometers
		148.75	km x 148.75 km
	Nebraska's Contribution	1062.05	square kilometers
		32.59	km x 32.59 km
Nitrate Safety Levels			
http://water.usgs.gov/nawqa/nutrients/pubs/est_v36_no10/est_v36_no10.html#DISC			
	Current	< 2	mg/l
	Safe	10	mg/l
		2,910,985,857,592.92	mg
		1,259,134,678,365.46	liters
	Current grey water	2.31189396	mg/l

Exhibit S - Water Footprints for Sugar production across Regions

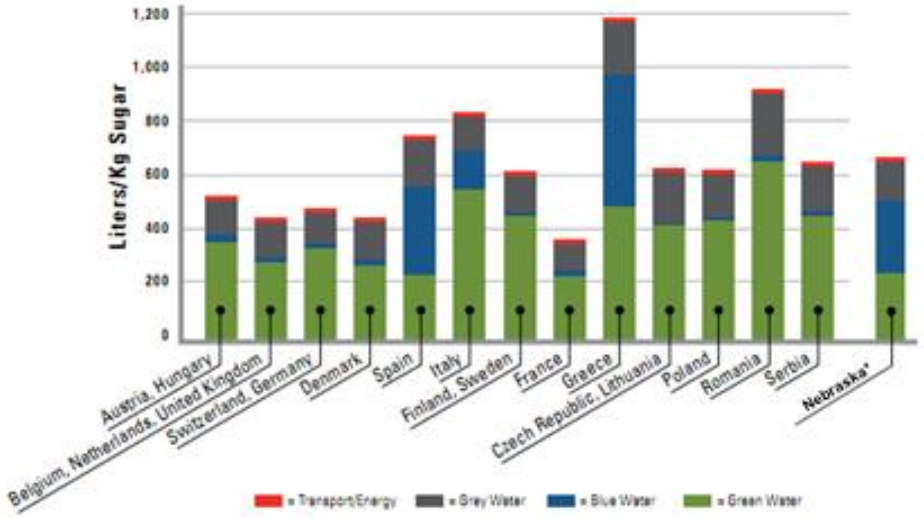
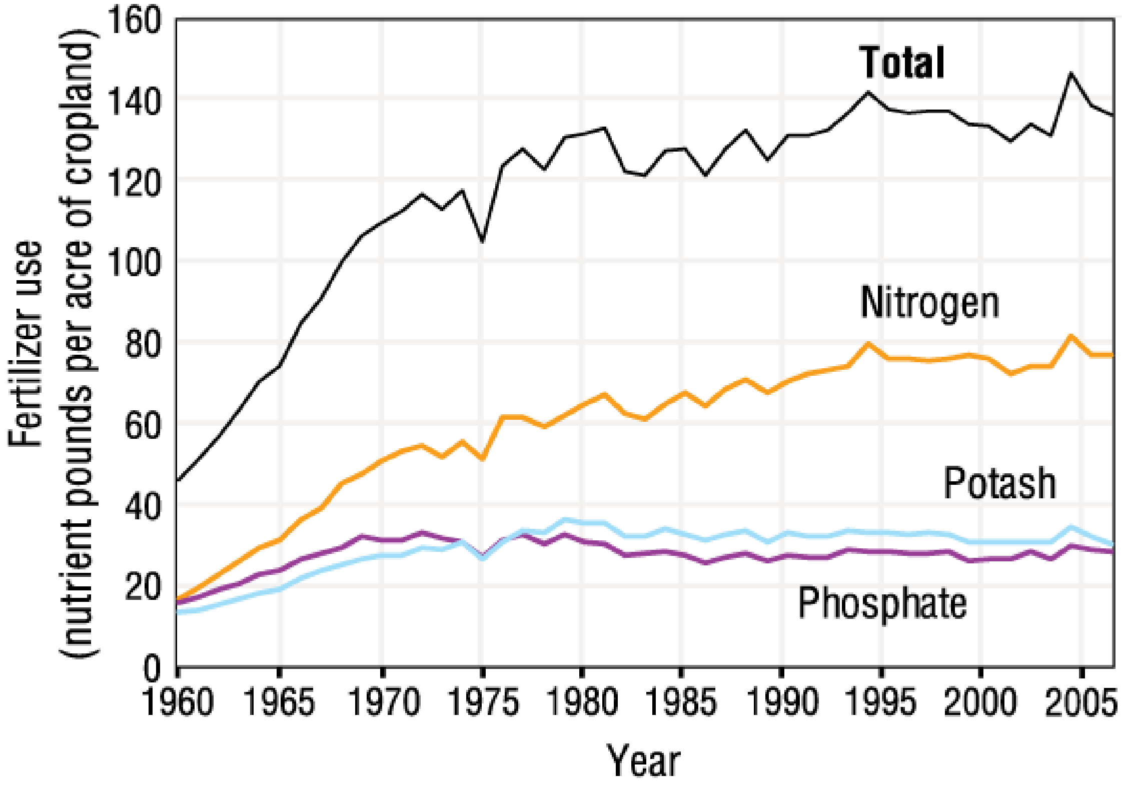


Figure 8. Water Footprints of Beet Sugar Across Growing Regions

*Water Footprint of Corn Syrup

Exhibit T – Commercial Fertilizer Use in the U.S. – 1960-2006

Exhibit 4-16. Commercial fertilizer use in the U.S., 1960-2006[a]

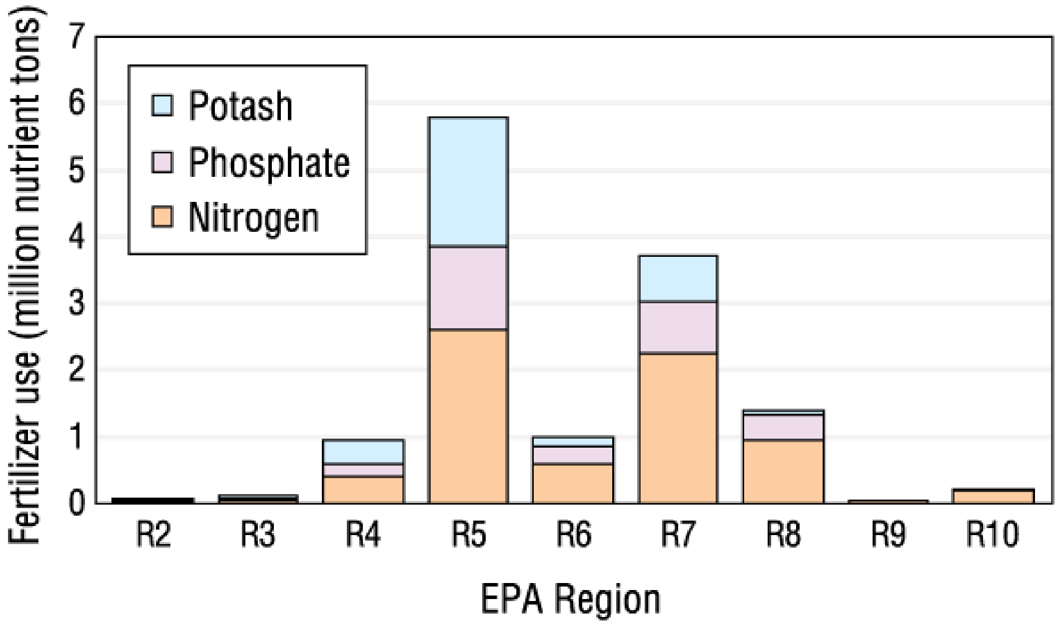


[a] Based on sales data. Per-acre use based on the total acreage of harvested or failed cropland, as determined by USDA's National Agricultural Statistics Service.

Data source: *USDA ERS, 2007a, 2007b*

Exhibit U – Fertilizer Use for Four Common Crops

Exhibit 4-17. Fertilizer use for four common crops (corn, cotton, soybeans, and wheat) in major agriculture-producing states, by EPA Region, 2005-2006[a]



[a] **Coverage:** States surveyed by USDA's Agricultural Resource Management Survey (ARMS) Program in 2005-2006 for corn, cotton, soybeans, and wheat. Each commodity was surveyed in a different subset of states, which together account for a substantial portion of the nation's production of that particular commodity. No states in Region 1 were surveyed by the ARMS Program for corn, cotton, soybeans, or wheat.

EPA Regions

Data source: *USDA NASS, 2006b, 2007b*

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