LEAN & WATER TOOLKIT

Achieving Process Excellence Through Water Efficiency

www.epa.gov/lean

How to Use This Toolkit

This toolkit uses icons in the page margins to help you find and follow important information in each chapter.

Identifies an **important point** to remember

Defines an **important term** or concept

Presents a **technique or resource** that helps capture, communicate, or apply new knowledge

Chapters also include one or more **"To Consider"** text boxes that contain questions to help you explore how the information relates to your organization.

This is one of a series of Lean and Environment publications from the U.S. Environmental Protection Agency. For more information, visit the EPA Lean website at www.epa.gov/lean.

Acknowledgments

The U.S. Environmental Protection Agency (EPA) is grateful for the valuable assistance of the organizations and individuals who helped develop this toolkit and who shared experiences, tools, and techniques for integrating Lean manufacturing and water efficiency. EPA's Office of Policy sponsored and led the development of this toolkit, while EPA's Office of Water provided considerable input.

This toolkit has benefited from the collective expertise and ideas of many individuals. In particular, EPA would like to thank the following individuals for their thoughtful contributions:

Michael Abouezzi, Senior Director, Lean Six Sigma and Total Productive Maintenance, PepsiCo

Barruch Ben-Zekry, Manager of Environmental Sustainability for Operations, Levi Strauss & Co.

Scott Butler, Vice President of Operations and Technical Services, Del Monte Foods

Lynn Coleman, Environmental Engineer, Hazardous Waste and Toxics Reduction Program, Washington State Department of Ecology

Rob Currie, Director, Environment, Health and Safety, Baxter International

Michelle Gaither, Technical Research Lead, Pacific Northwest Pollution Prevention Resource Center

Amy Goldman, Director, Global Environmental Management Initiative

Reza Hosseini, Manager of Environmental Site and Compliance Assessment, Levi Strauss & Co.

Bruce Karas, Director, Sustainability, Environmental and Safety, Coca-Cola North America

Deborah Kennedy, Senior Principal Engineer, Resource Conservation, PepsiCo

Robert ter Kuile, Senior Director, Environmental Sustainability, Global Public Policy, PepsiCo

Jessica McGlyn, Director, World Business Council for Sustainable Development, U.S. Inc.

Rob Meyers, Director, Environmental Sustainability, Global Operations, PepsiCo

John Radtke, Water Resource Manager, Coca-Cola North America

Jason Schulist, Director of Program Office, DTE Energy

Mike Sklar, Continuous Improvement Manager, DTE Energy

Charles Souders, Manager, Environmental Compliance, Johnson & Johnson/McNeil Consumer Healthcare

David Walker, Senior Director, Environmental Sustainability, PepsiCo

This toolkit was prepared for EPA by Ross & Associates Environmental Consulting, Ltd. (www.ross-assoc.com) in association with Industrial Economics, Inc. (EPA Contract # EP-W-10-002).

Table of Contents

Executive Summary i

Preface iv

Chapter 1 Introduction 1

Importance of Water to Industry 1

Benefits of Addressing Water with Lean 2

Getting Started with Lean and Water 6

Chapter 2 Water Use and Water Waste at Industrial Facilities 11

Definition of Water Waste 11

Industrial Water Use 12

Water End Uses: How Water Is Used at Facilities 15

Measuring Facility Water Use: Metering and Submetering 17

Costs of Water Waste 20

Chapter 3 Finding Water Waste on the Factory Floor 25

Water Gemba Walks 25

Developing a Water Balance 28

Water Waste and Value Stream Mapping 33

Root Cause Analysis 38

Chapter 4 Lean and Water Efficiency Improvement Strategies 41

Kaizen Events and Just-Do-Its to Reduce Water Use 41

Integrate Water Efficiency into Everyday Lean Practices 45

Lean and Water Applications for Facility Operations and Support Processes 50

Chapter 5 Lean and Water Beyond the Factory Floor 53

Lean and Water Efforts in Your Supply Chain 53

Engaging with the Community 58

Lean Product Design 61

Chapter 6 Conclusion 67

Your Lean and Water Journey 67

Concluding Thoughts 68

Appendices 69

Appendix A: Water Efficiency Resources and Technical Assistance Providers 69

Appendix B: Water Cost Calculator 76

Appendix C: Water Unit Conversions and Calculations 79

Appendix D: Water Efficiency Opportunity Checklist 85

Appendix E: Glossary of Water Terms 88

Boxes

Key Benefits of Addressing Water with Lean (Box 1) 2
Example Results From Lean and Water Efforts (Box 2) 3
Learning to See Water Waste and Costs (Box 3) 4
Types of Water-Related Business Risks (Box 4) 5
Water Metrics (Box 5) 7
Water-Intensive Industries (Box 6) 12
Common Costs Associated with Water Use (Box 7) 21
Steps to Take During a Gemba Walk (Box 8) 26
Examples of Water Gemba Walk Success (Box 9) 28
Information to Collect for a Water Balance (Box 10) 32
Water Footprinting Tips (Box 11) 33
Asking Why Five Times (Box 12) 39
Key Water-Efficiency Questions (Box 13) 41
Water Kaizen Event Examples (Box 14) 42
Waterless Cleaning of Gatorade® Bottles (Box 15) 44
Frito-Lay: Engaging Employees in Water Efficiency (Box 16) 46
Water-Efficient Cleaning Strategies (Box 17) 49
Proactive Maintenance Tips to Reduce Water Use (Box 18) 50
Questions to Identify Water-Savings Opportunities
in Facility Operations and Support Processes (Box 19) 51
Dubois Chemical and Steelcase: An Innovative Lean Water Supplier Partnership (Box 20) 54
Green Suppliers Network Lean and Water Successes (Box 21) 55
Levi Strauss & Co. and the Better Cotton Initiative (Box 22) 58
PepsiCo's Positive Water Balance Project in India (Box 23) 59
Examples of Water Conservation through Product Design (Box 24) 64

Figures

Figure 1: Impact-Difficulty Matrix 8
Figure 2: Lean and Water Implementation Strategies 10
Figure 3: Water Scarcity Map of the World 13
Figure 4: Breakdown of Water Uses in Two Industries 16
Figure 5: Example Water End Uses at an Industrial Facility 17
Figure 6: Portable Water Meter 18
Figure 7: Costs Associated with Water Use 20
Figure 8: Typical Water Balance Calculation 29
Figure 9: Simplified Elements of a Water Balance 30
Figure 10: Adding Water Use to Value Stream Map Process Box 34
Figure 11: Value Stream Map Incorporating Water Use Metrics 35
Figure 12: Process Boxes Showing Water Waste 36

Figure 13: Water Inputs and Outputs Identified on a Value Stream Map 37
Figure 14: Fishbone Diagram of Excessive Water Use 39
Figure 15: Five Water-Savings Strategies 43
Figure 16: Sign to Encourage Water Conservation 45
Figure 17: Dual Flush Toilet Visual Control 47
Figure 18: Six Pillars of 6S (5S + Safety) 48

Tables

Table 1: Typical Water Use Per Ton of Product 14
Table 2: High-Impact Water Use Sectors 14
Table 3: Costs Associated with Water Used in an Industrial Process 22
Table 4: Key Areas to Check During a Water Gemba Walk 27
Table 5: Example Water Balance Summary 31
Table 6: Table for Evaluating Water Reuse Potential 44
Table 7: Methods Used in Lean Design 62
Table 8: Questions to Ask During Lean Product Design 63

Acronyms and Abbreviations

3P	Production Preparation Process or Pre-Production Planning
5S	Sort, Set in order, Shine, Standardize, Sustain
BMP	Best management practice
C/O	Changeover time
C/T	Cycle time
E3	Economy, Energy, and Environment
EHS	Environmental Health and Safety
EPA	Environmental Protection Agency
GEMI	Global Environmental Management Institute
gpf	Gallons per flush
gpm	Gallons per minute
LEED	Leadership in Energy and Environmental Design
MEP	Manufacturing Extension Partnership
NIST	National Institute of Standards and Technology
psi	Pounds per square inch
TPM	Total Productive Maintenance

Executive Summary

This *Lean and Water Toolkit* describes practical strategies for using Lean manufacturing—the production system developed by Toyota—to reduce water use while improving operational performance. Drawing from the experiences and best practices of multiple industry and government partners, this toolkit explores opportunities to identify and eliminate "water waste," including:

- Water losses and leaks
- Non-value added or inefficient use of water
- Missed opportunities to reuse water
- Wastewater discharges
- Unnecessary water use and risks throughout the supply chain
- Missed opportunities to address customers' water-efficiency goals

This toolkit is a supplement to EPA's *Lean and Environment Toolkit* (www.epa.gov/lean/toolkit), which addresses all types of environmental wastes and improvement opportunities.

Why Address Water Using Lean

Companies recognize water use and availability as a critical business concern. While direct water costs may be low, many indirect costs associated with water use can make the full cost of water substantial. Community concerns about water and the risk of water supply disruptions can increase pressures on companies to reduce water use. Incorporating water use reduction into Lean initiatives provides an efficient and effective means to:

1. Uncover cost savings and operational improvements
2. Reduce water-related business risks
3. Deliver value for customers and employees

Facilities already using Lean can often easily incorporate water considerations into value stream maps and other Lean efforts. At the same time, facilities conducting water efficiency initiatives may find that Lean tools provide a powerful means to drive effective implementation and results. Connecting Lean and water efforts can engage employees in powerful and rewarding ways that build capacity and momentum to solve problems and create value.

Understand Water Uses and Costs

The toolkit discusses common water end uses in industrial and manufacturing facilities and discusses costs associated with water use. Costs of water include not only the cost of purchasing water, but also costs associated with treatment, heating, conveyance, and regulatory compliance. Metering and sub-metering are important tools for understanding actual water use within a facility and tracking it over time.

Find Water Waste

The toolkit discusses several techniques to find water waste and opportunities at your facility, including:

- **Water Gemba Walks:** Have a team walk the factory floor together to observe and inventory inefficiencies related to water use.
- **Water Balance:** Develop a diagram of your facility's water use that shows and quantifies the flows of water into and out of each process or operation in the facility.
- **Value Stream Mapping:** Add information on water use and/or costs to Lean value stream maps to help identify water waste and develop implementation plans for Lean and water efficiency improvement efforts.
- **Root Cause Analysis:** Use root cause analysis methods to explore the underlying causes of water waste and inform improvements.

Improve Operations and Processes with Lean and Water Strategies

Solutions to reduce water waste can be identified during Lean events and in daily implementation of Lean principles and tools. The toolkit discusses facility operations and support functions in which there may be specific improvement opportunities. Strategies include:

- **Waste Elimination Culture:** Encourage employees to identify water waste throughout their daily activities, and create a culture in which they are empowered to continually improve the way your facility uses water.
- **Kaizen Events and Just-Do-Its:** Pursue opportunities to address water waste during Lean kaizen events. Consider focusing kaizen events specifically on water waste or water-intensive processes. Also find quick opportunities for individuals to immediately improve a process or operation in just-do-it projects.
- **Standard Work:** Embed water use management and efficiency tasks into standard operating procedures to engage all employees in proactive water-efficiency activities.
- **Visual Controls:** Use signs and visual controls to reinforce water waste reduction practices and standard work. Clearly display information on water use and costs to raise awareness.
- **5S:** Incorporate water management and waste reduction activities into 5S housekeeping activities, such as cleaning and inspections, to engage all employees in identifying and eliminating water waste.
- **Total Productive Maintenance:** Enable teams of workers to quickly identify and correct problems, fix leaks, and improve water efficiency while optimizing the effectiveness of your manufacturing equipment.

These Lean tools can be used at a facility in concert with water-efficient best management practices (BMPs) that are often available from industry associations and government agencies.[1] Industrial facilities can target their efforts to the most effective solutions using these technology and process-based improvements.

Extend Lean and Water Efforts throughout the Value Chain

Looking beyond facility operations can allow you to uncover new ways to reduce water use and risks, while adding value and improving business operating conditions and market opportunities. Strategies include:

- **Supply Chain Initiatives:** Work with your suppliers to improve understanding of water use, costs, and risks. Provide incentives and technical support to help suppliers identify and eliminate water waste. Collaborate with supply chain partners to address water-related opportunities through joint Lean events and other initiatives.

- **Engage Local Communities:** Educate and engage your employees in water-efficiency efforts at your facility, and encourage them to adopt similar practices at home. Partner with community members and local organizations to conduct projects or Lean events that improve water use and/or quality in the community.

- **Product Design:** Incorporate water efficiency and reuse as design criteria into Lean product and process design methods, as a powerful means of reducing the water use of products throughout their lifecycle.

Starting Your Lean and Water Journey

There are many ways to get started with identifying and reducing water waste and improving business results using Lean. Consider using the strategies and techniques in this toolkit to help you:

1. Learn more about how your facility uses water
2. Engage employees in Lean and water improvement efforts
3. Connect Lean and water efforts to sustainable water management strategies

We hope the strategies and tools in this toolkit will help you on your Lean and water journey—enabling you to reduce water waste and costs, improve processes, and foster positive relations with your customers and community.

[1] Appendix A provides information on water efficiency resources and technical assistance providers that offer helpful information on BMPs. Also consider contacting your local water utility or the industry or trade association in your sector to inquire about water-related BMPs and resources.

Preface

Purpose of This Toolkit

*The **Lean and Water Toolkit** offers Lean implementers practical strategies and techniques for improving common Lean results related to time, cost, and quality, while also reducing water use, costs, and risk.* Environmental Health and Safety professionals will also find useful information in this toolkit for how to leverage Lean and Six Sigma business improvement methods to eliminate water waste. Finally, the toolkit introduces Lean practitioners to the wide array of water efficiency resources available from EPA and other organizations.

The "Lean" methods discussed in this toolkit are organizational improvement methods pioneered in the Toyota Production System. *Lean production* and *Lean manufacturing* refer to a customer-focused business model and collection of methods that focus on the elimination of waste (non-value added activity) while delivering quality products on time and at a low cost. *Six Sigma* is a business model that focuses on improving quality by eliminating variation; it is often combined with Lean. The toolkit assumes that you are familiar with Lean methods. For those who want to learn more about Lean, see EPA's Lean and Environment website (www.epa.gov/lean).

Key Questions Addressed by This Toolkit

Lean works well when it focuses on identifying and eliminating waste. This toolkit contains strategies and techniques that can enable Lean practitioners to easily identify water waste and improvement opportunities alongside the myriad other wastes and improvement opportunities uncovered by Lean. To accomplish this, the toolkit aims to answer the following questions:

What is water waste?

Water is required in substantial quantities to produce goods from food products to silicon chips. *Water waste* is water that is used beyond the point at which it ceases to add value to the customer. Excess water use often leads to wastewater, which can harm human health and the environment through the pollutants it collects, and overdrawing water resources in certain regions can exacerbate water scarcity concerns. Water can be wasted in the supply chain, through facility operations, and in product use and disposal. This toolkit will help you to recognize water waste so that you can work to reduce it.

Why should you address water waste with Lean?

Substantial water savings can ride the coattails of Lean improvement. By eliminating manufacturing wastes, such as unnecessary processing and cleaning, businesses also reduce the water and associated labor and energy costs needed for cleaning, conveyance, cooling, and heating. Chapter 1 describes benefits of combining Lean and water efficiency efforts and discusses how to get started. Chapter 2 provides an overview of industrial water use, including information on water uses, water metering, and water costs.

How do you know how much and where water is used in your facility?

A key step in effective Lean and water efforts is determining where to target water efficiency improvement activities. Chapter 3 discusses techniques for measuring water use and identifying opportunities to reduce water use in the context of Lean. Methods include gemba walks, water balance, value stream mapping, and root cause analysis.

How can you reduce water use with Lean methods?

Chapter 4 examines specific opportunities for using Lean methods to improve water efficiency, including kaizen events, standard work, visual controls, 5S, and total productive maintenance. These strategies present ways that you can integrate water efficiency principles and practices into the practical, implementation-based tools of Lean manufacturing and the waste-elimination culture fostered by Lean.

How can you use Lean to pursue water efficiency opportunities beyond your facility's operations?

For many companies, water costs and risks may be driven by factors and activities beyond the facility fence-line. Similarly, opportunities to capture market value and win customers may require considerations upstream to manufacturing activities. Chapter 5 explores strategies to leverage Lean initiatives and methods to reduce water risks in your supply chain and to engage the local community in water saving initiatives. Chapter 5 also discusses how Lean product design methods can be used to improve water efficiency and add value by addressing customer water needs.

CHAPTER 1
Introduction

Water is a crucial resource for the world economy; Lean provides a framework in which organizations can address water waste while saving costs, reducing risks, and adding customer value. This chapter includes the following sections:

- Importance of Water to Industry
- Benefits of Addressing Water with Lean
- Getting Started with Lean and Water

Importance of Water to Industry

Companies worldwide identify water issues as a critical business concern. Water is essential for a range of industrial processes and support functions, facility operations, and as an ingredient for many products. Water use is increasing much faster than population growth, and regional and seasonal differences in water availability can lead to shortages and even water-related conflicts. The World Economic Forum reports that 44 percent (2.8 billion) of people currently live in areas of the world that are water stressed, and, if present trends continue, water scarcity will affect the livelihood of one-third of the world's population by 2025.[2]

> *"I am convinced that, under present conditions and with the way water is being managed, we will run out of water long before we run out of fuel."*
>
> **Peter Brabeck-Letmathe, Chairman**
> **Nestle Corporation**
>
> Source: "A water warning: Peter Brabeck-Letmathe, chairman of Nestlé, argues that water shortage is an even more urgent problem than climate change," The Economist, November 19, 2008. www.economist.com/node/12494630.

Corporations are recognizing the important role they play in addressing water resource challenges, and companies are responding by engaging in efforts to measure, report, and reduce their water use. In a survey conducted by the Carbon Disclosure Project of 302 of the world's largest 500 companies, 89 percent of responding companies had developed specific water policies, strategies, and plans, and 67 percent indicated that responsibility for water-related issues lies at the Board or Executive Committee level.[3] The United Nations' CEO Water Mandate, launched in 2007, is designed to help companies develop, implement, and report on water sustainability policies and practices. Industry-led associations such as the World Business Council for Sustainable Development and the Global Environmental Management Initiative also have major water initiatives.

One key reason why companies choose to use water more efficiently is to improve their relationship with the communities that surround industrial facilities. Water use is of paramount importance to a facility's relationship with its surrounding community. Facilities that use less water in drought-

[2] World Economic Forum, "The Bubble Is Close to Bursting: A Forecast of the Main Economic and Geopolitical Water Issues Likely to Arise in the World during the Next Two Decades," Draft Report for Discussion at World Economic Forum.

[3] Carbon Disclosure Project, "CDP Water Disclosure 2010 Global Report," available at www.cdproject.net/CDPResults/CDP-2010-Water-Disclosure-Global-Report.pdf.

prone areas leave more water available for residential use. Some companies even risk being forced to withdraw from regions where water is a scarce resource, a problem that is likely to recur as water scarcity increases in many regions around the globe. In some cases, communities around industrial facilities show much greater concern for the amount of water a facility uses than the amount of energy it uses.

This toolkit provides strategies and tools for addressing water issues within the context of Lean manufacturing and other business process improvement methods.

Benefits of Addressing Water with Lean

Lean provides powerful tools for delivering value to customers in a manner that minimizes waste and risks from unnecessary water use. *Explicit consideration of water waste during Lean implementation can create significant value for an organization, helping to deliver quality products and services that customers want, when they want them.* Research sponsored by EPA and others shows that some water use and waste reduction benefits typically ride the coattails of Lean efforts, yet other opportunities to reduce wastes, risks, and non-value added activity associated with water may be overlooked. There are three key benefits of addressing water with Lean, as listed in Box 1 and further described below.

Key Benefits of Addressing Water with Lean (Box 1)

1. Uncover cost savings and operational improvements.
2. Reduce water-related business risks.
3. Deliver value for customers and employee.

Uncover Cost Savings and Operational Improvements

Learning to see and eliminate waste is a cornerstone of Lean initiatives. *Water waste is often a sign of inefficient production and non-value added activity, and it frequently indicates opportunities for saving costs and time*. Lean and water strategies can help you to uncover cost savings and improvements in areas of your facility's operations that may not have received as much attention in your Lean efforts. For production processes that are highly dependent on water or that have water-intensive support processes such as wastewater treatment, the operational and environmental benefits from Lean and water efforts are even more significant.

Learning to see water and other environmental waste during Lean efforts can reveal significant business improvement opportunities, further strengthen Lean results, and improve environmental performance. Box 2 provides several examples of how companies have used Lean and Six Sigma methods to reduce water use, save costs, and improve their performance.

Example Results From Lean and Water Efforts (Box 2)

✓ **IBM** used Six Sigma tools to reduce water consumption and operating costs in wafer fabrication processes, saving $3 million annually, reducing water usage by 27 percent, and increasing production by over 30 percent.

✓ **GE** combined high-tech water metering and other water efficiency practices with its kaizen improvement methodology, resulting in a 30 percent drop in water use since 2006.

✓ **DTE Energy** saved 20 million cubic feet of water (79 percent) and $700,000 annually in a Lean Six Sigma project examining electric substation water use.

Sources: IBM, "Green Sigma Overview," Presentation to EPA, June 2009; GE info cited in Carbon Disclosure Project, "CDP Water Disclosure 2010 Global Report," page 25, available at www.cdproject.net/CDPResults/CDP-2010-Water-Disclosure-Global-Report.pdf; and Jason Schulist, DTE Energy, "Lean Towards Sustainability: How to Use Lean and Six Sigma Methods to Drive Your Sustainability Journey," Presentation at Green Six Sigma Conference, May 19, 2009.

While many places have very low direct costs for water and wastewater, there are also indirect costs to water use. These costs can be significant, yet they are often hidden in overhead or support cost centers (see Box 3 for examples of how facilities have uncovered water waste and costs). Examples of water costs include:

- **Raw Material Costs:** Costs of measures to ensure that purchased water supply is of sufficient quality for use at a facility. For example, some facilities may bear costs for labor, equipment, and materials needed to improve water quality before use (e.g., when water is a key product ingredient), as well as for chemicals and other raw materials needed to treat and manage water at the facility and before discharging it. Water treatment costs associated with deionized water and reverse osmosis can be substantial.

- **Energy**: Costs for the energy required to heat and cool water, pump or transfer water, operate water-consuming equipment, treat water and wastewater, and other functions.

- **Pollution Control:** Wastewater service costs paid to a utility, and/or industrial pretreatment costs, for the energy, labor, materials, equipment, and chemicals needed to treat wastewater before discharging it from the facility.

- **Regulatory Compliance:** Costs for regulatory compliance activities such as completing permit applications and tracking and reporting wastewater discharges to regulatory agencies. In the United States, industrial, municipal, and other facilities must obtain National Pollutant Discharge Elimination System permits if the facilities discharge water pollutants directly into U.S. waters. Pretreatment regulations govern industrial facilities that discharge into municipal sewer systems. Also, in some food and consumer product industries, water use may be important to address Food and Drug Administration sanitation requirements.

Lean and water strategies such as those outlined in this toolkit help to reveal these costs and identify process improvement solutions. The next chapter provides more information about water end uses and costs.

Learning to See Water Waste and Costs (Box 3)

- ✓ A **wood products company** began metering water into two parallel process units and discovered one was using significantly more water than the other. After some investigation, the company identified and implemented maintenance practices that would substantially lower water use while also preventing equipment failure and downtime.
- ✓ A **food processing company** regarded the water supply from its groundwater well as essentially free. While completing a facility water balance, it metered the amount of hot water used for one process step. Once the company realized it was heating 25 gallons per minute of ground water from 55 degrees to boiling, it began to think of opportunities to reduce and reuse the energy in the hot water rather than sending it down the drain.
- ✓ A small, **high tech silicon wafer company** was paying its city water utility $1.20 per hundred cubic feet of water. After calculating the cost of pretreating its process water and adding wastewater treatment and discharge expenses, the company realized that the full cost of water was five times the initial cost of purchasing water. These insights led the company to reuse rinse water in the process, reducing total water use and demand for ultra pure water without affecting product quality.

Reduce Water-Related Business Risks

Lean provides an effective platform for reducing facility water use and the associated water-related business risks. While the specific risks that individual facilities face vary, examples of water-related risks include water shortages and reliability issues, water quality issues that drive the need for additional water treatment, increasing water costs, and supply chain interruptions. In some water-scarce regions, there may be challenges with meeting basic human needs for clean water and sanitation; competition for scarce water resources may be intense between uses associated with public water supply, agriculture, industry, and fisheries. *Climate change is predicted to exacerbate many of these water risks—increasing global temperatures will likely lead to increases in water demand, water scarcity, more vulnerable ecosystems, and more frequent extreme weather events.*[4] How companies respond to water risks can also have important implications for how local communities and customers perceive those companies.

[4] For more information on water and climate change, see CERES and Pacific Institute, "Water Scarcity & Climate Change: Growing Risks for Businesses & Investors," February 2009, available at: www.pacinst.org/reports/business_water_climate/full_report.pdf. For a discussion of business perspectives on the connections between water, energy and climate change, see World Business Council for Sustainable Development, "Water, Energy and Climate Change: A Contribution from the Business Community," March 2009, available at: www.wbcsd.org.

Types of Water-Related Business Risks (Box 4)

Companies face a variety of risks related to water security, including:

✓ **Business Interruption:** Risks that the supply of water may be disrupted in the supply chain, production, and/or product use.

✓ **Reputation:** Risks related to public scrutiny of how companies respond to water resource challenges and engage with communities, stakeholders, and employees.

✓ **Regulatory:** Risks of increased government regulations or restrictions on water use and water pollution, as well as the associated costs to respond to the requirements.

✓ **Access to Capital:** Risks of financial institutions adopting stricter lending and investment policies based on water uncertainties.

Source: World Economic Forum, "The Bubble Is Close to Bursting: A Forecast of the Main Economic and Geopolitical Water Issues Likely to Arise in the World during the Next Two Decades," Draft Report for Discussion at World Economic Forum Annual Meeting 2009, January 2009, page 39, www3.weforum.org/docs/WEF_ManagingFutureWater%20Needs_DiscussionDocument_2009.pdf.

Reducing non-value added water use is a key strategy for mitigating water risks. Integrated Lean and water strategies offer practical solutions that support multiple business objectives such as increased efficiency, reduced costs, improved customer responsiveness, and decreased water and energy use. By engaging employees in teams to identify and eliminate sources of water waste in your facility—alongside other production wastes such as over processing, defects, and delays, your facility can proactively reduce water risks while also supporting operational goals. Proactively engaging with local utilities and communities to collaboratively address water resource challenges can provide additional opportunities to reduce business risks and increase value. These efforts will make your facility less vulnerable to risks and better positioned to succeed given changes in water supply, demand, and quality.

Deliver Value for Customers and Employees

Reducing water use and risks through Lean, Six Sigma, and other process improvement methodologies can foster a competitive advantage for some businesses. Customers and employees may view proactive environmental improvement efforts as an important attribute, affecting customer loyalty and the ability to attract and retain employees. In some market segments, "green" attributes are an important factor that can give a product or company competitive advantage. People around the world view water issues as a key sustainability challenge. For example, more than 90 percent of the 32,000 people polled in 15 countries for a GlobeScan and Circle of Blue survey in 2009 perceived "water pollution" and "freshwater shortage" to be serious problems (70 percent considered them very serious problems).[5] Some companies can tap into significant market niches by providing customers with water-efficient choices and solutions.

[5] GlobeScan and Circle of Blue, "Water Views: Water Issues Research," August 19, 2009, www.circleofblue.org/waternews/wp-content/uploads/2009/08/circle_of_blue_globescan.pdf.

Participation in international or national water sustainability programs or local water efficiency efforts can provide businesses with public recognition and a competitive advantage for their water management achievements. For businesses that manufacture water-using appliances, parts, or products, companies can use design methods to make their products as water-efficient as possible throughout their lifecycles, from manufacturing to use and disposal. These methods can allow companies to cater to the steadily growing markets for green building and green products. There are also awards and competitions that provide recognition and media publicity for water-related innovations and efficiency accomplishments.

Reducing your facility's water use and the water that your products require during use can add value for your "downstream" customers—saving them water and energy costs and helping them meet their water-efficiency goals. Business interest in gathering and disclosing water use and risk information, through initiatives such as the Global Reporting Initiative and the Carbon Disclosure Project's Water Disclosure Initiative, may increase in the coming decade as water becomes a more critical business issue in some supply chains and industry sectors. Chapter 5 discusses ideas for engaging with customers, suppliers, and communities on Lean and water efforts, as well as incorporating water issues into Lean product design.

Getting Started with Lean and Water

There are many ways for a facility to get started with reducing water waste and finding Lean and water improvement opportunities. *While the possibilities can be daunting, the important thing is to begin, even if the effort is small.* Consider starting out with small steps, such as tracking water use as a metric at your facility with the goal of reducing use. This can be a great strategy for smaller facilities. Here are some ideas for initiating a Lean and water effort.

Learn More About How Your Facility Uses Water

A key first step is learning how your facility uses water and identifying the process areas, support functions, and facility operations that have the greatest water waste and improvement opportunities. Strategies include beginning to track water metrics as part of Lean and process improvement activities and installing water meters on processes that use large amounts of water. Box 5 lists examples of water metrics that facilities can use. It is helpful for facility managers and Lean champions to track water usage regularly, and to share this information with floor staff. Regularly monitoring water use data can help you determine the impact of peak periods (e.g., during summer and/or busier production months) and help you spot variations that could be signs of problems.

Water Metrics (Box 5)

Facility-Wide Metrics

- ✓ Volume of water used each month or other appropriate time period (e.g., gallons/month or gallons/shift)
- ✓ Volume of wastewater (e.g., gallons/month or gallons/shift)
- ✓ Water used for specific end uses (e.g., gallons/per month for outdoor irrigation, cooling water evaporation, heated process water, bathrooms and kitchens, etc.)*

Metrics Normalized to Production

- ✓ Volume of water used per product (e.g., gallons/pound of product, gallons/product)
- ✓ Volume of wastewater discharged per product (e.g., gallons/pound of product or gallons/product)

*Chapter 2 of this toolkit has more information on water end uses, metering, and costs.

To be most effective in Lean and water implementation efforts, Lean champions or operations managers should connect with environmental and facilities personnel early on to discuss plans for Lean and water efforts. Environmental Health and Safety (EHS) personnel can assist with developing water balances and other assessments of facility and process water use, including gathering data on water use and costs, as well as helping prioritize Lean and water activities.

After completing an initial water assessment, managers can consider it in the context of other planned Lean events and prioritize opportunities for involving EHS personnel in value stream mapping and kaizen events based on when their environmental expertise will add the most value.

Engage Employees in Lean and Water Improvement Efforts

Lean provides a solid framework to empower cross-disciplinary employee teams to identify and eliminate excess water use and other production waste, thereby realizing both environmental and Lean gains. Most likely your efforts to examine water use and waste will generate numerous ideas for process improvements and potential solutions. Ideas could include water efficiency and reuse opportunities and/or Lean events to improve water-intensive processes.

- Motivate employees and managers by communicating corporate sustainability goals and incorporating water efficiency into performance targets and incentives.
- Consider trying out some of the Lean and water improvement ideas in this toolkit, but don't limit employee teams to those ideas—encourage their creativity and initiative.
- Train employees on how to identify water waste and improvement opportunities, building their capacity to problem solve and help meet your facility's water use reduction targets.

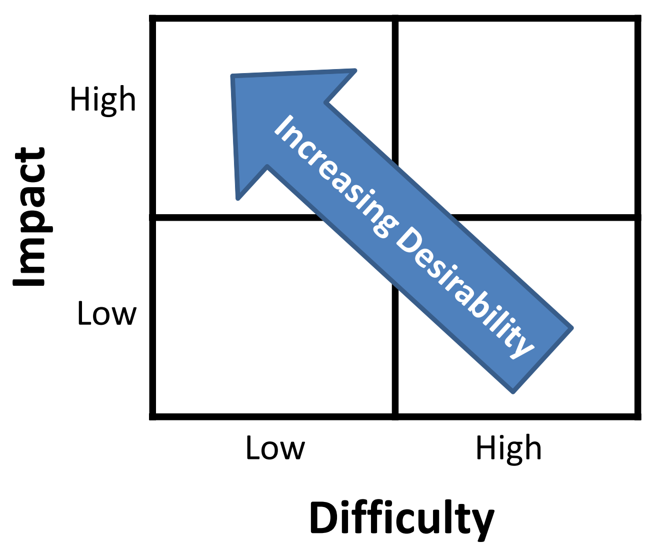
- Actively solicit employee suggestions for kaizen events or other improvement projects, by inviting ideas in meetings and conversations and/or by using a suggestions board or box.

A significant benefit of involving employees throughout your facility in Lean efforts is the opportunity to create a culture of continuous improvement. When employees are engaged in identifying ways to improve water efficiency, they are more likely to note these opportunities and areas of water waste throughout their normal day-to-day operations. You might find that improved water efficiency becomes a continual trend at your facility, and not just something that happens within the confines of a specific Lean exercise or event.

Focus your facility's initial Lean and water efforts on high-impact, easy-to-implement strategies, in order to achieve the highest likelihood of success. An *Impact-Difficulty Matrix* such as the one in Figure 1 can be useful for prioritizing among process improvement and implementation options. Lean event participants can plot their ideas onto the four quadrants in the matrix based on whether or not an idea would have a large or small impact (either in terms of operational and/or environmental objectives) and whether or not it would be difficult to implement. This process lets people see visually which projects are most "ripe" for Lean.

Connect Lean and Water Efforts to Sustainable Water Management Strategies

Figure 1: Impact-Difficulty Matrix



Lean and Six Sigma provide operational tools that can support a broader corporate water sustainability strategy. Lean's focus on performance measurement, continual improvement through employee engagement, waste elimination, improved efficiency, increased profits and customer satisfaction can be leveraged to support corporate water management efforts to measure and report water use, factor water into business decisions, and implement the practical and effective solutions. If your organization already has a sustainability policy and/or specific water efficiency goals, consider how Lean and water strategies could be used to enhance and accelerate those efforts.

Risk-Based Water Sustainability Strategies

Depending on the importance of water to your business, it may be worth developing a risk-based water sustainability strategy and then seeing how Lean and water efforts could support implementation. A number of resources can help you assess specific water-related risks, determine the business case for water sustainability, and develop implementation plans. These include:

- Global Environmental Management Initiative's (GEMI's) *Connecting the Drops Toward Creative Water Strategies: A Water Sustainability Tool*™, www.gemi.org/water

- World Business Council for Sustainable Development's *Global Water Tool*, www.wbcsd.org/web/watertool.htm

- *GEMI's Local Water Tool*™ (scheduled to be released in spring 2012), www.gemi.org/GEMIInteractiveTools.aspx

This toolkit complements broader water sustainability strategy resources (such as those listed above) by exploring practical opportunities to leverage facility Lean and Six Sigma and similar process improvement initiatives to reduce water waste.

True North Goals and Targets

Lean experts often extol the motivational power of setting goals and targets that represent the "True North" for operations. As noted by Lean expert Robert Hall of the Association of Manufacturing Excellence, "*True North* is what we should do, not what we can do, the ultimate ideal for the overall process, and for every sub-process within it."[6] True North goals, targets, and metrics are powerful tools for inspiring and focusing employee attention and creativity to both continuously improve and find breakthrough solutions. For example, **Nike, Inc.** developed "North Star" goals and metrics to define what sustainable products and a sustainable company would look like, which includes a focus on water stewardship.[7] Consider what the True North target is for water use in your facility. For many facilities, the True North targets may be zero wastewater and zero water use that is not incorporated into the product.

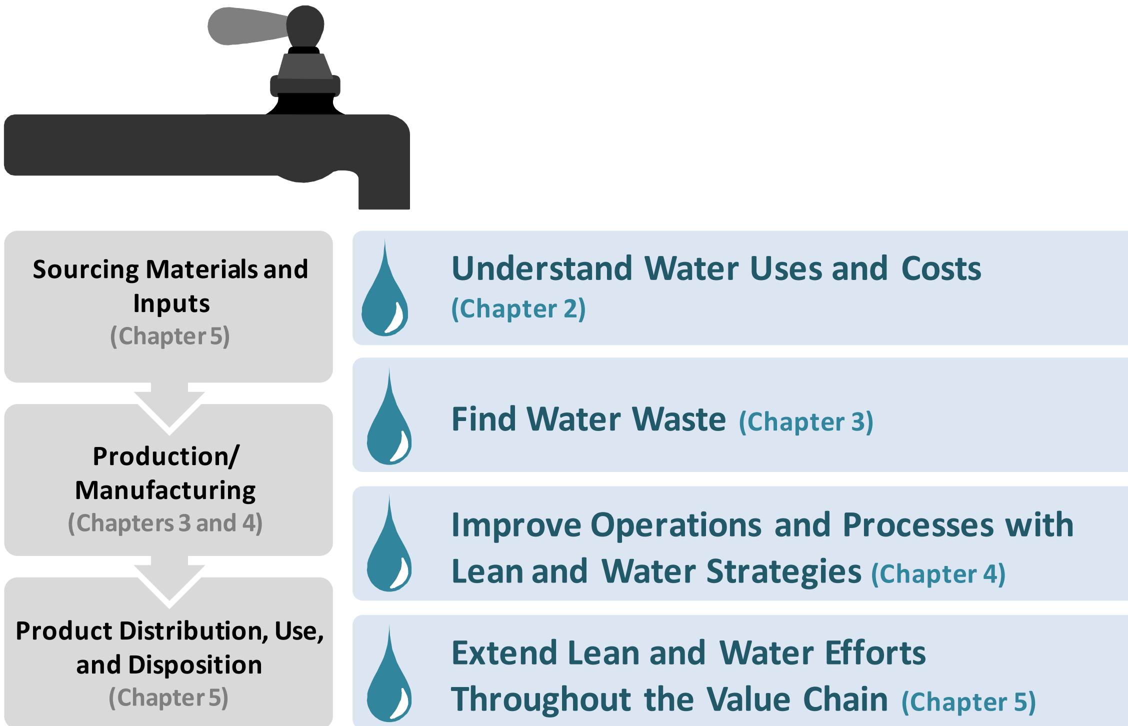
Examining the Full Value Chain

To achieve sustainability goals, it's important to look beyond a facility's direct operations. Lean methods can support water use and risk reduction efforts not only at areas within the direct control of a manufacturing or industrial facility, but also throughout the lifecycle or extended value chain for a product or service—from the extraction and processing of raw materials, through production processes, and onto product distribution, use, and disposition. While the primary focus of this toolkit is on reducing water use at your facility, Chapter 5 discusses opportunities to extend Lean and water techniques to other areas. Figure 2 provides an illustration of how the content of the toolkit links to a value chain.

[6] Robert Hall, "The Toyota Production System Seeks True North," Lean Directions e-Newsletter, 2011, available at: www.sme.org/cgi-bin/get-newsletter.pl?LEAN&20040709&1&.

[7] For more information on Nike's North Star, see http://www.nikebiz.com/crreport/content/environment/4-1-0-overview.php?cat=overview.

Figure 2: Lean and Water Implementation Strategies



To Consider

- ✓ Is water use responsible for major costs, waste, or risk at your organization? If you don't know, how would you find out?
- ✓ How has Lean affected your organization's use of water?
- ✓ How could your organization benefit from efforts to reduce water waste using Lean? (Think about time and cost savings, reduced risks and liabilities, added value to customers, etc.)
- ✓ What ideas do you have for reducing water waste using Lean?

CHAPTER 2

Water Use and Water Waste at Industrial Facilities

Understanding water use is an important first step in efforts to reduce water-related wastes, costs, and risks. This chapter contains the following sections:

- Definition of Water Waste
- Industrial Water Use
- Water End Uses: How Water Is Used at Facilities
- Measuring Facility Water Use: Metering and Submetering
- Costs Associated with Water Use

Definition of Water Waste

Key Term

Water is one of the most critical resources in the world, and is necessary for all types of industry. Water is required in substantial quantities to create goods from food products to silicon chips. In this toolkit, the term "*water waste*" refers to use of water beyond the point that optimizes value to the customer. This includes non-value-added water use throughout facility operations and support processes, and from the supply chain through production, product use, and waste disposal. Water waste can cause harm to health and well-being of people and ecosystems by diverting water from other needs and beneficial uses. Reducing water waste can help ensure that present and future generations have access to a sustainable water supply.

Key Term

Improve your facility's water efficiency by reducing water waste, not only by reducing water intake, but by finding creative ways to use water more efficiently. *Water efficiency*, as the term is used in this toolkit, refers to reductions in the amount of water used per unit of production. *Water efficiency* refers to the minimum amount of water needed to perform a task. (Note that water-efficiency improvements do not necessarily mean that a facility's total water use is decreased, since increases in production may offset water efficiency gains.) Examples of water waste include:

- Loss of water through material failures, such as leaky hose nozzles
- Discarding water that could be reused, such as treated rinse water
- Wastewater discharges
- Water used by high-flow appliances instead of more efficient alternatives
- Use of water in excess of necessity, such as the use of too much water for facility or parts cleaning

Understanding the many places where water waste occurs is an important first step for identifying areas for improvement.

Industrial Water Use

The use of water by industries, both in the United States and throughout the world, represents a significant portion of total water use. U.S. industrial water use is estimated to be more than 18.2 billion gallons per day (from direct water withdrawals, not including water use from public water supply).[8] While industrial water withdrawals account for just five percent of total water withdrawals in the United States, thermoelectric power water withdrawals account for 49 percent. Industrial and manufacturing businesses also use about 12 percent of the public water supply. Industrial water users include facilities involved in sectors such as chemicals, food and beverage, paper and associated products, steel, electronics and computers, metal finishing, petroleum refining, and transportation equipment. Overall, two of the most water consuming sectors of the economy are agriculture and thermoelectric power, although other industries may use a significant proportion of public water supplies in some areas.

The share of industrial water use can be much greater in certain geographic areas, and these areas can experience substantial supply pressures. Figure 3, below, shows a geographic distribution of water scarcity across the globe. Areas prone to water scarcity will likely experience continued competition for water resources, which can impact your relationship with the surrounding community. *Be aware of your facility's location relative to potential water scarcity, and consider water competition when siting new facilities or building relationships with new suppliers.* In the United States, the National Integrated Drought Information System maintains a user-friendly web portal(www.drought.gov) with current information, forecasts, maps, reports, and resources addressing drought conditions and water scarcity.

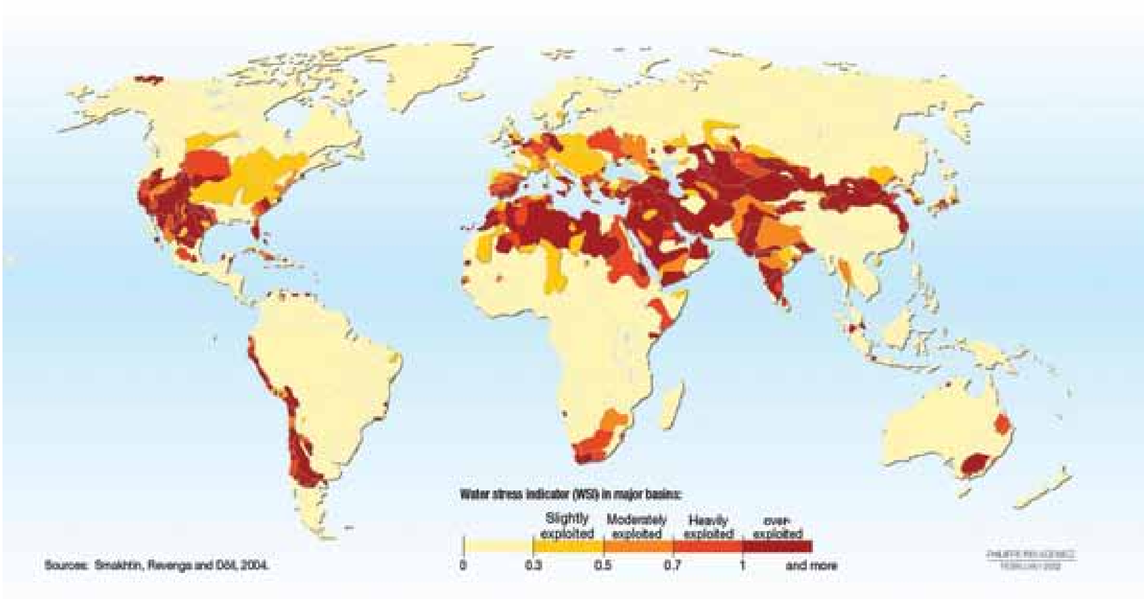
Industrial water use varies by sector, as different activities require different inputs of water. Box 6 lists eight industries that require substantial inputs of water.

Water-Intensive Industries (Box 6)

- ✓ Agriculture
- ✓ Apparel
- ✓ Beverages
- ✓ Biotechnology/pharmaceuticals
- ✓ Electric power
- ✓ Forest products
- ✓ High-tech (including semiconductor manufacturing)
- ✓ Metals/mining

[8] Kenny, Joan F. et. al. Estimated Use of Water in the United States in 2005. USGS. 2009, http://pubs.usgs.gov/circ/1344/ The USGS data does not include industrial water use drawn from municipal water systems, only direct withdrawals from surface and groundwater sources. Actual industrial water use is likely greater. For information on water use outside of the U.S., see AQUASTAT, Food and Agriculture Organization of the United Nations, "Water Withdrawal by Sector, Around 2003," data downloaded November 2010, www.fao.org/nr/water/aquastat/main/index.stm. Note that FAO data includes thermoelectric cooling water withdrawals in its industrial water totals.

Figure 3: Water Scarcity Map of the World



Source: United Nations Environment Programme, Map of Water Stress Indicator in Major Basins, 2004, available at: http://maps.grida.no/go/graphic/water-scarcity-index.

Water is a very important resource to many industries, and as a result, there are many opportunities to reduce water use. In the case of the high-tech industry, which uses considerable quantities of water to manufacture semiconductors and other components, water is vital to industry operations. Cleaning and rinsing silicon chips can require billions of gallons of water per year; to produce a single chip can use up to 7,900 gallons.[9] Apparel also ranks high in the list of water-intensive industries, with cotton production and textile processing requiring substantial inputs of water. Among industrial manufacturers, the forest products sector is the third-largest consumer of water in the U.S., requiring high volumes of water for pulp and paper manufacturing. The electric power industry directly uses water extensively for cooling and emissions scrubbing; fossil fuel plants and nuclear power plants require hundreds of liters of water for every kilowatt-hour of electricity that they produce.[10] Table 1 shows typical water quantities required to produce one ton of several manufactured products.

[9] Uphadyay, Sanjay, "Microelectronics – Fostering Growth Opportunities in the Ultrapure Water Market." Frost & Sullivan. August 19, 2011, available at: www.frost.com/prod/servlet/market-insight-top.pag?docid=240394448

[10] CERES and Pacific Institute, "Water Scarcity & Climate Change: Growing Risks for Businesses & Investors," February 2009, available at: www.pacinst.org/reports/business_water_climate/full_report.pdf

Table 1: Typical Water Use Per Ton of Product	
Paper	21,000–528,000 gallons
Beer	2,113–6,604 gallons
Sugar	792–105,668 gallons
Steel	528–92,460 gallons
Soap	264–9,246 gallons
Gasoline	26–10,566 gallons

Source: United Nations World Water Assessment Programme, United Nations World Water Development Report: Water in a Changing World, 2009, available at: www.unesco.org/water/wwap/wwdr/wwdr3/.

There is much variation among industrial sectors in relative water use, and the need for water varies greatly across the stages of the product or service value chain, from suppliers through production to product use. *It is important to know where in the value chain your industry's water use is heaviest, so that you can appropriately target improvement efforts.* For example, the apparel industry uses high volumes of water in raw material production, whereas the biotech and pharmaceuticals industry uses most of its water resources in direct operations. Table 2 shows the relative intensity of water impact (ranging from zero to three squares) in different segments of the value chain for several industry sectors.

Table 2: High-Impact Water Use Sectors

	Raw Material Production	Suppliers	Direct Operations	Product Use/ End of Life
Apparel	■ ■ ■	■		■
High-Tech/ Electronics	■	■		■
Beverage	■ ■	■	■	
Food/Agriculture	■ ■ ■		■ ■	
Biotech/ Pharmaceuticals			■	
Forest Products	■		■ ■	
Metals/Mining	■ ■		■ ■	
Electric Power/ Energy	■ ■		■ ■	

Source: CERES and Pacific Institute, "Water Scarcity & Climate Change: Growing Risks for Businesses & Investors," February 2009, available at: www.pacinst.org/reports/business_water_climate/full_report.pdf.

Water End Uses: How Water Is Used at Facilities

In order to reduce water waste in industry, it is important to understand the many ways that water is used within facilities. *Understanding water end uses is critical to identifying water savings opportunities.* While end uses of water vary by industry and by facility, there are categories of water use that are present at most industrial facilities. Water use in most industries can be classified into the following broad end uses:

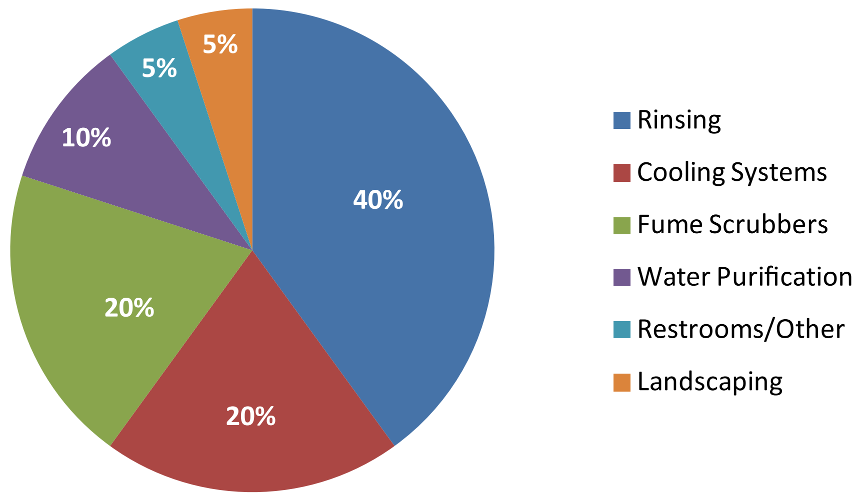
- Production processing and in-product use
- Auxiliary processes (e.g., pollution control, labs, and cleaning)
- Cooling and heating (e.g., cooling towers and boilers)
- Indoor domestic use (e.g., restrooms, kitchens, and laundry)
- Landscape irrigation

These broad categories encompass many of the ways industrial facilities use water. Among U.S. industrial customers, cooling operations (including cooling towers and open cooling systems) comprise the single largest category of industrial water end use, with more than 50 percent of industrial and commercial water demand combined going toward cooling.[11]

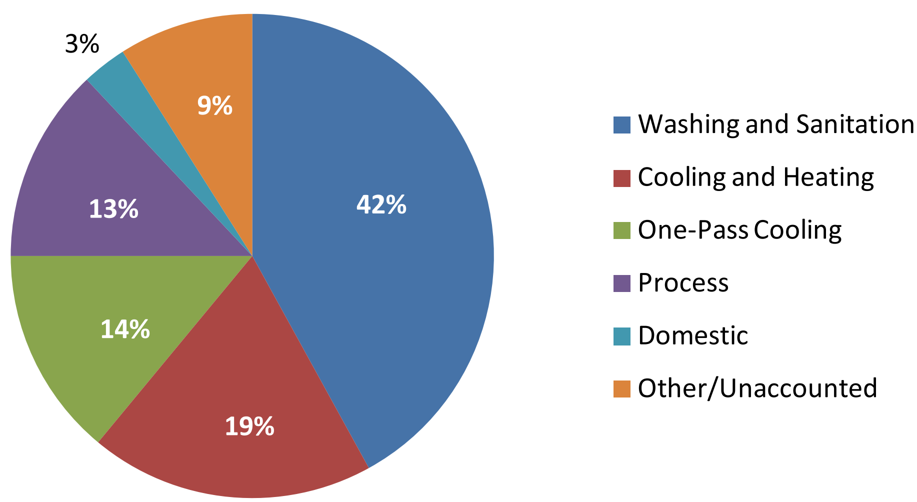
The amount of water required for the various end uses differs by industry. Service and manufacturing facilities require the most water for washing and processing, while food and beverage facilities use most of their water intake in product preparation. Figure 4 shows examples of water end uses in the computer and electronics manufacturing industry and the food processing industry.

[11] Vickers, Amy. Handbook of Water Use and Conservation. WaterPlow Press. 2001.

Figure 4: Breakdown of Water Uses in Two Industries



Computer and Electronics Manufacturers



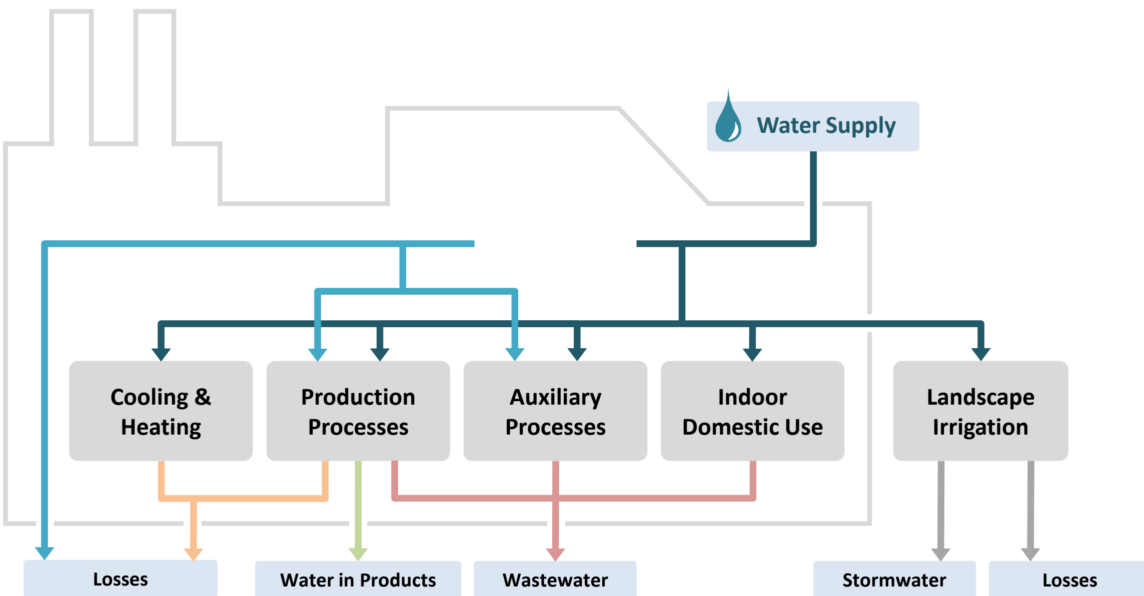
Food Processors

Source: Adapted from New Mexico Office of the State Engineer, "A Water Conservation Guide for Commercial, Institutional and Industrial Users," July 1999, available at: www.ose.state.nm.us/water-info/conservation/pdf-manuals/cii-users-guide.pdf.

Major end uses of water often provide the greatest opportunities for water waste reduction and efficiency improvement. For example, in many food, beverage, and pharmaceutical companies, cleaning process equipment can account for as much as 50 to 70 percent of a facility's total water use, and represents a substantial opportunity to save water.[12] Figure 5 illustrates how water flows through several different end uses at an industrial facility; note that this diagram does not incorporate all reuse options. Think of how a similar diagram would look that shows the water use at your facility.

[12] General Electric Company Water & Process Technologies, "Solutions for Sustainable Water Savings: A Guide to Water Efficiency," 2007, available at: www.gewater.com/pdf/Capabilities%20Brochures_Cust/Americas/English/Bulletin1040en.pdf

Figure 5: Example Water End Uses at an Industrial Facility



Beyond these categories of water end use, specific industries have processes that demand significant amounts of water. For example, in the textile industry, a typical continuous fabric bleach range machine can consume 11,000 gallons of water per hour.[13]

Measuring Facility Water Use: Metering and Submetering

To gain a better understanding of water use patterns at your facility, it is almost always helpful to use water meters. Many Lean methods rely on the availability of timely and accurate information on key performance metrics. By measuring water use and flows at the facility and/or process level, it becomes much easier to identify water efficiency opportunities. As the saying goes, you can't manage what you don't measure. There are two types of water meters: *Source meters* measure the amount of water being supplied to the facility, while *submeters* measure usage for specific activities such as cooling towers, process use, or landscape water use.

Water meters can be either portable or fixed on specific equipment. *Use portable water meters to measure water flows for processes or operations in your facility*, as part of Lean efforts such as gemba walks, value stream mapping, and kaizen events (strategies discussed in chapters 3-4). You can strap a hand-held acoustic water meter onto a pipe at a few places where you think there might be excessive water use. Compare the water data from the master meter to the water flowing through the pipes in the process to confirm where there are potential water savings opportunities. These data can help you develop a water balance (described in chapter 3). See Appendix B for resources to help you determine rates of water use, including calculations and unit conversions.

[13] North Carolina Department of Environment and Natural Resources, Water Efficiency Manual for Commercial, Industrial and Institutional Facilities, May 2009, available at www.p2pays.org/ref/01/00692.pdf.

Figure 6: Portable Water Meter

Source: Eno Scientific, www.enoscientific.com

Accurately measuring water use can help you identify areas for targeted reductions and track progress from water-efficiency upgrades. Submeters can also help identify leaks and indicate when equipment is malfunctioning. In some cases, it may also be useful to measure water pressure; a drop in pressure can indicate the presence of a leak. However, especially for smaller facilities, it will not necessarily make sense to use meters everywhere. Consider using meters when you have a need to closely track data; for example, before and after a process improvement event on a water-intensive process. You can use the data provided by the meters to compare water use and see how your efforts have improved your facility's water efficiency. Larger facilities can also integrate meters into centralized building management systems, making it easy to electronically track water usage, generate reports, and trigger alerts when leaks or anomalies are found. For additional advice on when to use water meters, consult your local water utility or the resources in Appendix A.

Key Poi

Installing the correct meter and ensuring it functions properly are critical to accurate water measurement. There are many types and sizes of meters intended for different uses, so it is important to choose the correct one. Improper sizing or type of meter can cause problems. For example,

[14] Smith, Timothy A. Plumbing Systems and Design. Water-Meter Selection and Sizing. 2008. www.park-usa.com/home.aspx?elid=71&arl=108

an undersized water meter can cause excessive pressure loss, reduced flow, and noise. Oversized meters are not economical and do not accurately measure minimal flow rates.[14] It is also important to ensure that water meters are properly calibrated according to the manufacturer's recommendation and that appropriate maintenance practices are followed on metering equipment. Most meters have internal mechanical parts and will begin to under-register the amount of water used as the meter gets older and the mechanical parts wear down. When abnormal water measurements are detected, check the metering equipment to ensure that the results are not due to metering equipment failures.

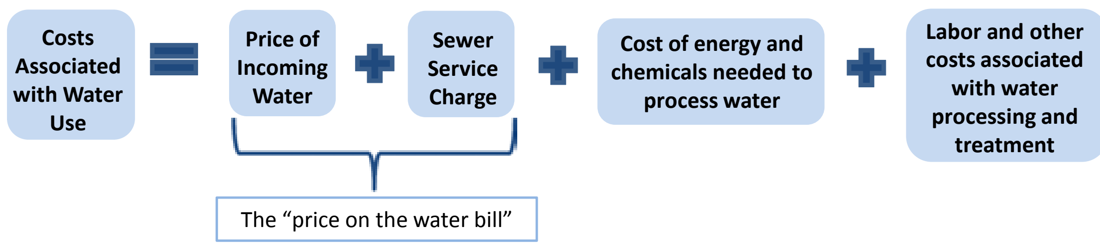
By metering water use at the facility and process levels, facility personnel can compile data to inform Lean improvement efforts. Here are some practical tips for using water meters as a part of Lean efforts:

- Use flow meters and water quality or cleanliness standards to establish standard work for water usage, flow, and pressure levels, taking into consideration "set points" recommended by equipment specifications and facility operating procedures. These baseline levels give important context of what accounts for "normal" operating parameters against which improvements and new water losses can be assessed.
- Use data that meters provide to determine the appropriate frequency for aggregating and reporting water measures (e.g., hourly, daily, or weekly) that best meets your facility's needs.
- Show employees how to read and use water meters as part of Lean activities such as gemba walks, value stream mapping, and kaizen events, so that they can identify water savings opportunities.
- Post water use reduction goals and water usage information on the factory floor on Lean production control boards or in other accessible places to raise awareness of water use and efficiency among employees.
- Track data from water meters over time. Portfolio Manager, an online building performance benchmarking tool available from the ENERGY STAR program can help you track and benchmark water consumption data. For more information on the Portfolio Manager, see Appendix A.

Costs of Water Waste

As noted in chapter 1, costs associated with water use include more than the direct costs you pay for water supply, but also the costs of water as it travels through processes and operations (see Figure 7). Box 7 provides examples of water costs, such as energy, pollution control, regulatory compliance, and raw material costs.

Figure 7: Costs Associated with Water Use



The cost of water use at a facility can be much greater than the amount on the water bill.

Estimating the many components of total water cost for a facility can begin with the cost of water purchased from utilities, but should also include the cost of steps required to process, use, and discharge the water. These costs can amount to a good deal more than what appears on a utility bill. When estimating water costs, it is important to consider these and other indirect costs throughout all functions of a facility. Be sure to use estimated future rates when assessing water costs, in order to project the level of savings that will be possible when improvements are made.

Common Costs Associated with Water Use (Box 7)

Raw Material Costs:

- ✓ Water purchased from utilities; marginal costs of purchasing additional water versus costs of conservation
- ✓ Cost of water treatment, filtering, and softening before use
- ✓ Costs for chemicals needed to treat and manage water

Energy Costs:

- ✓ Cost of energy to heat water
- ✓ Cost of energy to pump water from its source, or within the facility itself
- ✓ Energy and labor costs for operating and maintaining water-using equipment

Pollution Control Costs:

- ✓ Wastewater and stormwater service rates, including surcharges
- ✓ Total cost of treating wastewater for disposal, including labor, energy, chemicals, equipment, and residual disposal
- ✓ Marginal costs of increasing effluent treatment capacity when water demand increases

Regulatory Compliance Costs:

- ✓ Labor costs for regulatory compliance activities such as completing permit applications, monitoring compliance, and reporting wastewater discharges to regulatory agencies

Source: Adapted from North Carolina Department of Environment and Natural Resources, Water Efficiency Manual for Commercial, Industrial and Institutional Facilities, May 2009, available at www.p2pays.org/ref/01/00692.pdf.

Key Poi

Full costs associated with water use often vastly outweigh the direct costs. The direct cost of purchasing water from a utility may not seem significant enough alone to merit the effort to reduce water use, but when the full cost of water is assessed, the financial savings can be substantial. Table 3 shows an example of the various costs of water in an industrial process. In this example, the estimated savings from implementing improvements using direct water and sewer costs alone is only 56 percent of the estimated savings using the full cost of water. The flexible cost savings of conserved water is estimated to be 40 percent of total treatment cost. Flexible treatment costs refer to expenses that vary according to the volume of water treated (e.g., energy used to pump and treat water, treatment chemicals); fixed costs (e.g., capital equipment used for treatment) do not typically vary as wastewater throughput changes.

Table 3: Costs Associated with Water Used in an Industrial Process	
Activity	**Unit Cost ($/1000 Gallons)**
City Water Purchase	**$3.55**
Sewer Rate	**$3.99**
Deionized using reverse osmosis	
Equipment	$0.57
Energy	$1.20
Labor	$1.43
Total deionized water	$2.31
Deionized water (flexible cost)*	40% x $2.31 = **$0.92**
Wastewater treatment	
Sludge disposal	$3.46
Treatment chemicals	$2.44
Energy	$0.32
Labor	$6.25
Total wastewater treatment	$12.47
Wastewater treatment (flexible cost)*	40% x $12.47/gallon = **$4.98**
Total cost of water	**$13.44**

** Flexible cost savings of conserved water is estimated to be 40 percent of total treatment cost.*

Source: Adapted from North Carolina Department of Environment and Natural Resources, Water Efficiency Manual for Commercial,Industrial and Institutional Facilities, May 2009, available at www.p2pays.org/ref/01/00692.pdf.

New Tool

Appendix B contains a *Water Cost Calculator* that provides a template for calculating common costs associated with water use at industrial facilities. It may also be useful to estimate the potential water and dollar savings that would result from implementing water efficiency measures at your facility; see Appendix C for some equations that you can use to guide these estimates.

In some water-stressed areas, industrial facilities may face the possibility of an even greater water-related cost—that of lost revenue from the need to curtail production in the event of water supply disruptions. Competition for water across residential, agricultural, industrial, and environmental needs during periods of water scarcity may lead local water managers to impose limits on industrial water use. Understanding the vulnerability to disruption of local water supplies can be an important consideration when assessing the true costs of water use when expanding or developing new facilities.

The next chapter discusses strategies for understanding how water is used at your facility and identifying opportunities to reduce water use and improve operations.

To Consider

✓ What are the primary water end uses at your facility?

✓ What processes and facility operations use the most water?

✓ What costs are associated with your facility's water use? What indirect costs may be unaccounted for?

CHAPTER 3

Finding Water Waste on the Factory Floor

Some of the most substantial reductions in water use can be found right on the factory floor. This chapter describes several simple techniques to foster an understanding of where water goes in a facility and where it can be saved, including the following:

- Water Gemba Walks
- Developing a Water Balance
- Water Waste and Value Stream Mapping
- Root Cause Analysis

While all of these techniques evaluate aspects of facility water use and can support your Lean efforts, each has a different level of detail, time, and staff investment required—ranging from a facility walk to a multi-day value stream mapping event. Consider the level of effort desired before getting started to conduct the most effective analysis for your facility's needs.

Water Gemba Walks

New Tool

Key Term

A useful way to identify ways to reduce water consumption is a "gemba walk." A *water gemba walk* is an exercise in which employees and managers walk the factory floor together to observe and inventory inefficiencies related to water use. *Gemba* is a Japanese term meaning "the real place;" in the context of Lean manufacturing, gemba typically refers to the place where work happens (e.g., factory floor). Water gemba walks enable a team to quickly locate "low-hanging fruit" that save water at a small cost. They help facilities to:

- Identify major sources of water loss, such as leaks, that can be repaired for significant savings
- Acquire a more complete understanding of the major end uses of water and flows of water in the facility than can be achieved solely by analyzing water utility bills
- Instill floor managers and workers with the importance of looking for and noticing leaks and inefficiencies, helping to create a culture of water efficiency

Before you conduct your gemba walk, first, determine the purpose and scope of the walk. How large an area will the walk cover, and how long will it take? How long will the team look at certain aspects of plant operations? What information or data would equip the team to best see wastes and opportunities? Second, obtain copies of relevant documents and data, including the last year of water utility bills or water consumption logs, the floor plan of the facility if available, and process diagrams for focus areas. Third, select the members of the gemba walk team. A small team is best, with approximately five to seven people constituting an ideal team size. Include workers and managers familiar with the area, outsiders, new employees and veterans, as well as an EHS representative in order to get a diversity of perspectives. A brief training can orient your team to the purpose of a gemba walk and help them feel empowered to spot wastes throughout the walk.

Once you have your team assembled, use the *Steps to Take During a Gemba Walk* in Box 8 to find water waste and improvement opportunities at your facility.

Steps to Take During a Gemba Walk (Box 8)

1. Identify all water-consuming equipment, high-use areas, and meter locations.
2. Note all water losses, evaporative losses, and water incorporated in product; excessive water pressure; and leaks.
3. Observe shift clean-ups and process changeovers.
4. Quantify water flow rates and usage.
5. Note the water quality used in each process step.
6. Determine water quality needs for each process, and quality of wastewater discharged.

When employees are engaged and interested in finding wastes and identifying ways to improve water efficiency, the benefits of your gemba walk can continue well beyond the exercise itself. The training that your employees receive to conduct a gemba walk, or other Lean exercises, combined with immediate engagement in the exercises themselves, can help to create a culture in which employees routinely seek out ways to improve water efficiency.

Consider conducting your gemba walk during a time when the facility is shut down, as this can be a good time to find unexpected losses. You can also collect data during your gemba walk on the nature of the water in use at various steps throughout each process; knowing when treated water is necessary and when lower-quality water might be okay will help you identify reuse opportunities later. Table 4, *Key Areas to Check During a Water Gemba Walk*, lists several common areas in industrial facilities in which water inefficiencies can be observed during a gemba walk.

Table 4: Key Areas to Check During a Water Gemba Walk

Process and Equipment Use • Cleaning, Washing, Rinsing • Metal Finishing • Painting • Dyeing and Finishing • Photo Processing • Process Water Reuse • Product Fluming (Water Transport) • Pretreatment/filtration systems • Pump and Conveyor Lubrication • Water Use in Products	**Other Facility Support** • Floor Washing • Air Emission Wet Scrubbers • Building Washing • QA/QC Testing • Laboratories • Landscaping and Irrigation • Dust and Particulate Emission Control • Decorative Fountains and Ponds • Vehicle Washing • Cooling Water for Air Compressors and Vacuum Pumps • Hazardous Waste Storage and Effluent
Cooling and Heating • Single-Pass Cooling • Cooling Towers • Boilers, Hot Water, Steam Systems • Air Washers • Boiler Scrubbers	
Sanitary and Domestic • Toilets • Faucets • Urinals • Showers • Wash-up Basins	**Kitchens** • Food Preparation and Cleaning • Dishwashers • Ice Machines • Faucets • Food Disposals

Source: Adapted from North Carolina Department of Environment and Natural Resources, Water Efficiency Manual for Commercial, Industrial and Institutional Facilities, May 2009, available at www.p2pays.org/ref/01/00692.pdf.

Key Poi

Leak detection during a gemba walk can be one of the best low-cost, high-yield steps for reducing water waste in a facility. Leaks exist in all facilities, and can result in water loss ranging from a fraction of a percent of a facility's total water use all the way up to a substantial portion. Low water pressure, dirty water, and a high quantity of water that cannot be accounted for are all signs of a leak. Bluing tablets or dyes can be used to easily check for leaks in tanks, toilets, or other water holding vessels. Sonic or acoustic leak detection equipment can be used to check for leaks in underground pipes. A simple drip gauge can help you conduct a basic estimate of how much water is lost due to a leak. Many leaks can be repaired with simple measures such as tightening or replacing fittings.[15] In some cases, it may be best to enlist the services of a professional leak-detection company to identify more complex leaks.

[15] North Carolina Department of Environment and Natural Resources, Water Efficiency Manual for Commercial, Industrial and Institutional Facilities, May 2009, available at www.p2pays.org/ref/01/00692.pdf.

Box 9 lists some examples of successful gemba walk and leak detection efforts.

Examples of Water Gemba Walk Success (Box 9)

- ✓ **Kirtland Air Force Base** performed leak-detection gemba walks, in which teams walked water lines with acoustic listening devices to find leaks, surveying 90 percent of water distribution lines on the base. The teams found that 31 leaks were dripping away nearly 16 percent of the base's water at a rate of 333 gallons lost per minute. Repairs after the survey saved over 179 million gallons per year.
- ✓ In one **DTE Energy** plant, water pressure on the upper floors of the building was problematically low. Observations on the factory floor revealed that an open valve on a new water treatment system was responsible for the low water pressure. By installing a $3,000 variable valve, the company saved half a million dollars that it would have spent on a booster pump.
- ✓ **Del Monte Foods** used a water gemba walk to identify potential water savings in a recirculation line that was forked from eight inches to two four-inch pipes. By combining the freshwater line with the main line, the facility was able to save 300,000 gallons per day.

Sources: U.S. Department of Energy Federal Energy Management Program. "Distribution System Audits, Leak Detection, and Repair: Kirtland Air Force Base – Leak Detection and Repair Program." 2009; information provided by Jason Schulist and Michael Sklar, DTE Energy, May 2011; and Scott Butler, Del Monte Foods, "The Del Monte Production System: Lean to Green Integrative Future," Presentation at Green Six Sigma Summit Presentation, May 2009.

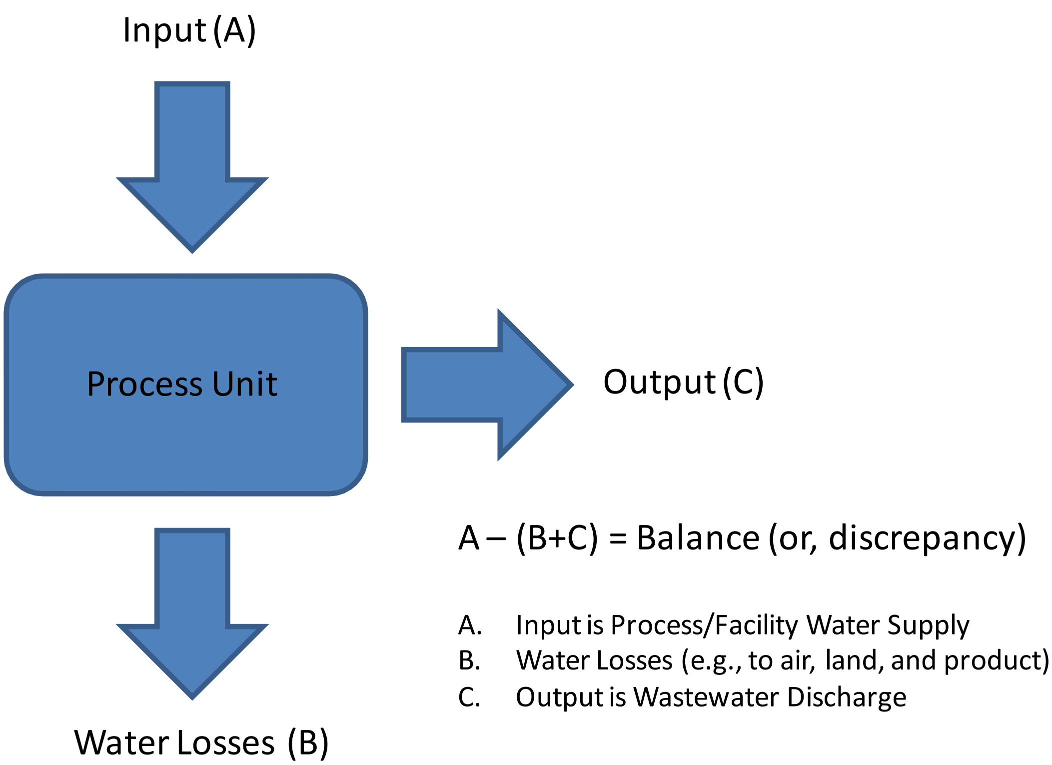
Developing a Water Balance

While a gemba walk will help you identify potential water-savings opportunities, developing a water balance will give you a more thorough picture of overall water use at your facility. A water balance is a high-level, simple assessment of the input and output of water in your facility that can help to identify opportunities for improving water efficiency. A water balance might be appropriate for your facility, especially if you are just beginning your journey with Lean and water and have not conducted a more detailed water audit.

New Tool

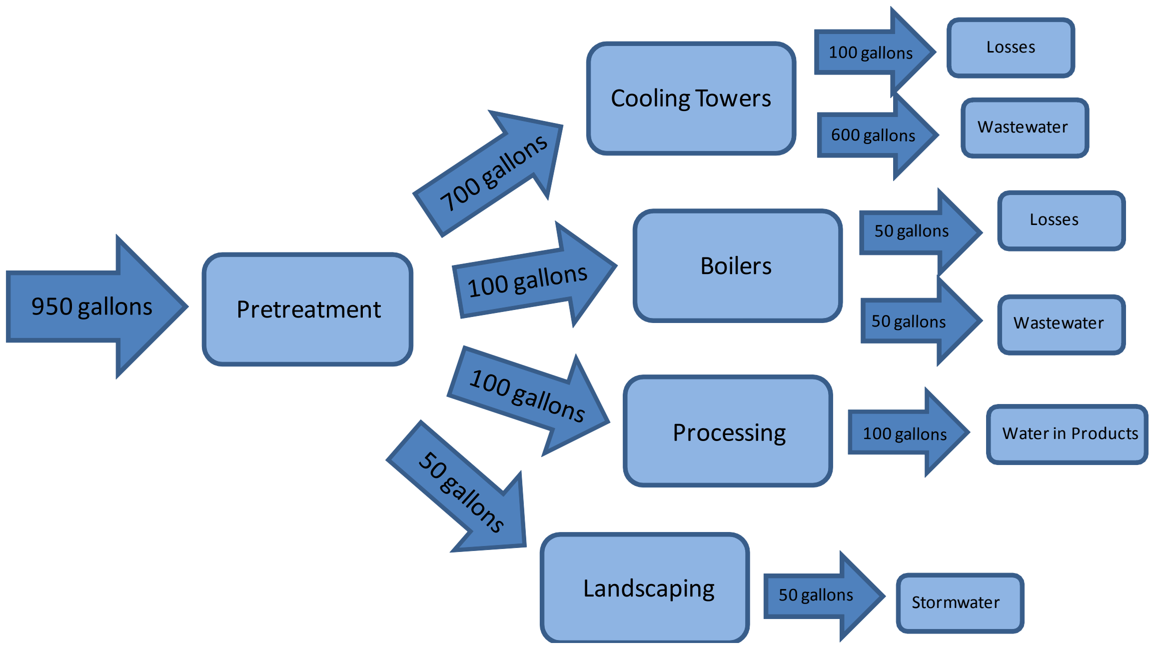
A *water balance* is a chart, table, or diagram of a facility's water use that shows the flows of water into and out of each process or operation in the facility. It typically includes every water-consuming component on-site and all flows out of the facility. A water balance can also include data on the cost of water. Figure 8 illustrates the fundamental approach to developing a water balance. Water balances can also be developed as part of value stream maps.

Figure 8: Typical Water Balance Calculation



When creating a water balance, make note of all water use in the facility and track water flows from the source through all operations at the facility to water losses and outputs including evaporative losses, input to products, and wastewater discharge. All uses of water in a facility should be included in a water balance. Common end uses of water are discussed in chapter 2, and include processing and auxiliary processing, heating and cooling, indoor domestic use, and landscape irrigation. *The water balance should capture all of the flows into and out of each process at the facility, and should verify that there is a balance between flows in and flows out.* Compare the estimated or measured total of end uses with the incoming metered amount. Be sure to account for losses, such as evaporation, as well as wastewater discharge. The Simplified Elements of a Water Balance figure (Figure 9) below shows an example of the components of a simple water balance for a facility, while Table 5, *Example Water Balance Summary*, presents overview information on water use by process from a water balance.

Figure 9: Simplified Elements of a Water Balance



The process of putting together a water balance helps to capture a baseline of a facility's current water usage (see Box 10). A water balance will help you identify sources of risk such as leaks and compliance concerns. Some companies choose to conduct water balances at varying levels of detail on a regular basis in an effort to locate ways to reduce water use and discover hidden water-savings dividends.

Table 5: Example Water Balance Summary			
Water Uses	**Input (Gallons/Year)**	**Output (Gallons/Year)**	**Loss (as a % of Water Use)**
Cooling: tower make-up and boiler make-up	8,484,000	8,248,000	236,000 (2.8%)
Process use	6,298,000	6,186,000	112,000 (1.8%)
Cooling: air compressors and pumps	7,654,000	7,455,000	199,000 (2.6%)
Landscaping	1,675,000	1,533,000	142,000 (8.5%)
General washing, sanitation and maintenance	1,101,000	1,095,000	6,000 (0.5%)
Food preparation: dishwasher	624,000	613,000	11,000 (1.8%)
Subtotal	26,660,000	25,130,000	1,530,000 (5.7%)
Total Water Loss	**1,530,000 Gallons/Year**		

A spreadsheet developed by GEMI to help you create a water balance for your facility is available at: www.gemi.org/waterplanner/calc-waterbalance.asp.

Benefits of compiling a water balance include:

- Ability to identify processes that present the best targets for reducing water use
- Establishment of baseline water use data, from which improvements in efficiency can be benchmarked
- Creation of a tool with which to compare different water-efficiency improvement strategies

Information to Collect for a Water Balance (Box 10)

To complete a water balance, collect data on the volume of water flows for each process or operation in your facility including:

- ✓ Water and sewer bills from the previous one to three years
- ✓ Numbers, sizes, and locations of water meters
- ✓ Sources of incoming water
- ✓ Diagrams of plumbing and water pipes, as well as irrigation schematics
- ✓ List of water-consuming processes
- ✓ Information about unsewered wastewater (wastewater not discharged to municipal sewer systems, such as through separate permitted discharges)

An outside expert could be the best option to help conduct a water balance for some facilities. Contact your local water utility to ask whether it provides assistance for developing water balances; some utilities provide this service (or related services) free of charge. In many cases, a water balance can make it easy to identify steps to take to improve water efficiency. If there is a discrepancy between the input and output of water in your facility that becomes apparent after preparing your water balance, you might use that baseline to create a target future state that reduces the discrepancy by a set percentage. Several of the resources in Appendix A provide information about developing water balances, more involved assessments such as water footprints (see Box 11) and audits, and benchmarking and tracking tools such as ENERGY STAR's Portfolio Manager.

More Detailed Water Audits, Water Assessments, and Water Footprints

In the event that a more detailed assessment of water use and risks is desired, an organization could consider conducting a water audit, water source vulnerability assessment, and/or water footprint analysis. While the results of these methods can inform the use of Lean to improve facility water efficiency, they are typically conducted as stand-alone efforts that can require substantial effort and investment. These methods are only described briefly below in this toolkit.

- A *water audit* typically involves a more comprehensive, time-intensive, facility-wide effort to assess a facility's water use and efficiency improvement opportunities. A water audit may include activities described in this toolkit, such as metering and baselining, but it typically focuses on the full facility in a discrete, brief period (e.g., during a 1–2 week effort). You may choose to follow specific standards when conducting the audits, such as those of the American Society of Heating, Refrigerating, Cooling and Air-Conditioning Engineers.
- A *water source vulnerability assessment* generally looks outside of the facility at factors that have potential to affect the supply and cost of water that the facility and surrounding community relies upon. This assessment can help a facility determine the risks of water supply disruptions or costs fluctuations and identify steps that may help to reduce these risks.

- *Water footprinting* analysis refers to the total volume of fresh water that is used directly and indirectly to run and support the business, encompassing both water use within an industrial facility and throughout its supply chain. You might consider conducting a water footprint to gain a more complete understanding of the places where water is used inefficiently throughout your supply chain—upstream among suppliers and downstream by users of the facility's output or products. While a water footprint can be time-consuming and difficult to prepare, it can be helpful in identifying improvement opportunities throughout the supply chain. Box 11 provides tips for conducting water footprint analyses, while chapter 5 discusses strategies for engaging suppliers to reduce water use and risks.

Water Footprinting Tips (Box 11)

What information should water footprint analyses contain?

✓ Track surface and groundwater sources, rainwater stored in the soil, and polluted water as inputs and outputs from a facility. This can help address concerns about water scarcity and use.

✓ Include the geographical location of water withdrawals and discharges, as well as direct and indirect water use.

✓ Work with suppliers to get data on water inputs and outputs from their operations; often this is where the most water is used.

✓ Consider also estimating your products' end-use footprint, which is any water used by consumers when they use the product.

✓ Note the scarcity and drought vulnerability of your suppliers—a water footprint can be a valuable tool to identify business risks.

✓ Present the water footprint information in a clear and compelling manner, such as a diagram showing water flows and quantities.

For additional guidance on water footprinting, see the Water Footprint Network website, www.waterfootprint.org.

Water Waste and Value Stream Mapping

Like water balances, value stream mapping can be a powerful tool for identifying water waste and savings opportunities. *Value stream mapping* is a Lean method for creating a visual representation of the flows of information and materials across all the activities involved in producing a product for a customer. In a value stream mapping event, two maps are developed: a map of the current state showing key data about existing processes and a future state map showing changes that can be made to reduce waste. Value stream maps can be developed at the value-stream level (e.g., for a product family) or at the process level after your team has selected a process to investigate more closely.

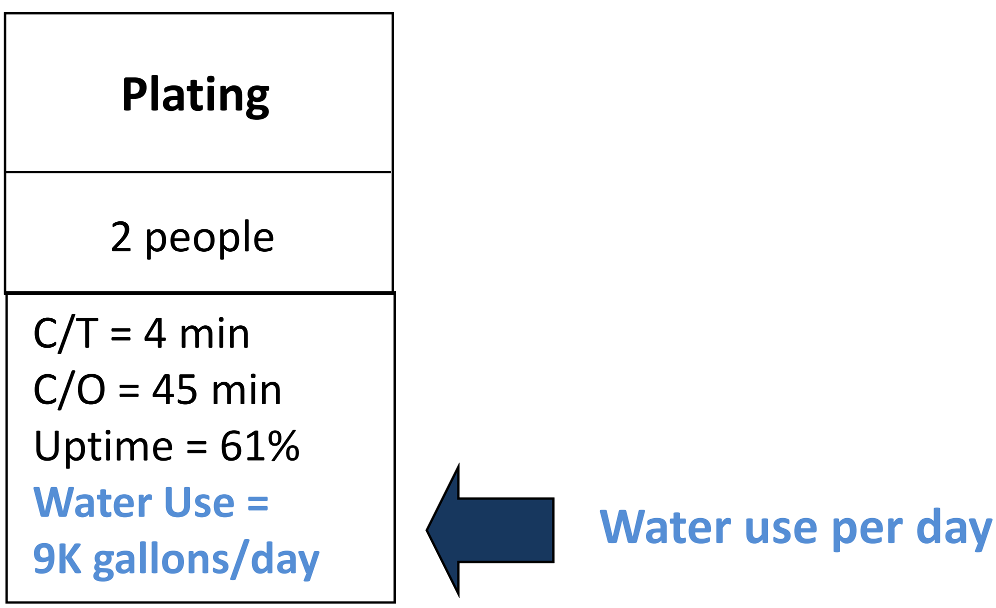
By adding water data to value stream maps, value stream mapping can help you:

- Gain a better understanding of where the greatest water waste occurs
- Identify areas where improvements can be made to reduce excess water use and other wastes
- Develop an implementation plan for process improvements to reduce wastes in the value stream, prioritizing water efficiency projects alongside other Lean and environmental projects
- Quantify the expected savings from implementing those improvements
- Create a culture of efficiency as team members from supervisors to floor workers become engaged in cutting waste

Adding Water Waste to Value Stream Maps

Value stream maps depict all the activities in a value stream or a process, along with key metrics that primarily relate to time. Incorporating water considerations into a value stream mapping exercise is as simple as adding the amount of water used at each step onto the value stream map. Figure 10, *Adding Water Use to Value Stream Map Process Box*, shows a process data box with data on the water use by a particular process included. Costs associated with the water used by each process or process step could also be added; however, to be fully representative, these costs should include indirect costs such as those for support functions.

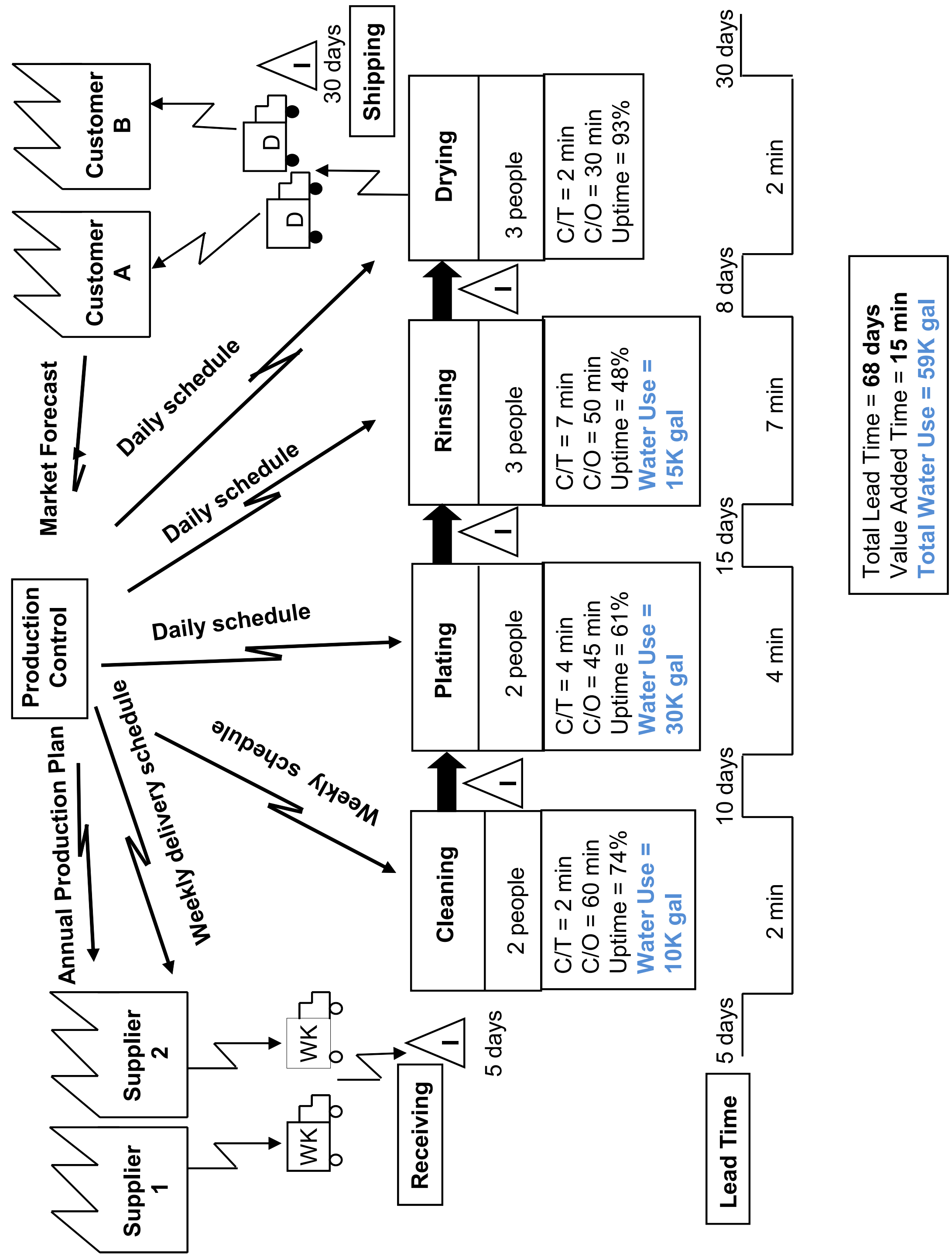
Figure 10: Adding Water Use to Value Stream Map Process Box



New Tool

Figure 11, *Value Stream Map Incorporating Water Use Metrics*, shows an example of a current state value stream map that has been modified (with additions in blue) to include data on the amount of water used at each step. Most activities that consume water are tracked in the map; however, note that this map does not include water loss as a result of leaks and evaporation or other losses that can occur between process steps.

Figure 11: Value Stream Map Incorporating Water Use Metrics



Many teams develop value stream maps using sticky notes to represent each step in a process. This enables team members to move things around easily and helps them create the most accurate picture of the process possible.

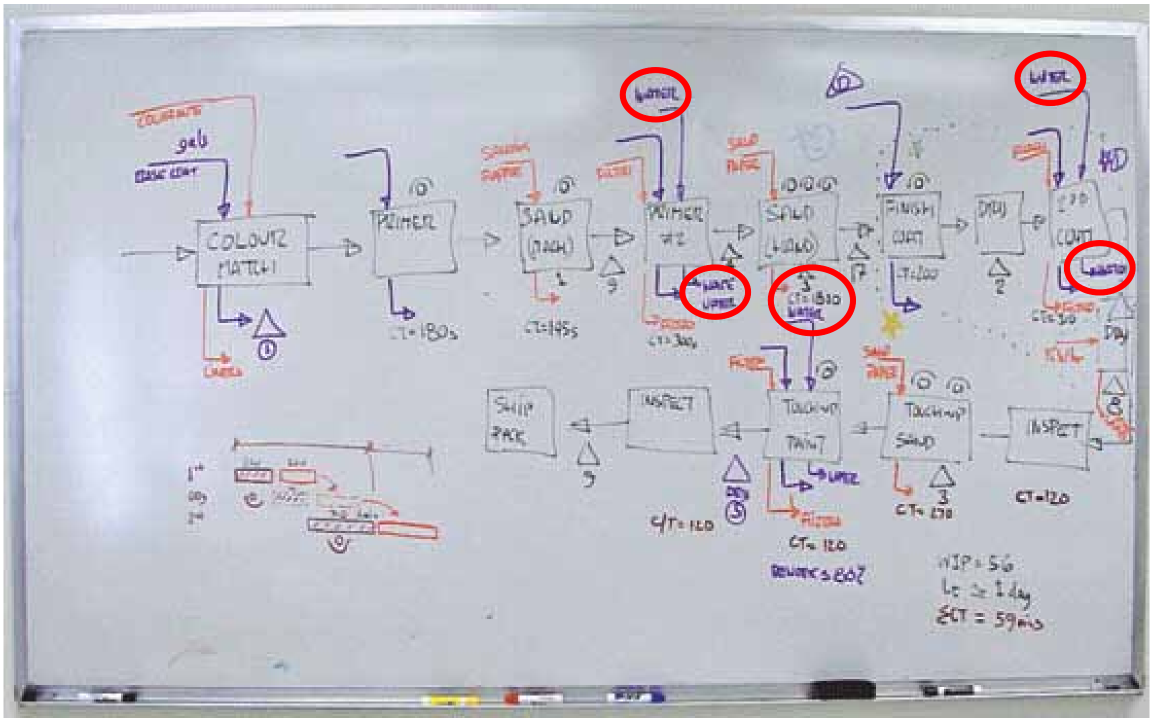
To create a visual representation of the areas in the value stream map that use the most water, try using different colors of sticky notes for high- and low-water using steps. See Figure 12 for an example of the use of sticky notes to create a value stream map, with water data added to several of the notes.

Figure 12: Process Boxes Showing Water Waste

Another way to show water inputs and outputs associated with your facility's processes is by drawing lines into and out of each process data box on your value stream map. In Figure 13, the red circles show where water and wastewater flows have been identified; other waste streams are identified as well. See EPA's *Lean and Chemicals Toolkit* for more information on this approach.[16]

[16] Value stream mapping is described in chapter 3 of the Lean and Chemicals Toolkit, available at http://www.epa.gov/lean/environment/toolkits/chemicals/ch3.htm.

Figure 13: Water Inputs and Outputs Identified on a Value Stream Map



After creating a current state map, your value stream mapping team will create a future state map that envisions ways to eliminate waste in the value stream and identifies areas for future process improvement projects, such as kaizen events or just-do-its (described in the next chapter). With water data included on the current state value stream map, your team will be able to easily identify opportunities for increased water efficiency and can work together to identify, prioritize, and develop an implementation plan for improvement projects that can meet both Lean and environmental goals. Incorporating water waste into value stream mapping allows water efficiency projects to be combined with and considered together with other operational improvements.

The implementation plan is a key product from the value stream mapping event. Take care to develop an implementation plan that details the steps to carry out the improvements you have identified, being sure to assign responsibility for each step of the plan. Consult with facility EHS staff and permitting authorities before making any changes that could affect facility emissions or wastewater discharges.

For more information on adding environmental metrics to value stream maps, see chapter 3 of EPA's *Lean and Environment Toolkit*.[17]

[17] Available on the EPA Lean Manufacturing and the Environment website at: www.epa.gov/lean/environment

Root Cause Analysis

When you find a water waste in your facility, whether during a gemba walk or a value stream mapping exercise, it's important to ask, "Why did this happen?" There is a set of Lean tools that can help you answer this question. *Root cause analysis* is the process of identifying a problem and working through possible components to identify the most basic reason why the problem is occurring. Once the cause of the problem is identified, you can prevent its recurrence. Two tools of root cause analysis include fishbone diagrams and the "5 whys" approach.

Explore water waste you've found in a *Fishbone Diagram* (also known as an Ishikawa Diagram), which shows potential causes of a problem by grouping causes into major categories to identify the source of inefficiencies. To investigate water waste using a fishbone diagram, first identify the specific problem you wish to investigate; perhaps a spike in water use at the facility, or a leaky pipe or valve. Write the primary problem you wish to investigate in the head of the diagram, usually on the right side. The "bones" of the diagram represent groupings of potential causes of the problem; common categories include the following:

- Measurements
- Material
- Man (or Personnel)
- Methods
- Machines
- Environment

Along each grouping, many detailed sub-causes are listed. Figure 14 on the next page, *Fishbone Diagram of Excessive Water Use*, shows an example of a fishbone diagram that one facility used to assess its water use.

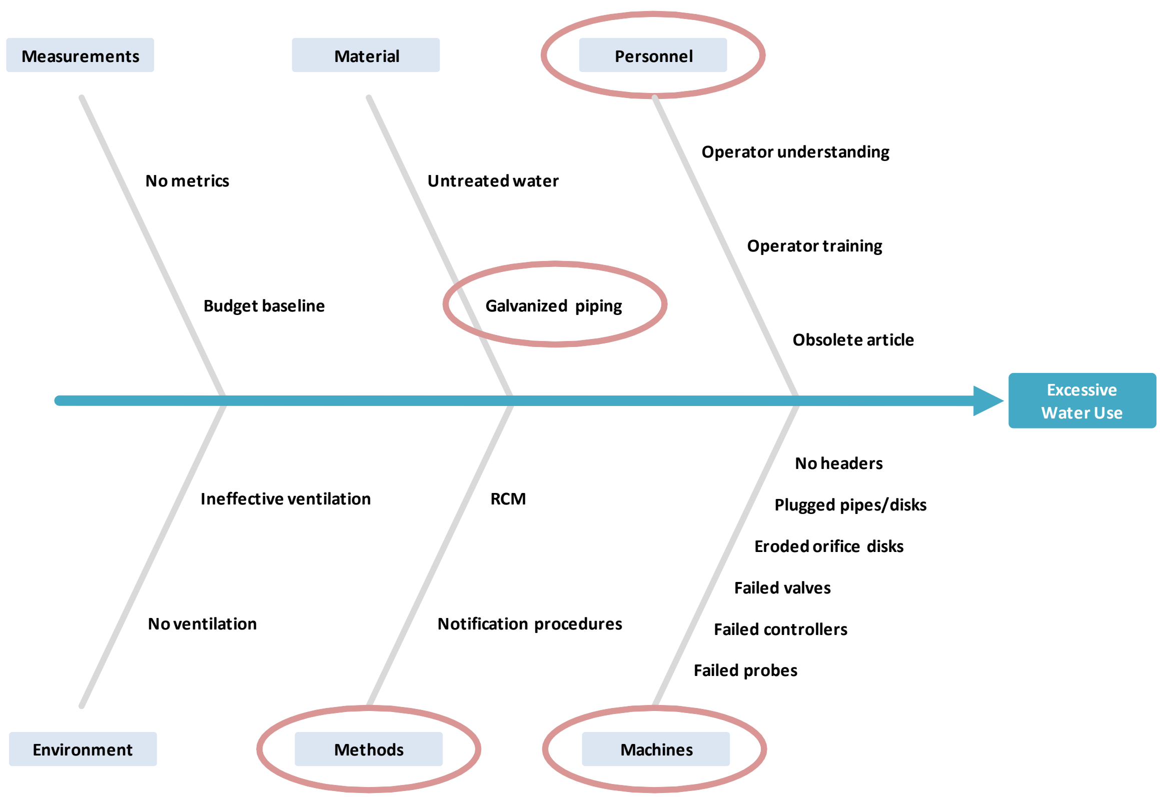
Another root cause analysis tool is the "*5 whys*" technique. The approach uses a systematic questionnaire technique to search for root causes of a problem. Simply ask "Why?" when considering the primary problem, "Why is excessive water used here?" Follow up with additional "Why?" inquiries until you drill down to the root cause of the problem. The goal of the exercise is to pursue further until the root of the problem is identified. Be aware that there is sometimes more than one cause of a problem.

Asking Why Five Times (Box 12)

1. *Why are we using so much water?*
   The parts need to be cleaned before painting.
2. *Why do the parts need to be cleaned?*
   The parts fail quality checks if they aren't cleaned before being painted.
3. *Why do painted parts fail quality checks?*
   The paint doesn't adhere when part surfaces are not prepared properly.
4. *Why do the surfaces of the part need to be prepared?*
   The surfaces get contaminated by oils used in the previous process.
5. *Why are oils used in the previous process?*
   The oils are used to prevent corrosion during storage.

Based on an example from Robert B. Pojasek, "Asking 'Why?' Five Times," Environmental Quality Management (Autumn 2000): 83.

Figure 14: Fishbone Diagram of Excessive Water Use



Source: Schulist, Jason. Lean Towards Sustainability: How to Use Lean and Six Sigma Methods to Drive Your Sustainability Journey. DTE Energy. 2009.

Completing a root cause analysis exercise should be a precursor to brainstorming potential solutions to water waste problems at your facility. By using these tools, you can ensure that you address the root cause of the problem first, instead of merely treating the symptoms. Chapter 4 explains how to take the knowledge about your facility's water use that you have gained through the tools listed in this chapter and apply that knowledge to reduce water use.

To Consider

- ✓ Where are the largest sources of water waste in your facility? If you don't know, what steps will you take to find out?
- ✓ Are there processes or areas at your facility that could use non-potable or lower quality recycled water?
- ✓ What resources might be available in your area to help you conduct a water balance or water audit?
- ✓ Where in your facility might be a good target for a water-focused value stream mapping activity?

CHAPTER 4

Lean and Water Efficiency Improvement Strategies

After you've taken the important first steps to understand how your facility uses water, there are a number of ways to reduce your water use through Lean and water efficiency efforts. This chapter describes the following:

- Kaizen Events and Just-Do-Its to Reduce Water Use
- Integrate Water Efficiency into Everyday Lean Practices
- Lean and Water Applications for Facility Operations and Support Processes

Kaizen Events and Just-Do-Its to Reduce Water Use

There are three key questions to ask to identify water-efficiency opportunities:

Key Water-Efficiency Questions (Box 13)

✓ Can we stop or prevent water losses (e.g., leaks)?

✓ Can we reduce water use (e.g., changing equipment, plumbing, processes, and/or behaviors)?

✓ Can we recycle or reuse water for another purpose (e.g., recirculating water within a process, reusing process water for another application, capturing rainwater, etc.)?

Lean's implementation-based methods of kaizen events and just-do-its are powerful strategies for putting water efficiency into practice—just-do-its for easy changes and kaizen events for more involved projects. A *kaizen event*—also known as a rapid process improvement event—is a 2–5 day period when a cross-functional team examines a process and makes rapid changes to improve it.

Before initiating significant process changes, remember to consult with your local utility or environmental agency to make sure that all facility permitting requirements are met. EHS staff at your facility can provide guidance on which changes may trigger regulatory or worker health and safety issues.

Water Kaizen Event Examples (Box 14)

GE conducted week-long water kaizen events at three of its largest water-consuming sites in 2009, including monitoring and assessing water use facility-wide and developing water-reduction projects with associated financial benefits.

✓ These kaizen efforts, combined with flow monitoring and water-conservation efforts at the largest water-consuming site, helped GE reduce water use 30 percent, from 15.3 billion gallons in 2006 to 10.7 billion gallons in 2009.

Through an environment, health, & safety kaizen event at one site, **United Technologies Corporation** eliminated 40,000 gallons of wastewater per year and saved $50,000 per year by changing how the facility managed test cells, an underground storage tank, and its waste streams.

✓ The facility no longer sends water to the storage tank, and waste fluids from the process (e.g., oils) are collected separately to allow for reuse, recycling, or reclamation.

✓ These efforts are expected to further reduce wastes, up to a total savings of 75,000 gallons and $150,000 per year.

GE, "Ecomagination 2009 Annual Report," pp 16-17, http://ge.ecomagination.com/report.html; World Business Council for Sustainable Development (WBCSD), "Eco-efficiency Gains Ground: United Technologies Corporation (UTC)," WBCSD Case Study, August 10005, available from www.wbcsd.org.

Two types of kaizen events to reduce water use include:

New Tool

- ***Water Kaizen Events***: Consider conducting some kaizen events that are specifically designed to find and implement water efficiency opportunities (see Box 14 for examples). Good places to target include processes or areas of facility operations that use significant amounts of water. Some companies, such as GE, use kaizen events to look for water-efficiency opportunities across a single facility. Water balances and value stream maps with water data can provide good ideas for where to focus water kaizen implementation activities.

- ***Kaizen Events on Water-Using Processes:*** Even if the main objective of a kaizen event is not water efficiency, it's helpful to keep an eye out for water-efficiency opportunities. There may be opportunities to reduce water use, such as by adjusting equipment or reusing water, while also improving other aspects of the process. Use the *Key Water-Efficiency Questions* in Box 13 above to identify water-savings opportunities.

Key Term

Often when you're looking for water waste, perhaps while using strategies described in the last chapter, you'll find easy solutions that can be implemented right away. These are good things to address with "just-do-it" Lean activities. *Just-do-its*, or "quick wins," are actions that individuals can take immediately to improve a process or operation. Many actions to stop water losses (such as fixing leaks or shutting off water that shouldn't be running) or simple equipment adjustments to conserve water (such as reducing water flow) fall in this category.

Water Efficiency Strategies

Ways to reduce water use range from simple strategies, such as adjusting the flow of water or installing water-saving devices on equipment, to more involved options such as reusing water or changing to a low-water or waterless process. There are five general types of water-saving strategies (see Figure 15). Consider these strategies as you brainstorm improvement ideas in kaizen events and other Lean efforts. Key things to keep in mind include:

- Consider water efficiency improvements in the context of other process improvements and Lean performance goals, in order to get the best results.
- Evaluate how the process changes might affect wastewater volume or quality, or have other environmental impacts. (For example, switching from a water-based lubricant to an oil-based lubricant or solvent could have implications for worker health and/or the environment.)
- Consider which water-efficiency best management practices and technologies make sense for your facility.
- Adopt visual controls, "mistake proof" devices on equipment (e.g., automatic shut offs), and/or procedures to help ensure that process changes are effective and can be easily maintained.
- After testing potential solutions, making changes, and evaluating actual performance, be sure to develop or update the standard work for the activity so that workers can easily identify the current, best way to perform an activity. (Standard work is also further discussed below.)

Figure 15: Five Water-Savings Strategies

✓ Adjust water flow
✓ Modify existing equipment or install water-saving devices
✓ Change to more water-efficient equipment
✓ Reuse or recycle water (treat if needed)
✓ Shift to a low-water or waterless process

When evaluating water reuse opportunities, it's important to consider both water quality and water quantity. Not all processes need the cleanest, highest-quality water. In many cases you may be able to reuse the "waste" water from one process or operation as an input to another process or for another use at your facility (e.g., air handling condensate, reverse osmosis reject water, etc.), as long as you match the quality of water needed for its intended use. You may need to do some testing

Key Poi

and additional treatment of the process water to make sure it is acceptable for the next use. *When evaluating the feasibility of using process water for irrigation or other outdoor uses, check with your local utility or water pollution control agency about restrictions on water reuse applications.* The water may require testing to ensure it meets pollutant limits.

Waterless Cleaning of Gatorade® Bottles (Box 15)

PepsiCo switched from cleaning Gatorade® bottles with water to a new method of cleaning with purified air. The new cleaning process works so well that it is being adopted by bottling facilities around the world, achieving a 20 percent reduction in water consumption throughout the process and saving billions of gallons of water.

New Tool

You can use the *Table for Evaluating Water Reuse Potential* below as a simple guide to identify possible ways to reuse water to meet the water quality and quantity needs of processes. You may also want to consider using reclaimed municipal water or water from another facility for certain uses. For more information on water reuse strategies, consult EPA's Guidelines for Water Reuse (www.epa.gov/nrmrl/pubs/625r04108/625r04108.pdf).

Table 6: Table for Evaluating Water Reuse Potential

Process/ Operation	Water Need		Water Discharge	
	Volume	Quality	Volume	Quality
Cooling				
Boilers				
Restrooms				
Kitchen				
Landscape				
Process A				
Process B				
Process C				

It may be possible for your facility's water to be reused by another industry or business. Look for these potentially symbiotic relationships with other facilities in order to stretch the value of your water even further for the community.

Integrate Water Efficiency into Everyday Lean Practices

A variety of Lean tools—including standard work, visual controls, 5S, and total productive maintenance (TPM)—help workers identify and eliminate waste in their daily activities, as described further below. Along with other wastes, these Lean tools can reinforce and promote strategies to reduce unnecessary water use.

Waste Elimination Culture

You can integrate water efficiency into the "culture of Lean" at your facility, developing the capacity of your employees to identify water waste in their normal work practices and find solutions that help meet your facility's Lean and water goals. When your workers are passionate about improving the way your facility uses water, the gains you achieve can become self-sustaining into the future.

Lean is built around the framework of eliminating waste and striving for perfection, or "True North," as discussed in chapter 1. It is most successful when employees are fully engaged in driving out waste and identifying improvement opportunities. *In the long run, developing people to be effective problem solvers is more important than implementing specific tools.* It is critical, therefore, to train employees on how to identify water waste and to encourage and motivate them to work towards your organization's water efficiency goals. The use of goals or targets combined with incentives and support resources can be a powerful way to drive change and performance improvement. Frito-Lay's "Gallon per Pound Challenge" Program, described in Box 16, provides an example of a successful water efficiency program anchored by metrics and employee engagement.

Figure 16: Sign to Encourage Water Conservation

Frito-Lay: Engaging Employees in Water Efficiency (Box 16)

Frito-Lay's "Gallon per Pound Challenge" established a water efficiency program for all manufacturing sites to exceed 95 percent water use efficiency. The program creates a culture of conservation through awareness, training, and accountability.

- ✓ Through mid-year 2007, the sites' collective water efficiency has improved to over 80 percent, which translates to a reduction in water use of over 1 billion gallons per year.
- ✓ Achieving the goal of 95 percent minimum efficiency for all sites will result in an additional water savings of approximately 800 million gallons per year.
- ✓ Frito-Lay earned a 2007 Water Efficiency Leader Award from EPA for these water-efficiency efforts.

The Challenge is anchored by a **water efficiency scorecard**, which is emailed to a wide array of stakeholders monthly.

- ✓ Water efficiency is calculated by dividing standard water consumption by the actual water consumption reported by the site. If a site uses more water than the standard, an efficiency score of less than 100 percent will result.
- ✓ The scorecard includes monetary savings opportunities for sites operating below 100 percent efficiency, as well as savings associated with improvements.
- ✓ Periodically a "did you know" section with best practices is distributed with the scorecard to help raise awareness.

Frito-Lay's **utility wall program** involves an event held at each site each day where a cross-functional team of technicians and workers gather to compare actual water consumption over the prior 24-hours to standard consumption and the site's goals.

- ✓ Utility walls enable teams to identify excessive water use and develop action plans to find and correct sources of variance.
- ✓ Teams identify areas where flow measurement and control devices can drive conservation, and ensure that viable water-efficiency projects are completed and working optimally.

Standard Work

Key Term

Standard work refers to an agreed-upon set of work procedures (sometimes referred to as standard operating procedures) that establish the best and most reliable method of performing a task or operation. Standard work helps sustain previous Lean improvements as well as serves as the foundation for future continuous improvement (kaizen) efforts. Incorporating water-efficient practices into standard work for processes helps to make them common practice.

Whenever you change operational practices to reduce water use or install new equipment that requires different operations, be sure to update the standard work for those operations. Water-efficiency strategies include both behavior changes and technological changes, but even technology-based changes may involve a behavior component. For example, workers need to properly operate and maintain new water-efficient equipment. Use standard work to reinforce desired behaviors.

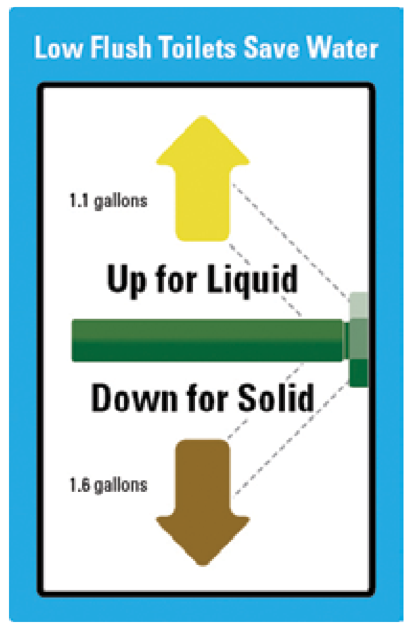
Visual Controls

Often used as part of standard work, *visual controls* support standardized procedures and display the status of an activity so every employee can see it and take appropriate action. Visual controls make it easier to perform actions the correct way and notice when there are problems.

Visual controls are essential for supporting behavior-based water efficiency strategies. Examples of visual controls to encourage water efficiency include:

- Signs to encourage employees to use less water
- Placards on water-using equipment showing proper operation (e.g., could include optimum water flow level)
- Water meters or sub-meters on high water using processes or equipment (see discussion in chapter 3)
- Displays of facility water use and water-use reduction goals on production control boards, along with other performance metrics (cost, quality, time, safety, environmental, etc.)

Figure 17: Dual Flush Toilet Visual Control



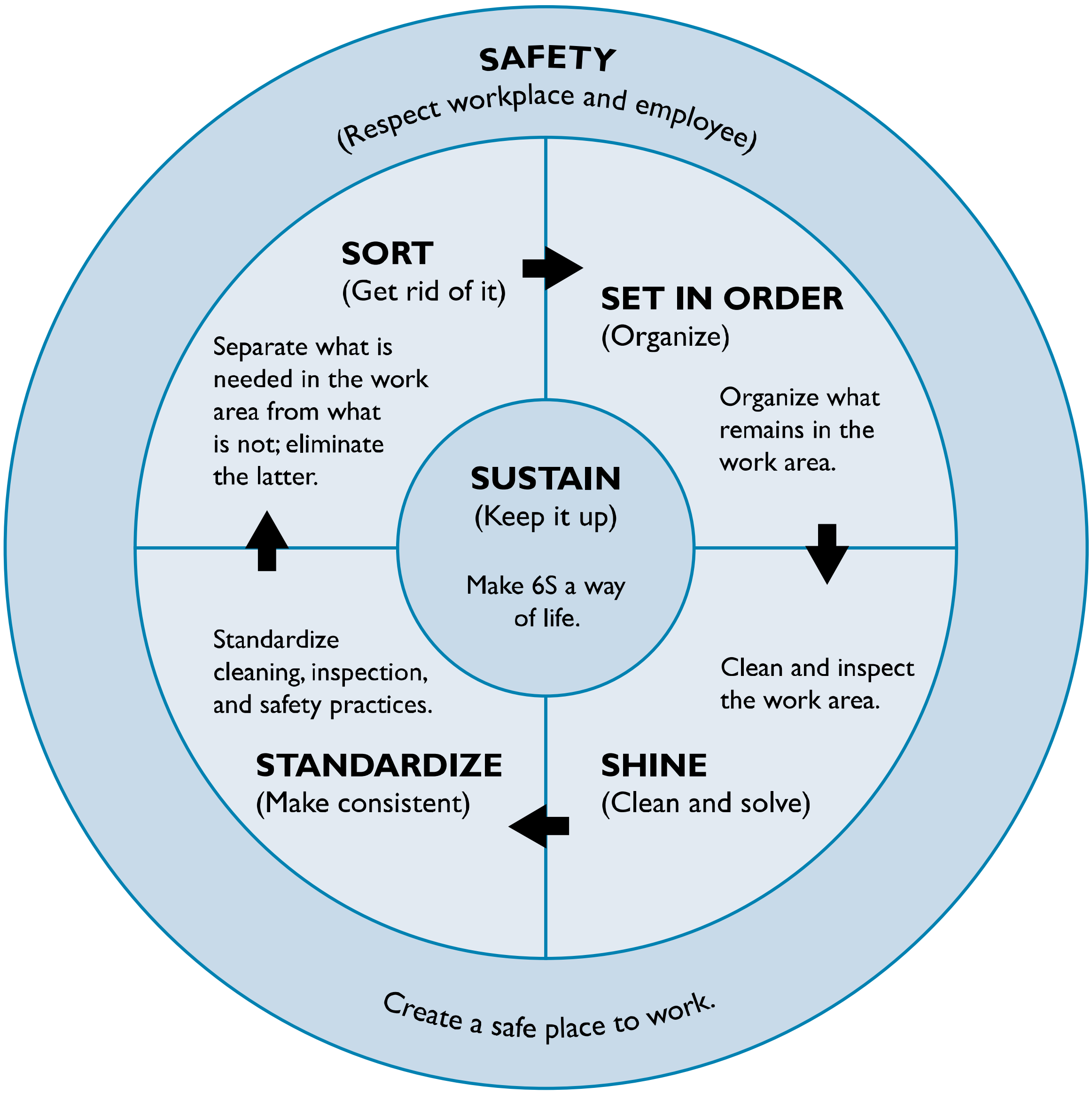
5S

Another way to incorporate water efficiency into Lean is through 5S. *5S* is a systematic, five-step process used to create and maintain a clean, orderly work environment. Many organizations add a sixth "S" for safety, creating *6S (5S + Safety)*. The six pillars of 6S consist of:

- **Safety** (Respect workplace and employee): Create a safe place to work by removing workplace hazards.
- **Sort** (Get rid of it): Separate items that are not needed in the work area.
- **Set in order** (Organize): Organize the items that remain in the work area.
- **Shine** (Clean and solve): Clean and inspect equipment and the work area.

- **Standardize** (Make consistent): Standardize cleaning, inspection, and safety practices.
- **Sustain** (Keep it up): Maintain a clean, orderly, and safe work area.

Figure 18: Six Pillars of 6S (5S + Safety)



Source: Adapted from Productivity Press Development Team, 5S for Operators: 5 Pillars of the Visual Workplace, Productivity Press, 1996.

One key step that is relevant to reducing water use is "Shine," since water is often used in cleaning and rinsing. Many industrial and manufacturing businesses use large amounts of water to flush lines, rinse parts and tanks, and clean equipment, floors, and other areas. These cleaning and rinsing practices often are large sources of wasteful water use and, therefore, opportunities for water savings. Educate employees on how to do the "Shine" step using less water, considering some of the *Water-Efficient Cleaning Strategies* in Box 17 below.

New Tool

Since employees work attentively to maintain a clean and neat work environment in 5S, it presents a good opportunity to spot water waste. In daily 5S shop floor sweeps, encourage employees to check for water leaks in pipes, hoses, plumbing fixtures, and equipment, as well as turn off water that shouldn't be running. Add checking for leaks to 5S checklists and other approaches implemented under "Standardize" and "Sustain" steps, so it becomes standard practice.

Water considerations are also relevant to "Safety." Preventing water from being on the shop floor and walkways can eliminate slipping hazards. Repairing hot water and steam leaks can prevent burns.

Water-Efficient Cleaning Strategies (Box 17)

Dry Clean-up First:

✓ Use brooms, brushes, squeegees, and/or other tools to remove materials and debris in dry form before using water for secondary cleaning. (This saves water, reduces wastewater, and enables recovery of process materials.)

Eliminate Unnecessary Water Use for Floor Washing:

✓ Sweep or use a water broom instead of hosing floors.

✓ Spot mop if necessary.

"Mistake-Proof" Your Equipment:

✓ Use hoses that have automatic shut-off nozzles.

✓ Use efficient spray nozzles, high-pressure washers, and/or flow restrictors to clean efficiently while reducing water use. (High-pressure, low-volume sprays generally work better than low-pressure, high-volume sprays.)

Use Efficient Spray Washing and Rinsing Techniques:

✓ Use water wisely, and turn off water when not in use.

✓ Do not use a hose as a broom; doing so wastes time, water, and energy.

✓ Optimize spray and rinsing techniques, and document the best practices in the standard work for the process.

For more suggestions, see North Carolina Department of Environment and Natural Resources, "Water Efficiency Manual for Commercial, Industrial and Institutional Facilities," May 2009, www.p2pays.org/ref/01/00692.pdf.

Total Productive Maintenance

As a key strategy for finding and preventing water losses, as well as other equipment failures, *Total Productive Maintenance* (TPM) is also relevant to water efficiency. TPM is a Lean method that focuses on optimizing the effectiveness of manufacturing equipment. TPM focuses on team-based maintenance that involves employees at every level and function.

A key practice in TPM is to maintain equipment in a manner that enables workers to quickly identify and correct problems that may result in leaks or spills. Since many facility operations use water, not just production processes, it's important to extend the preventative maintenance practices of TPM to non-production areas (e.g., restrooms and irrigation) when looking for water issues. Box 18 outlines *Proactive Maintenance Tips to Reduce Water Use* that can be incorporated into a TPM program. For more tips and suggestions, see EPA's "WaterSense at Work: Best Management Practices for Commercial and Institutional Facilities," available at www.epa.gov/watersense.

Proactive Maintenance Tips to Reduce Water Use (Box 18)

- ✓ Adopt a user-friendly system for reporting water leaks, and fix leaks immediately.
- ✓ Inspect hot and cold water lines, steam lines and traps, water-using equipment, and plumbing fixtures routinely to identify potential problems and keep them operating properly.
- ✓ When performing maintenance on water-using equipment, replace worn parts and check to make sure that water-saving features (e.g., automatic shut-off valves) are operating properly.
- ✓ Shut off water supply to equipment in areas that are not in use.

Lean and Water Applications for Facility Operations and Support Processes

As noted earlier, the most water-consuming aspects of your facility may not be production processes; other facility water uses include cooling towers (which are often the largest water end use), boilers, support processes, restrooms, kitchens, and irrigation. Water balances, value stream maps, and other strategies in chapter 3 describe how to identify the largest sources of water waste at your facility. These represent good targets for kaizen events to reduce water use. Consider the *Questions to Identify Water-Savings Opportunities in Facility Operations and Support Processes* in Box 19 to identify initial opportunities.

Questions to Identify Water-Savings Opportunities in Facility Operations and Support Processes (Box 19)

Cleaning

✓ Can process cleaning or facility cleaning be accomplished without using water (i.e., using pressurized air to clean products or containers, sweeping debris off the floor)?

Process Equipment

✓ Can process equipment reuse water (closed loop) or use reclaimed water from other parts of the facility?

Cooling and Heating

✓ Has your facility replaced once-through cooling systems with a multi-pass cooling tower or closed systems?

✓ Can you optimize the blow-down/bleed-off controls on boilers and cooling towers?

✓ Have you considered switching to air-cooled equipment instead of water-cooled equipment?

✓ Does your facility reuse condensate water?

Restrooms and Kitchens

✓ Do restrooms have water-efficient fixtures (e.g., WaterSense labeled toilets and urinals, faucet aerators, and showerheads)?

✓ Do kitchens use new water- and energy-efficient dishwashers (e.g., ENERGY STAR qualified models)?

Landscaping and Irrigation

✓ Has your facility designed its landscape to consider the local climate and grouped plans by similar watering needs?

✓ Does your facility use drip irrigation, low-flow sprinklers, and optimized watering schedules to minimize water use?

Leaks

✓ Have you identified and repaired leaks throughout your facility?

New Tool

Appendix D, *Water Efficiency Opportunity Checklist*, is a more extensive checklist for identifying water-savings opportunities throughout your facility.

Along with the questions in Box 19 and Appendix D, a wide array of resources are available that provide information on low-cost, water-efficiency measures for common components of facility operations, as well as resources that provide guidance and examples relevant to specific industries. Consider these water-efficiency strategies in your Lean improvement projects. Examples of resources with guidance for specific operations and/or industries include:

- "Water Efficiency Manual for Commercial, Industrial, and Institutional Facilities" by the North Carolina Department of Environment and Natural Resources, http://savewaternc.org/bushome.php.
- "WaterSmart Guidebook" by the East Bay Municipal Utility District of Oakland, California, www.ebmud.com/for-customers/conservation-rebates-and-services/commercial/watersmart-guidebook.
- "WaterSense at Work: Best Management Practices for Commercial and Institutional Facilities" by EPA Office of Water, www.epa.gov/watersense.
- "Facility Manager's Guide to Water Management" by the Arizona Municipal Water Users Association, amwua.org/pdfs/facility_managers_guide.pdf.

See Appendix A for details about these and other water efficiency resources.

To Consider

✓ What just-do-it actions can you identify to reduce water use?

✓ What processes or operations would you consider for kaizen events focused on water efficiency?

✓ What water-reuse options might there be at your facility? What steps will you take to learn more about those opportunities?

✓ What ideas do you have for adding water-efficiency practices into everyday Lean practices (e.g., through Lean training, use of metrics, incentive programs, standard work, visual controls, 5S, TPM on water-using equipment, or other means)?

✓ What other ideas do you have for reducing water use with Lean or other process improvement efforts?

CHAPTER 5

Lean and Water Beyond the Factory Floor

Looking beyond your facility operations—such as your supply chain, interactions with your community, and how you design products—can allow you to uncover new ways to reduce water use and risks, while adding value and improving business operating conditions and market opportunities. This chapter examines:

- Lean and Water Efforts in Your Supply Chain
- Engaging with the Community
- Lean Product Design

Lean and Water Efforts in Your Supply Chain

Depending on your industry sector, the greatest opportunities for water use reduction may be in your supply chain, rather than your facility's own operations. As discussed in chapter 1, companies whose suppliers have water-intensive operations may feel pressures from customers or other stakeholders to reduce water use within their supply chain. It is important for your business to understand water use and risks throughout the value chain—including upstream in supplier operations and downstream in customer activities. In particular, the water needed to extract and process raw materials may be significant in some sectors, while other stages, such as product-use, are more important for others.

Some water impacts in the supply chain can be addressed by engaging your suppliers in your Lean and water efforts. The techniques in this toolkit can be applied at both large and small companies. Here are some ideas to get started:

- Ask suppliers about their water use and their water efficiency efforts.

- Invite customers and/or suppliers to participate in a Lean and water value stream mapping event, water gemba walk, or water kaizen event at your facility to learn from your experience and share their perspectives.

- Offer to participate in your customer's and/or supplier's Lean events if your business has relevant expertise.

- Share training materials you've developed, best practices, and success stories of your Lean and water efforts to educate suppliers on these efforts.

- Invite suppliers to participate in training sessions with your employees. For example, the furniture manufacturer Steelcase invites its suppliers to attend workshops covering Lean and environment topics at its "Steelcase University."

- Start a dialog with your suppliers about Lean and water projects to initiate together.
- Encourage suppliers to develop and share short- and long-term water reduction goals and report progress against the goals.
- Provide incentives, recognition, and/or financial support for suppliers to conduct Lean and environmental improvement efforts and/or for suppliers that help you meet your water efficiency goals.
- Consider focusing first on suppliers that are located in water-scarce areas, where reducing water consumption can have the greatest positive impact on community relations.

For some smaller companies, working with your supply chain may be more challenging than is the case for larger companies. One option for smaller facilities is to inform your suppliers that they may access resources available through local utilities, such as technology rebates or free or subsidized water audits.

Dubois Chemical and Steelcase: An Innovative Lean Water Supplier Partnership (Box 20)

Furniture manufacturer Steelcase worked with Dubois Chemical on a demonstration project exploring an alternative pretreatment washing process on one of Steelcase's finishing lines.

✓ The team analyzed the total cost of ownership (for energy, labor, water/sewage, and process chemicals) in the current and future state process maps, and relied on water recycling and other strategies to save time, energy, water, and chemicals.

Due to the project's success, Steelcase has deployed it on seven powder coating lines. Results include:

✓ Saved $1 million per year.

✓ Eliminated phosphates from pretreatment discharge.

✓ Met 2007 emergency water-reduction requirements in Atlanta.

✓ Reduced water use by 80 percent, chemical volume used by 20-30 percent, and waste discharged by 85-95 percent.

✓ Saved 45 million gallons of water per year.

Sources: Steelcase/Dubois info from: Mary Ellen Mika and Keith Lane, "Joint Case Study: Reducing Your Water Footprint" presentation at 23 September 2008 Corporate Climate Response Conference; Mary Ellen Mika et al., "E3 and GSN: Learning, Evolving, and Expanding" presentation at 2011 Manufacturing Innovations Conference.

Some companies participate in Lean supply chain initiatives that focus on environmental objectives, such as water use reduction. For example, in the U.S. Green Suppliers Network Program, Lean service providers at Manufacturing Extension Partnership centers partner with environmental specialists to deliver "Lean and Clean" process assessments for companies in the supply chains of larger organizations on a fee-for-service basis (see Box 21). The assessments use value stream mapping with an added focus on environmental metrics and costs to identify opportunities for improvements in resource use. Many of the assessments include support for implementation. A similar program called E3 (Economy, Energy, and Environment) incorporates Lean, environmental, and energy technical assistance and also involves local utilities as partners.[19] Companies should encourage their suppliers to consult their local water and energy utilities to find rebates or incentives for efficient technologies and process improvements.

Green Suppliers Network Lean and Water Successes (Box 21)

Southwire and **Pacific Gas & Electric (PG&E)**

- ✓ Southwire, a manufacturer of wire and cable products and a key supplier of PG&E, participated in a Green Suppliers Network review in 2008 at its Carrollton, Georgia plant.
- ✓ Based on the value stream map-based review and the team's recommendations, the facility implemented a water-looping system that recycled water without affecting product quality.
- ✓ These efforts cut facility water use by more than 9 million gallons (over 90 percent) and saved more than $70,000 annually.

McNeil PPC and **Johnson & Johnson**

- ✓ McNeil-PPC Inc., which manufactures Listerine® products for Johnson & Johnson, participated in a Green Suppliers Network review project in 2007, with the support of Johnson & Johnson.
- ✓ With value stream mapping, the team found that 450 gallons of Listerine® and 60 gallons of water were wasted per line change.
- ✓ The team recommended solutions to minimize changeover wastes. These recommendations have significantly reduced the amount of water that the facility would otherwise use.
- ✓ With changes such as reusing water for boilers, using flavors instead of water to clean equipment, sequencing flavors from light to dark, switching to waterless conveyor belts, and using closed-loop cooling, the facility has cut wastewater discharge by 25-30 percent.

Sources: Green Suppliers Network, www.greensuppliers.gov/results/success.html and information provided by Charlie Souders, Johnson & Johnson/McNeil Consumer Healthcare, June 29, 2011.

[19] For more information on the Green Suppliers Network, see www.greensuppliers.gov, and for more information on the E3 initiative, see www.epa.gov/greensuppliers/e3.html.

Another way that companies can influence supplier actions is through policies and programs that encourage water efficiency. Examples include:

- **Procter & Gamble (P&G)** has adopted a Supplier Environmental Sustainability Scorecard, which produces annual supplier sustainability performance ratings for suppliers based on environmental data and qualitative assessments the suppliers provide, which include data on water use. Suppliers receive higher ratings for contributing to P&G's environmental initiatives, and P&G recognizes suppliers receiving the highest rating in the process.[20]

- **PepsiCo** has a Supplier Sustainability Outreach Program, in which suppliers regularly submit metrics to track their progress toward short-term and long-term goals in energy, water, and waste efficiency. The program prepares suppliers to join ENERGY STAR, which is required for all U.S.-based suppliers. Suppliers gain access to PepsiCo resources, training, tools, and an invitation to the Global Environmental Sustainability Summit. Fuel, electricity, and water savings from the program totaled $1.2 million as of the third quarter of 2010. Forty co-packers and suppliers across 102 manufacturing sites participate, and the program continues to expand in the United States and globally.

- **Levi Strauss & Co.** is adjusting its policies to allow more water recycling and reuse at contract finishing facilities—it now allows reclaimed water to be used at finishing facilities through onsite treatment, internal recycling, or from a nearby treatment facility. Uses for reclaimed water include landscaping, toilets, and heating, ventilation, and cooling systems.

- **Wal-Mart** provided over 100,000 suppliers with a sustainability survey to collect information about their environmental performance. The survey includes questions on the total water use of facilities that produce products for Wal-Mart, as well as guidelines for conducting a water footprint and improving water efficiency at facilities. Future phases of Wal-Mart's "Sustainability Index" project include the development of a database of information on product lifecycles and a tool to help merchants and customers understand the sustainability of products.[21]

Consider the following five strategies to promote Lean and water efficiency efforts with your suppliers, keeping in mind that some of these might be less feasible or applicable for small facilities.

- **Require reporting from suppliers:** Requests for reporting on water use and efficiency efforts sends a message to supply chain businesses that the company cares about water. It may also help you understand business risks and opportunities to assist suppliers in reducing water use or risk. Benchmarking of water metrics (e.g., water intensity

[20] For more information about P&G's sustainability work with suppliers, see www.pg.com/en_US/sustainability/environmental_sustainability/operations_suppliers/supplier_engagement.shtml.

[21] For more information on Wal-Mart's Sustainability Index, see http://walmartstores.com/Sustainability/9292.aspx.

ratios that relate water use to production levels) may be useful to set goals and performance targets. Companies can encourage suppliers to utilize ENERGY STAR's Portfolio Manager or other tools to track environmental performance.

- **Examine product specifications:** Evaluate how procurement requirements affect the amount of water required to produce or transport the product to facilities. Some companies may be able to reduce the water used in their supply chains by changing their sourcing specifications.

- **Provide recognition, awards, and/or incentives:** Recognizing supply-chain water and environmental initiatives can raise awareness of and encourage water use reduction and best-practice sharing among suppliers. Stories of water-saving efforts may also be of interest to customers.

- **Consider supplier requirements:** It may be appropriate to consider water-related performance in the selection of suppliers, particularly in water-intensive parts of your supply chain. Performance targets or certification requirements (e.g., ISO 14001) could also be incorporated into procurement requirements or partnership agreements. Consider developing sector-specific standards to reduce overall environmental impacts (e.g., the Business and Institutional Furniture Manufacturers' Association Sustainability Standard).[22]

- **Provide, subsidize, or make referrals for technical assistance:** Companies can provide technical assistance or training on Lean and water approaches to supply chain partners. Alternatively, encourage participation of supply chain partners in "communities of practice" to share information on water efficiency and environmental improvement opportunities. Manufacturing Extension Partnership centers provide support for Lean training and can help you integrate water efficiency considerations into your supply chain. Organizations can also make suppliers aware of water efficiency resources and services available from local utilities and other sources.

- **Collaborate on joint Lean and water projects:** Collaborate with your suppliers and/or your customers to develop approaches to reduce water use and risks, or to capture new market opportunities. Consider using the ideas, strategies, and tools in this toolkit as a starting point for a discussion about Lean and water opportunities to pursue.

[22] This standard is available at: www.bifma.org/public/SusFurnStd.html

Levi Strauss & Co. and the Better Cotton Initiative (Box 22)

Levi Strauss & Co. completed a third-party lifecycle assessment to understand the environmental impact of an iconic product, Levi's® 501® jeans. The company discovered that:

✓ Forty-nine percent of water consumption for Levi's® 501® jeans occurs in cotton production, while another 45 percent occurs after consumers take the products home.

✓ The remaining water use is divided among fabric production (2 percent), finishing (3 percent), and retail (1 percent).

Recognizing the importance of the cotton production stage, Levi Strauss & Co. joined the Better Cotton Initiative (www.bettercotton.org) in 2008 to change the way it grew cotton.

✓ The Better Cotton Initiative seeks to make global cotton production better for the people who produce it, better for the environment, and better for the apparel sector's future.

✓ Pilot projects in countries such as Brazil, India, Mali, and Pakistan work to reduce the environmental impacts from cotton production while supporting local economies.

✓ In Pakistan, participating farms cut water use by over 30 percent, 11.7 billion cubic meters of irrigation water in 2010.

Source: Levi Strauss & Co., "CEO Water Mandate Communication on Progress 2010," www.levistrauss.com/sites/default/files/librarydocument/2010/12/lsco-ceo-water-mandate-cop-2010.pdf.

Engaging with the Community

In many cases, water stewardship is a key component of a facility's ability to operate in a community. Depending on where your facility is located, your business and the surrounding community may face different types of water resource challenges—such as water scarcity, infrastructure, or pollution concerns. Especially in water-scarce regions or during droughts, people in the community may have an increased interest in what your facility is doing to reduce its impacts on local water resources. Indeed, community engagement is recognized as a key pillar of water resource management by the United Nations CEO Water Mandate, which assists companies in developing and implementing sustainable water policies and practices.[23] Engaging proactively with your community on water conservation can be an effective way to mitigate water-related business risks as well as reduce your organization's overall water footprint.

[23] The UN CEO Water Mandate is available at www.unglobalcompact.org/Issues/Environment/CEO_Water_Mandate.

Two key strategies for effective community engagement include:

- Educate and engage your employees in water-efficiency efforts at your facility, and encourage them to adopt similar practices at home (e.g., check for leaks, use efficient appliances and faucets, turn off water when not in use, etc.). Build the capacity of employees to spot water waste and problem solve throughout their daily activities, on the job and off.

- Partner with community members and local organizations to conduct projects that improve water use, water quality, and/or water infrastructure resources in the community. Consider using Lean methods—such as a waste walk, kaizen event, or even a Lean design event—to rapidly brainstorm and test improvement ideas for projects, and include community stakeholders in those efforts.

Along with the value of community engagement, these strategies can have the benefit of partially or fully "offsetting" impacts the facility may have on local water resources. That is, a facility can support efforts that replenish the local water supply by at least the amount of water the business uses directly. In India, **PepsiCo** has achieved a positive net water balance in this way (see Box 23).

PepsiCo's Positive Water Balance Project in India (Box 23)

At its facilities in India, PepsiCo achieved a "positive water balance"—where businesses contributed more water to the communities than they consumed—in 2009 and 2010.

✓ Savings of over 3 billion liters of water in 2009 and over 4 billion liters in 2010 have been verified externally by Deloitte LLP.

As part of these efforts, PepsiCo India has.

✓ Reduced water usage in manufacturing by 45 percent since 2005.

✓ Partnered with government agencies and local organizations to increase people's access to clean water.

✓ Worked with agricultural universities to promote "direct seeding" of rice paddies, which allows seeds to be directly planted into the soil (without the need for a nursery) and avoids the need for flood irrigation. (This reduces water use by up to 30 percent.)

✓ Saved over 5 billion liters of water from 6,500 acres of direct-seeded paddy fields.

✓ In 2010, PepsiCo began working with the Nature Conservancy to explore ways to credibly achieve a positive water impact across its global operations.

Source: PepsiCo, "Replenishing Water Conserving the world's most precious asset: Water," http://pepsicoindia.co.in/purpose/environmental-sustainability/replenishing-water.html, accessed 28 July 2011.

Businesses can use Lean tools to engage with communities in collaborative problem solving to achieve social, economic, and environmental goals, such as water efficiency. For example, **DTE Energy**—a Detroit, Michigan based electric utility—has used tools including gemba walks, value stream maps, and "critical-to-sustainability" trees (a modification of "critical-to-quality" trees) with Detroit area businesses and community members to tackle the following projects:

- Partnered with a non-profit to manage combined sewer overflows by planting thousands of trees to reduce the stormwater runoff in Detroit.
- Found a new use for the buffer land around substations as community gardens, with thousands of pounds of produce harvested at each substation and donated to food pantries.
- Created a community-supported agriculture business model based on a gemba walk with the community that identified issues such as urban blight, meaningful work, neighborhood connectivity, and healthy living.

In areas where water scarcity and drought are issues, facilities can engage with communities to share knowledge, work toward solutions, and build goodwill. Here are two examples of companies who engaged in collaborative dialogue with their communities in response to problems with water scarcity in areas where their operations were located:

- **Coca-Cola** partnered with the United Nations Development Programme and Chinese government representatives to improve water efficiency in response to a severe drought threatening sugarcane growers. The first phase will be completed in 2011, and will focus on improving infrastructural facilities that support the farmers' work and life directly, such as optimizing irrigation facilities and recycling treated wastewater from sugar plants to improve farm production and water use efficiency. This first phase will provide approximately 500 million liters of water to rural residents and directly benefit 100,000 rural sugarcane farmers in the region. In future phases, this collaboration will pursue improvements in water efficiency in business operations, and will seek to ease pressure on local water supplies through continuing community water partnerships.[24]
- The chemical manufacturer **Sasol** identified water scarcity as a risk to its operations in South Africa, and pro-actively approached the problem by organizing a joint dialogue with community stakeholders, representatives of water-intensive industries in South Africa, government and non-governmental institutions, and local research institutions. The dialogue promoted cooperation among the stakeholders and between Sasol and its surrounding community, as the sharing of knowledge and experiences coalesced toward the formulation of several ideas for collective action toward improved water efficiency.[25]

[24] For more information about Coca-Cola's work with sugarcane growers in China, see www.thecoca-colacompany.com/dynamic/press_center/2011/03/chinas-sustainable-sugarcane-initiative.html.

[25] For more information, see http://sasolsdr.investoreports.com/sasol_sdr_2008/?page_id=141

Lean Product Design

Lean design methods are a group of Lean tools and techniques that aim to:

- Design (or redesign) high-quality products that meet customer needs with the least amount of waste (aspects that do not add value); and/or
- Design (or redesign) processes and equipment that add value to products using the least amount of time, material, and capital resources.

Taking a close look at the parts and processes that go into the creation of a product can help you to identify wastes, including water waste, and improve product quality, reduce costs, and potentially gain market advantage.

Lean product design methods often rely on a set of criteria to evaluate the best alternatives. *Incorporating efficient water use as a design criterion for product development can reduce water waste throughout the entire life cycle of the product.* Consider raw materials, synthesis, production, customer use, and the ultimate disposal or recycling/remanufacturing of the product when considering water use.

As with other aspects of Lean implementation, product design is most effective when it incorporates "whole systems" thinking focused on eliminating all forms of waste. Be sure to consider traditional Lean goals for both the product and the manufacturing process, such as product quality, customer service, cost, and time, when you incorporate water efficiency into the Lean product design process. Improving water efficiency should not mean lowering the quality of your finished product or decreasing the productivity of your facility. *Note that sometimes design alternatives that improve water efficiency can present trade-offs in which decreasing water use results in increased energy or chemical use; such endeavors may not be worthwhile depending on the overall impacts.* You can help ensure that your product quality remains high by adhering to product quality design standards, such as the U.S. Green Building Council's LEED standards for buildings,[26] EPA's WaterSense program standards for certain water-consuming products and appliances,[27] and sector-specific product standards.

There are several Lean tools to help design (or redesign) a product in a way that reduces wastes. Some of these tools are described in Table 7, below. For more information about these tools and an explanation of which tools to use in various product design stages, see chapter 6 of *The Lean and Chemicals Toolkit*.[28]

[26] The U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) standards are available at www.usgbc.org/DisplayPage.aspx?CategoryID=19.

[27] For more information about the U.S. EPA WaterSense Program, see www.epa.gov/WaterSense.

[28] Available at: www.epa.gov/lean/environment/toolkits/chemicals

Table 7: Methods Used in Lean Design[29]

Method	Description
3P (Production Preparation Process or Pre-Production Planning)	An integrated and highly detailed approach to product and/or process development, which involves rapidly designing production processes and equipment to ensure capability, built-in quality, productivity, and flow. 3P minimizes resource needs such as capital, tooling, space, inventory, and time.
Design for Lean Six Sigma	A method for designing processes that support Lean Six Sigma objectives, such as reduced variability, to improve yield, reduce waste, and accelerate time-to-market.
Design for Manufacturing & Assembly	A simultaneous engineering process designed to optimize the relationship between design function, manufacturability, and ease of assembly.
Failure Mode & Effects Analysis	A design review methodology that focuses on identifying the potential failure modes of a product, and subsequently determining ways to mitigate each risk of failure.
Quality Function Deployment and "Voice of the Customer"	An overall methodology that begins in the design process and attempts to map the customer-defined expectations and definition of quality into the processes and parameters that will fulfill them. It integrates customer interview and market research techniques with internal cross-functional evaluations of the requirements.
Value Engineering	An organized methodology that identifies and selects the lowest lifecycle cost options in design, materials, and processes that achieves the desired level of performance, reliability and customer satisfaction. It seeks to eliminate unnecessary costs in the above areas and is often a joint effort with cross-functional internal teams and relevant suppliers.

[29] For additional information about many of these tools, see: Mascitelli, Ronald. The Lean Design Guidebook. Technology Perspective: Northridge, CA, 2004. See also EPA's webpage on 3P, www.epa.gov/lean/thinking/threep.htm.

Table 8 lists examples of questions to ask when evaluating product design alternatives to identify ways to reduce water waste during all phases of the product life cycle.

Table 8: Questions to Ask During Lean Product Design

Life Cycle Phase	Questions to Ask
Sourcing Materials and Inputs	✓ Will raw material production prior to manufacture involve intensive use of water? ✓ Can you switch to materials that require less water in their production, or work with suppliers to reduce water use?
Production/ Manufacturing	✓ Will water be used to manufacture the product? Evaluate all new equipment and modifications. ✓ What steps can be taken to reduce the amount of water that will be used to manufacture the product (e.g., switch to water-less processes, reuse water, etc.) ✓ How can you design products to reuse water in multiple process steps (e.g., recovering rinses from cleaning, counter-current flow, or refiltering water)?
Product Distribution, Use, and Disposition	✓ How much water will the product require during use? ✓ What product design alternatives use less water (e.g., through reuse systems, water-efficient features, etc.)? ✓ What steps can you take to ensure that product performance is maintained as you implement water efficiency improvements? ✓ How will the product design affect customer water use? Can reductions in the product use phase be guaranteed? ✓ How can the design ensure customers will be satisfied with product performance even with reduced water use?

Some companies report that the "seven ways" method provides a useful means to identify a more diverse, creative set of improvement options to address specific water-related needs. This method is often used in the Lean design process. This method typically involves brainstorming of seven alternative approaches for addressing a specific improvement opportunity. Sometimes teams are encouraged to look at how similar tasks are accomplished in the natural world to spark creative thinking on alternatives. The team then scores the seven alternatives using pre-established, weighted criteria to select the preferred solution. Consider incorporating water efficiency into these criteria (water used to manufacture and/or full life-cycle water use) to ensure that product design alternatives are evaluated according to your Lean and water efficiency goals.

Examples of Water Conservation through Product Design (Box 24)

GE used the 3P (Production Preparation Process) Lean strategy to launch a new water-saving product line.

- ✓ Geospring™ hybrid water heaters, dishwashers, and top-loading washing machines are being redesigned from scratch using Lean manufacturing techniques.
- ✓ Production team members from engineers to technicians now work together in a cross-functional approach that involves everyone from design through production, using scaled-down equipment and product mockups to visualize improvements.
- ✓ This hands-on, whole-team approach has allowed employees to make adjustments in real-time, allowing problems to be identified early and producing dramatically simpler designs that cut total product development time.

Levi Strauss & Co. examined the design of its popular blue jeans to identify ways to reduce the water used to manufacture the product.

- ✓ Water<Less™ jeans reduce water consumption by an average of 28 percent, and up to 96 percent for some new products.
- ✓ These water savings were accomplished by reducing washing cycles, incorporating ozone processing into washing, and removing water from stone washing.
- ✓ While the production of Levi's® blue jeans, like many products, uses a significant amount of water in the supply chain as well as through consumer end use, the company made significant progress by addressing water use in the manufacturing process.

As described earlier in this chapter, there is great potential for water savings throughout a product's supply chain, including the acquisition of resources and raw materials, as well as the water that customers will use with the product or service. However, *if you are just getting started with Lean, consider focusing first on water use within your facility before branching into your supply chain and customer-use considerations.*

To Consider

- ✓ What parts of the extended value chain of your enterprise use the most water? If you don't know, how will you find out?
- ✓ Have you talked with any of your suppliers about Lean and environmental improvement efforts?
- ✓ What opportunities are there to offset water impacts and improve water resources for the local community?
- ✓ What changes could you make to the design of your products to reduce water wastes?

CHAPTER 6
Conclusion

This chapter includes the following sections:

- Your Lean and Water Journey
- Concluding Thoughts

Your Lean and Water Journey

We hope that this toolkit has provided you with practical ideas to leverage Lean methods to identify and eliminate water waste at your facility. Learning to see water waste and to identify improvement opportunities using Lean tools will help you to save money and be a better partner to your community by placing less of a burden on local water supply. There are many tools and techniques to get started with using Lean to reduce water waste. As described in more detail in chapter 1, here are three ways to get started with Lean and water efforts.

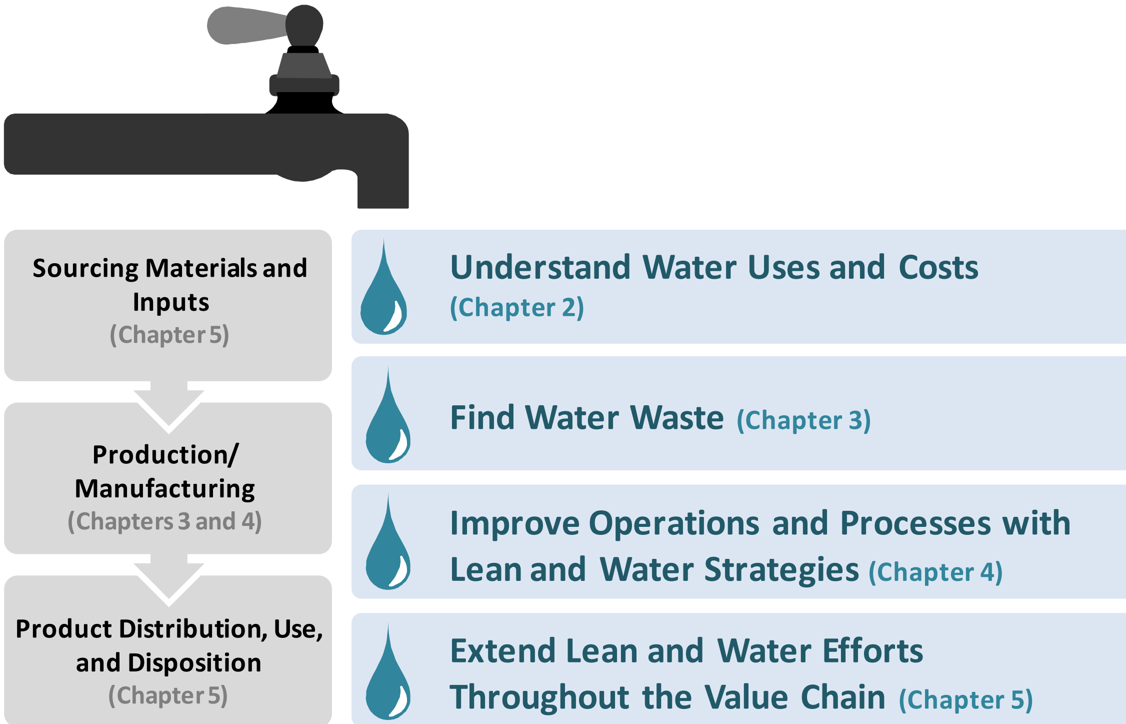
- **Learn more about how your facility uses water.** Connect with environment and facilities personnel to discuss opportunities to reduce water waste with Lean. Find water waste in your facility using tools like metering and water balances.

- **Engage employees in lean and water improvement efforts.** Involve employees in teams to brainstorm ways to reduce water use, encouraging their ideas to innovate improvement opportunities. Try out some of the strategies for eliminating water waste that are described in this toolkit.

- **Connect Lean and water efforts to sustainable water management strategies.** Use Lean tools to support a broader corporate water sustainability strategy. Identify what the "True North" goals and targets are for water use at your facility and track progress to inspire improvement and creative solutions. Look beyond direct operations to engage your customers, suppliers, and communities.

Many of the techniques in this toolkit can help you reduce water waste and identify savings rapidly; however, it is important to think about the bigger picture of how water is used across your organization. Figure 2, repeated below from chapter 1, illustrates how the tools and techniques described in this toolkit can help you to address water use throughout your value chain.

Figure 2: Lean and Water Implementation Strategies



Concluding Thoughts

We hope this toolkit spurs creative thinking and energy within your organization and encourages you to explore these opportunities. We aim to periodically release new versions of resources in EPA's Lean and Environment Toolkit series while working with partner companies and organizations to explore ways to improve efficiency using Lean. We also hope to learn from your experiences using this toolkit. Our goal is to refine the techniques presented, provide examples and case studies to illustrate the possible benefits of these tools, and present new techniques as they emerge. We wish you success on your Lean and water journey.

Your Thoughts on the Toolkit

Now that you have finished this toolkit, reflect on what you read by answering these questions:

- ✓ What strategies and tools in the toolkit seemed particularly interesting? Which ones were most applicable to your facility?
- ✓ What steps will you take next to advance Lean and water efforts at your facility?
- ✓ What other information and tools would help your organization to achieve your Lean and water goals?

APPENDICES

Appendix A: Water Efficiency Resources and Technical Assistance Providers

This appendix describes resources and places to go for more information concerning the following topics:

- Water Conservation and Efficiency Resources
- Technical Assistance Providers

This appendix focuses on resources that are directly applicable to manufacturing and industrial facilities; however, some resources and tools may have broader relevance and contain information that will be useful to commercial, institutional, and residential water users as well as industrial water users.

Water Efficiency and Conservation Resources

***At the Crest of a Wave: A Proactive Approach to Corporate Water Strategy*, Pacific Institute**
www.pacinst.org/reports/crest_of_a_wave/
Making the case that businesses and industrial facilities must prepare for water trends, this guide helps users to design and implement a two-stage water conservation strategy. Case studies and success stories include those from companies such as Unilever, Nestlé, Toyota, General Motors, Anheuser-Busch, GE, Proctor & Gamble, and more. The steps presented help corporations to create a comprehensive approach to managing water risks and opportunities.

***Collecting the Drops: A Water Sustainability Planner™*, Global Environmental Management Initiative (GEMI)**
www.gemi.org/waterplanner
This web-based tool and downloadable document provides step-by-step guidance and resources to help facilities conduct assessments of their water use and impacts on the water supply. Facilities can then use this information to develop water sustainability strategies, create action plans, and take actions to improve water resource management in their operations and community. The planner includes case examples of how GEMI member companies have engaged internal and external stakeholders and generated actions to improve water resource management and conservation. Modules include:

- Module 1: Facility Water Use and Impact Assessment Program
- Module 2: Water Management Risk Assessment Questionnaire
- Module 3: Case Examples and Links

***Commercial, Institutional, and Industrial (CII) Water Users: Manufacturing Introduction*, Alliance for Water Efficiency**
www.allianceforwaterefficiency.org/Manufacturing_Introduction.aspx
The Alliance for Water Efficiency Resource Library webpages offer information on CII water use and efficiency opportunities, as well as links to the research and information about this end user category. In manufacturing, major uses and topics include cooling water, process water, steam generation and boilers, sanitation, irrigation, food services, and housekeeping. The resource briefly discusses the need for and value of water audits for facilities and applying the strategies of reduce, reuse, and recycle for facility water consumption.

***Connecting the Drops Toward Creative Water Strategies: A Water Sustainability Tool™*, GEMI**
www.gemi.org/water/
This tool presents the business case for water efficiency, and provides guidance and case studies on water assessment, opportunity identification, planning, and implementation. Five core analytic modules comprise a roadmap to help facilities identify specific steps that they can take to reduce their water use:

- Module 1: Water Use, Impact, and Source Assessment
- Module 2: Business Risk Assessment
- Module 3: Business Opportunity Assessment
- Module 4: Strategic Direction and Goal Setting
- Module 5: Strategy Development and Implementation

***Cooling Towers: Water Use*, Washington State Department of Ecology**
www.ecy.wa.gov/tree/equipCT.html
Cooling towers are a significant area of water use for many facilities, and taking steps to assess and reduce water use in cooling towers can substantially lower a facility's overall water footprint. The Washington State Department of Ecology's Technical Resources for Engineering Efficiency (TREE) Team created this succinct checklist of conservation suggestions, questions to ask during a water use evaluation, and suggested data to collect to identify opportunities for water savings from cooling towers.

***ENERGY STAR Portfolio Manager*, U.S. Department of Energy and U.S. Environmental Protection Agency**
www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager
This tool allows users to track and access information about their facility's water consumption, inaddition to data about energy consumption. Water and energy use and cost data can be managed across multiple facilities in a secure, online interface. The tool allows you to track multiple water meters for each facility, identify meters with customized names and key information, benchmark your facilities relative to past performance, monitor costs, and share data with others inside or outside of your organization. By tracking energy and water metrics across facilities, users can identify opportunities for efficiency improvements, and can receive EPA recognition for superior performance.

***Facility Manager's Guide to Water Management*, Arizona Municipal Water Users Association**
http://amwua.org/pdfs/facility_managers_guide.pdf
This guide is intended to help commercial, industrial, and institutional facilities to identify areas to improve water use efficiency within reasonable economic parameters. The guide provides a step-by-step resource for creating a water management plan, and includes worksheets on topics such as water consumption history and estimated water balances. Several water end uses and options for reducing them are discussed, including domestic water use, cooling and heating systems, landscape water uses, and kitchen uses. The guide provides planning and policy-setting options, water management options, and guidance for empowering employees to effect changes to reduce water use.

***Federal Water Efficiency Best Management Practices*, U.S. Department of Energy**
www1.eere.energy.gov/femp/program/waterefficiency_bmp.html
The Federal Energy Management Program developed Federal Water Efficiency Best Management Practices in response to an Executive Order requiring federal agencies to find cost-effective ways to reduce their water use, in coordination with EPA's WaterSense Program. Toward the goal of reducing industrial, landscaping, and agricultural volumetric water consumption by 20 percent by 2020 (relative to a 2010 baseline), FEMP provides best practices for water management planning, information and education programs, water auditing and leak detection, and reducing water in several end uses, including:

- Boilers and steam systems
- Cooling towers
- Water-efficient irrigation
- Single-pass cooling equipment
- Toilets, urinals, faucets, and showerheads

***GEMI Local Water Tool*™, GEMI**
www.gemi.org/GEMIInteractiveTools.aspx
By spring 2012, GEMI plans to release a new tool, the *GEMI Local Water Tool*™, which will be an interactive, downloadable module that will help companies evaluate specific sites for water impacts and risks in order to devise site-specific sustainable water management strategies. This tool is designed to complement the Global Water Tool (described below), which can help a company identify and prioritize risks to its competitive position based on the link between its operations and the external water landscape. Companies can then employ the Local Water Tool to further evaluate the high water-risk locations and plan actions to manage those risks.

***Global Water Tool*, World Business Council for Sustainable Development**
www.wbcsd.org/pages/edocument/edocumentdetails.aspx?id=221&nosearchcontextkey=true
In order for a facility to manage current and future risks related to its water use, the Global Water Tool helps users map their water use and assess risks related to their global operations, comparing water needs to local conditions. The tool helps calculate water consumption and efficiency, comparing water consumption data through time to help assess improvements and monitor progress.

***Making Every Drop Work: Increasing Water Efficiency in California's Commercial, Industrial and Institutional (CII) Sector*, National Resource Defense Council**
www.nrdc.org/water/cacii
This guide provides practical suggestions for commercial, industrial, and institutional facilities to increase their water efficiency. Both small-scale, concrete steps to take and suggested higher-level strategic approaches toward water efficiency are described. The guide includes a list and descriptions of available technologies for reducing water consumption by a variety of common end uses.

***Performing a Business or Industry Water Use and Conservation Audit*, New Hampshire Department of Environmental Services**
www.des.state.nh.us/organization/commissioner/pip/factsheets/dwgb/documents/dwgb-26-16.pdf
This factsheet provides a short set of steps to audit water use in a business or industrial facility, analyze feasibility of conservation measures, and develop a conservation plan.

***Solutions for Sustainable Water Savings – A Guide to Water Efficiency*, General Electric Water & Process Technologies**
www.gewater.com/water_efficiency/index.jsp
This guide provides a practical framework for site managers, corporate officers, engineering firms, and water saving advocates to develop a water efficiency objective and meet this objective by applying a variety of tools and metrics. The manual covers baseline water footprinting, identifying efficiency opportunities, optimizing, implementing, and measuring.

***Waste Not, Want Not: The Potential for Urban Water Conservation in California*, Pacific Institute**
www.pacinst.org/reports/urban_usage
This report presents a comprehensive assessment of water use and conservation potential in the state of California, including industrial water use as well as commercial, institutional, and residential. It includes benchmarking data on water use for many industry sectors, a description of the methodology for estimating cost and water savings from water conservation strategies, and information on cost-effectiveness of various water conservation and efficiency improvements.

***A Water Conservation Guide for Commercial, Industrial, and Institutional Users*, New Mexico Office of the State Engineer**
www.ose.state.nm.us/water-info/conservation/pdf-manuals/cii-users-guide.pdf
This guide presents the business case for water efficiency, offers programmatic steps, conservation strategies for indoor and outdoor use, and process-specific and mechanical systems, and illustrates potential opportunities with fifteen individual case studies.

***Water Efficiency Manual for Commercial, Industrial, and Institutional Facilities*, North Carolina Department of Environment and Natural Resources**
http://savewaternc.org/bushome.php
This comprehensive manual provides sound principles of water conservation, strategies for conducting a successful water efficiency program, auditing tools, water management options, and examples

for three industry-specific processes: textiles, food and beverage, and metal finishing. Practical tools in the guide include assessment checklists, step-by-step instructions for conducting a successful water efficiency program, and explanations of approaches such as water balancing. The manual details water management options for several common end uses, including:

- Sanitary and Domestic Uses
- Cooling and Heating
- Boilers
- Kitchen and Food Preparation
- Commercial Laundries
- Cleaning, Rinsing, and In-process Reuse
- Reuse and Reclamation
- Landscaping

***Water Efficient Equipment and Design: A Guide for Non-Residential Construction and Development*, Austin Water Utility Water Conservation Division**
www.allianceforwaterefficiency.org/WorkArea/linkit.aspx?LinkIdentifier=id&ItemID=1018
Equipment and design practices for the construction of new industrial and commercial facilities help to build lifecycle water savings into the design of these buildings. Major renovations to existing facilities as well as new construction should be undertaken with a careful assessment of ways to reduce the facility's lifetime water use. This guide provides general guiding principles to ensure that facilities are constructed to maximize water conservation and efficiency, as well as specific steps and guidelines to follow in all steps of design and construction.

***Water Footprint Manual*, Water Footprint Network**
www.waterfootprint.org/?page=files/home
This guide provides a thorough description of the practice of water footprinting, including practical steps for estimating a water footprint and instructions for assessing the difference between a direct and indirect water footprint. This comprehensive guide to water footprinting instructs readers on estimating the footprint of a product as well as that of a business.

***WaterSense at Work: Best Management Practices for Commercial and Institutional Facilities*, U.S. Environmental Protection Agency**
www.epa.gov/WaterSense
The WaterSense Best Management Practices, which EPA's Office of Water developed in coordination with the Federal Energy Management Program, are a comprehensive set of recommendations and tips for how commercial and institutional facilities can improve their water efficiency. EPA's WaterSense Program helps water consumers identify best practices, resources, and tools to reduce their water use. Commercial and institutional water users can take advantage of lists of water-efficient products to install in their facilities, best management practices, and other ways to improve water efficiency.

***WaterSmart Guidebook*, East Bay Municipal Utility District, Oakland, California**
www.ebmud.com/for-customers/conservation-rebates-and-services/commercial/watersmart-guidebook
This extensive guidebook provides information on water-saving technologies currently available to commercial, industrial, and institutional businesses, as well as specific water efficiency strategies and tips for different business types such as paper manufacturing and metal finishing. Many water-using technologies, such as process water, are explored to show the areas in which the most water is used and where it can be saved.

Technical Assistance Providers

Water Utility Incentive Programs
Many utilities and local governments offer incentive programs to water utility customers to encourage the efficiency of water use in the industrial, commercial, and institutional sectors. Common approaches include a combination of water audits and rebates to help facilities realize water savings. Check with your local utility to see what incentives may be available. Some notable programs include those sponsored by the following utilities and localities, all of which saw significant reductions of water use by facilities that they serve:

- City of Austin and Austin Water Utility
  www.ci.austin.tx.us/water/conservation/
- Denver Water
  www.denverwater.org/Conservation/IncentivePrograms
- East Bay Municipal Utilities District
  www.ebmud.com/for-customers/for-commercial-customers/commercial-conservation-rebates-and-services
- Massachusetts Water Resources Authority
  www.mwra.state.ma.us/comsupport/waterconservationmain.htm
- Metropolitan Water District of Southern California
  http://www.bewaterwise.com/icp.html
- City of Phoenix
  phoenix.gov/waterservices/wrc/index.html
- City of San Jose Environmental Services Department
  www.sanjoseca.gov/esd/water-conservation/default.asp
- Seattle Public Utilities
  www.seattle.gov/util/Services/Water/For_Commercial_Customers/WATERCONS_200311261707523.asp

National Institute of Standards and Technology Hollings Manufacturing Extension Partnership

www.nist.gov/mep/

The National Institute of Standards and Technology (NIST) Hollings Manufacturing Extension Partnership (MEP) is a network of manufacturing assistance centers that provide Lean manufacturing training, Lean event facilitation, and other services to small-to-medium sized businesses to make them more competitive. Many MEP centers have experience providing integrated Lean and environmental services to businesses or have partnerships with environmental agencies to offer Lean and environment services.

Pollution Prevention Resource Exchange (P2Rx) Consortium

www.p2rx.org

The Pollution Prevention Resource Exchange (P2Rx™) is a consortium of regional pollution prevention information centers in the United States, funded in part through grants from EPA. These centers all provide pollution prevention information, networking opportunities, and technical assistance services to state agencies, local governments, businesses, and technical assistance providers in their region. Regional centers and contact information can be found on the P2Rx™ website, along with their collective information resources on Lean, water efficiency, and other topics.

Appendix B: Water Cost Calculator

You can use this table to calculate costs associated with water use at your facility. Write down the appropriate volumes, units, and unit costs, and multiply volume by unit cost to find the dollars spent on each cost area. Add these costs to find the total cost. *Note: Unit costs for water may varydepending on the season and/or based on water use (e.g., peak surcharges may apply above a certain level).*[30]

Factor	Costs to Consider (Excluding Labor & Maintenance Costs)*	Examples/ Description	Volume	Units (gallons)	Unit Cost ($ per gallon)	Total Cost (dollars)
Supply	Base Purchase Price	Utility (e.g. 10 cents per gallon)			$	$
	Peak Package Demand	(e.g. additional 1 cent per gallon for water supply over 10,000 gallons)			$	$
	Pumping costs (if self supplied)	Well-sourced			$	$
	Purchase of pre-treated water	Deionized, dealkylized, ultra-pure, softened			$	$
Cooling	Energy	Power to chillers, towers, etc., reducing heat load of wastewater prior to release			$	$
	Chemical	For towers, chillers, coolants			$	$

[30] Several resource tracking tools that may also be relevant. These include: Energy & Materials Flow & Cost Tracker from the Northeast Waste Management Officials' Association, www.newmoa.org/prevention/emfact; Water Conservation Tracking Tool (for water utilities) from Alliance for Water Efficiency, www.allianceforwaterefficiency.org/Tracking-Tool.aspx, and Portfolio Manager (for energy and water use) from the ENERGY STAR Program, www.energystar.gov.

* Total cost of water use should also include labor associated with operations, maintenance, accounting, and legal associated with all items listed.

Factor	Costs to Consider (Excluding Labor & Maintenance Costs)*	Examples/ Description	Volume	Units (gallons)	Unit Cost ($ per gallon)	Total Cost (dollars)
Treatment (Onsite)	Treatment chemicals	Softening, de-alkalyzed			$	$
	Filters, mem-branes, carbon	Purified, deionized			$	$
	Sludge disposal	Filtration			$	$
	Filter disposal	Solid waste			$	$
Wastewater Treatment	Pretreatment chemicals	Neutralizers, flocculants, etc			$	$
	Pretreatment energy	Evaporation, Treatment plant operation			$	$
	Sampling and testing kits (consumables)	pH, TSS, BOD/ COD			$	$
Wastewater Disposal	Sewer rate	Utility			$	$
	Surcharges for pollutant exceeding					$
	Permitting	Permit renewals				$
	Septic system maintenance				$	$
	Condensate or wastewater disposal if not sewered				$	$
	Sludge disposal				$	$

* Total cost of water use should also include labor associated with operations, maintenance, accounting, and legal associated with all items listed.

Factor	Costs to Consider (Excluding Labor & Maintenance Costs)*	Examples/ Description	Volume	Units (gallons)	Unit Cost ($ per gallon)	Total Cost (dollars)
Losses	Evaporative	Cost of make-up water			$	$
	Leaks**	Cost of make-up water			$	$
	Treatment or stormwater management of runoff from exterior use of supplied water	Irrigation or vehicle/building washing runoff			$	$
Other	Production process water use costs, other facility costs				$	$
TOTAL					**$**	**$**

* Total cost of water use should also include labor associated with operations, maintenance, accounting, and legal associated with all items listed.

** See Appendix C, "Water Unit Conversions and Calculations," for guidelines on calculating leak losses.

Appendix C: Water Unit Conversions and Calculations

This appendix provides reference material on water unit conversions as well as guidance for estimating water use and potential water and cost savings.

Water Unit Conversions[31]

Volume Unit Conversions					
Units	Equivalent				
	Liters (lL)	Gallons (gal)	Cubic Feet (ft^3)	Cubic Meters (m^3)	Acre-Feet (ac-ft)
Liters	1	0.2642	3.531×10^{-2}	0.0001	8.106×10^{-7}
Gallons	3.785	1	0.1337	3.785×10^{-3}	3.068×10^{-6}
Cubic Feet	28.32	7.481	1	2.832×10^{-3}	2.296×10^{-5}
Cubic Meters	1.000	264.2	35.31	1	8.106×10^{-4}
Acre-Feet	1.233×10^{6}	3.259×10^{5}	4.356×10^{4}	1,233	1

Flow Rate/Discharge Unit Conversions					
Units	Equivalent				
	Gallons per Minute (gpm)	Liters per Second (L/s)	Acre-Feet per Day (ac-ft/day)	Cubic Feet per Second (ft^3/s)	Cubic Meters per Day (m^3/day)
Gallons per Minute	1	6.309×10^{-2}	4.419×10^{-3}	2.228×10^{-3}	5.45
Liters per Second	15.85	1	7.005×10^{-2}	3.351×10^{-2}	86.4
Acre-Feet per Day	226.3	14.28	1	0.5042	1,234
Cubic Feet per Second	448.8	28.32	1.983	1	2.447
Cubic Meters per Day	1.369×10^{9}	8.64×10^{7}	6.051×10^{6}	3.051×10^{6}	1

[31] GEMI, "Unit Conversions," Collecting the Drops: A Water Sustainability Planner™, available at: www.gemi.org/waterplanner/unit-conversion.htm.

Calculations and "Rules of Thumb" for Estimating Water Use[32]

Use these guidelines and calculations to estimate water use in your facility. The information in this section draws primarily from *GEMI's Collecting the Drops: A Water Sustainability Planner™*, available at www.gemi.org/waterplanner.

Cooling Tower Usage

Cooling Tower Water Usage Calculations		
Tower Evaporation Rate C x ΔT/1000	C = tower recirculation rate in the units of pounds of water per minute	T = temperature difference across the cooling tower in degrees Fahrenheit
Cooling Tower Blow Down Rate	[Windage Rate x (Cycles of Concentration -1) - Tower Evaporation Rate] / (1- Cycles of Concentration)	Cycles of Concentration = conductivity or chloride level in the cooling tower blow-down/conductivity or chloride level in the cooling tower makeup water

- Windage Loss from Cooling Towers (Water Lost from Friction Between Wind and the Surface of the Water in Cooling Towers)
    - Commonly 0.1 to 0.3% of the Recirculation Rate
    - The tower recirculation rate can be obtained from the manufacturer's literature and/or head versus flow curve for the pump.

Cooling Tower Usage

Boiler Water Usage Calculations	
Boiler Make Up	Boiler Steam Rate - Condensate Return + Boiler Blow Down
Boiler Blow Down	Range of 4 to 8 % of Boiler Makeup

Sanitary Water Usage

- 10–25 gallons per person per shift in industrial settings (based on estimates in GEMI's *Collecting the Drops: A Water Sustainability Planner™*, 2007)
    - The lower value is used where there are just toilets. A higher value is used where there are toilets, showers, and full kitchen services (that is, food preparation and dish washing).

[32] "Calculations" and "Rules of Thumb" from GEMI, Collecting the Drops: A Water Sustainability PlannerTM, available at: www.gemi.org/waterplanner/calculations.htm and www.gemi.org/waterplanner/rules-of-thumb.htm.

- 20-35 gallons per employee per day for domestic demands (not including kitchens) in commercial/industrial settings (based on estimates in the North Carolina Water Efficiency Manual, 2009[33])
    - Savings of 25-35 percent in this domestic usage are readily achievable.

Irrigation Usage

- Number of sprinkler heads x the flow capacity per head (e.g., 2.5 gpm x the duration [minutes] of water application).
- Inspect the irrigation system during operation to determine if there are leaks from broken sprinkler heads and from water distribution lines.

Wastewater Streams from Water Treatment Operations

- Reverse Osmosis Reject Flow
    - Reject stream generally ranges from 10 to 50% of the feed to the system depending on the salinity and the desired purity.
    - Reject flow can be higher than the indicated range. Reverse osmosis reject streams can be used as cooling tower makeup if the water is softened prior to the reverse osmosis system.

Other Uses

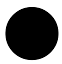
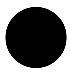
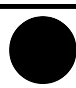
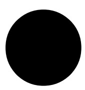
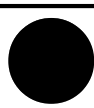
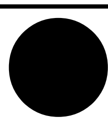
- Slab Washing
    - 5 gal/min for each hose
- 1 drip/second
    - 10,000 L/year or 2,642 gal/year
- Water Flow Estimation
    - Use a bucket and stop watch

Water Losses from Leaks

- Estimate leaks based on the size of the hole and the water pressure (see Leak Water Loss Guide below), or measure directly using a bucket and stop watch

[33] North Carolina Department of Environment and Natural Resources, Water Efficiency Manual for Commercial, Industrial, and Institutional Facilities, 2009, available at http://savewaternc.org/bushome.php.

Leak Water Loss Guide (Water Loss in Gallons at 50 PSI)

Leak this Size	Loss per Day	Loss per Month	Loss per Year
	120	3,600	43,200
	360	10,800	129,600
	693	20,790	249,480
	1,200	36,000	432,000
	1,920	57,600	691,200
	3,096	92,880	1,114,560
	4,296	128,880	1,546,560
	6,640	199,200	2,390,400
	6,984	209,520	2,514,240

Source: Washington State Department of Health Office of Drinking Water, available at www.doh.wa.gov/ehp/dw/water_use/water_use_efficiency.htm

Guidelines for Estimating Cost and Water Savings

It can be useful to estimate the potential long-term water and cost savings that will result from implementing water efficiency improvements in your facility. This section provides guidelines on producing estimates of these savings after implementing improvements to a process at your facility.

Current Water Use

First, to estimate the current water use of an entire process at your facility, identify the following information and use Equation 1 below.

- Average volume of water used during a full process or technology cycle.
    - This may be provided by the product manufacturer through product literature or the manufacturer's website, or by using the guidelines and calculations in the previous section of this Appendix. The water efficiency will be dependent upon the flow rate of each process cycle, duration of each cycle, and the number of cycles. If the water use from the full process is not available from the manufacturer, sum the water use from each part of cycle to determine the water use from the full process cycle.
- Average number of cycles per day
- Days of facility operation per year

Equation 1
Water Use of a Technology or Process Cycle (gallons/year) = Cycle Water Use (gallons) * Number of Cycles (per day) * Days of Facility Operation (days/year)

Water Use after Replacement or Retrofit

To estimate the water use of a more efficient technology or process change, use Equation 1, but substitute the average volume of water used during an improved process cycle.

Water Savings

To calculate water savings that can be achieved from a technology or process change, identify the following information and use Equation 2 below.

- Current water use as calculated using Equation 1
- Water use after replacement or retrofit as calculated using Equation 1

Equation 2
Water Savings (gallons/year) = Current Water use (gallons/year) – Water Use After Improvements (gallons/year)

Payback

To calculate the simple payback from a technology or process change, identify the following information and use Equation 3 below.

- Equipment and installation cost of the replacement or retrofit
- Water savings as calculated using Equation 2
- Facility-specific cost of water and wastewater

Equation 3
Payback (years) = Equipment and Installation Cost (dollars) / [Water Savings (gallons/year) * Cost of Water and Wastewater (dollars/gallon)]

Return on Investment

To calculate the return on investment of a technology or process change, calculate the amount of cost savings as compared to the initial investment using Equation 4.

Equation 4
Return on Investment = [(Water Savings (gallons/year) * Cost of Water and Wastewater (dollars/gallon)] – Equipment and Installation Cost (dollars)

General Calculations and On-Line Calculators

GEMI's *Collecting the Drops: A Water Sustainability Planner*™ has several on-line and downloadable calculators for measuring data related to water use and flows (see www.gemi.org/waterplanner/calculators.asp). These include:

- Flow rate calculator
- Friction loss and flow calculator
- Pump hydraulic horsepower calculator
- Water balance template and calculator

Appendix D:
Water Efficiency Opportunity Checklist

Water Efficiency Opportunity Checklist	
Facility/Building:	**Date Prepared:**
Prepared by:	**Reviewed by:**

Water Efficiency Practice		Yes	No
1.	**Organizational Water Efficiency Practices**		
a.	Have you set water use reduction goals and targets for your facility?		
b.	Are water meters installed on high water using processes, and are they working properly?		
c.	Do you have easy ways for employees to suggest ideas for water efficiency improvements (e.g., suggestion boxes)?		
2.	**Cooling and Heating**		
a.	Has once-through cooling water been eliminated with the use of chillers, cooling towers, or air-cooled equipment?		
b.	Has blow-down/bleed-off control on cooling towers and boilers been optimized?		
c.	Is condensate being reused?		
d.	Is treated wastewater (or other sources of water for cooling tower make-up) reused where possible?		
e.	Are cycles of concentration for cooling towers maximized through efficient water treatment?		
f.	Is a conductivity controller installed on each cooling tower?		
g.	Have cooling towers been equipped with overflow alarms?		
h.	Are high-efficiency drift eliminators in use?		
3.	**Restrooms and Kitchens**		
a.	Are water-efficient fixtures installed (e.g., WaterSense labeled faucets, toilets, urinals, and showerheads)? Are there signs on dual-flush toilets showing people how to use them?		
b.	Have you installed metered or spring-loaded faucets, or faucets with sensors?		

Water Efficiency Practice		Yes	No
c.	Have you adjusted plumbing to use the minimum amount of water that is functional?		
4.	**Process Use**		
a.	Have you installed timers to automatically shut off water flow when water is not required, such as at the end of a production cycle?		
b.	Are solenoids and automatic shut-off valves checked regularly to ensure that they are working properly?		
c.	Is equipment set to the minimum flow rates recommended by the manufacturer?		
d.	Have pressure-reducing devices been installed on equipment that does not require high pressure?		
e.	Can process equipment reuse water (closed loop) or use reclaimed water from other parts of the facility?		
f.	Have you replaced water-based transportation with either waterless techniques or recycled water?		
g.	Are signs posted near equipment encouraging employee awareness of water use, and discouraging tampering with equipment flow rate?		
5.	**Cleaning and Sanitation**		
a.	Are all hoses equipped with an automatic shut-off nozzle?		
b.	Has process cleaning or facility cleaning been replaced with waterless techniques (i.e., using pressurized air to clean products or containers, sweeping debris off the floor) where possible?		
c.	Are improved rinsing techniques used (counter-current systems, sequential use from high to lower quality needs, conductivity flow controls, improved spray nozzles/pressure rinsing, fog rinsing, etc.)?		
d.	Is spent rinse-water being reclaimed and reused for lower-grade processes or for other facility applications?		
e.	Have steps been taken to reduce the water used by steam sterilizers, such as jacket and chamber condensate cooling modification?		

Water Efficiency Practice	Yes	No
f. Are you using detergents that can easily be removed with little water?		
6. Landscaping and Irrigation		
a. Are low-flow sprinklers, trickle/drip irrigation, and optimized watering schedules in use?		
b. Are preventive maintenance techniques in place?		
c. Has your facility designed its landscape to consider the local climate and grouped plants by similar watering needs?		
d. Is grass planted only in places where it will provide optimal functional and aesthetic benefits?		
e. Are systems in place to capture and reuse rain water and storm water for landscaping, or for other uses (e.g., cooling tower make-up, process water, or dust suppression)?		
7. Leaks		
a. Are you conducting regular leak inspections?		
b. Are leaky faucets, faulty fittings, and broken pipes and hoses identified and repaired promptly?		
c. Are employees (including custodial crews) educated and empowered to identify leaks and point them out for repair?		
d. Is there a user-friendly method to report leaks?		

8. Comments:

9. Recommended Follow-Up Actions:[34]

[34] For additional guidance, see: EPA Office of Water, "WaterSense at Work: Best Management Practices for Commercial and Institutional Facilities," www.epa.gov/watersense; North Carolina Department of Environment and Natural Resources, Water Efficiency Manual for Commercial, Industrial and Institutional Facilities, www.p2pays.org/ref/01/00692.pdf; East Bay Municipal Utility District of Oakland, WaterSmart Guidebook, www.ebmud.com/for-customers/conservation-rebates-and-services/commercial/watersmart-guidebook; and Arizona Municipal Water Users Association, Facility Manager's Guide to Water Management, http://amwua.org/pdfs/facility_managers_guide.pdf.

Appendix E: Glossary of Water Terms

Most of the definitions provided here are from the Alliance for Water Efficiency's water glossary, available at www.allianceforwaterefficiency.org/Glossary.aspx. That glossary has a more extensive set of water-related terms and abbreviations.

B	
Best management practice (BMP)	Equipment or behavioral measure(s) established as the most practicable means of increasing water efficiency.
Blowdown (or Bleed-off)	Draining off the water in a cooling tower reservoir or boiler to avoid the buildup of excess dissolved solids.
E	
End use	A fixture, appliance, or other specific object or activity that uses water.
M	
Makeup water	Fresh water introduced into a cooling tower or boiler to replace water lost to evaporation and blowdown.
P	
Peak use (demand)	The maximum demand occurring in a given period, such as hourly or daily or annually. Peak use can incur surcharges above the normal base water cost charged by the utility.
R	
Reclaimed water	Municipal wastewater effluent that is given additional treatment and distributed for reuse in certain applications. Also referred to as *recycled water*.
Reverse osmosis	A process to remove dissolved solids, usually salts, from water. Salty water is forced through membranes at high pressure, producing fresh water and a highly concentrated brine.
S	
Source meter	A meter that measures the quantity of water being supplied to a facility.

Submeter	A meter that measures usage for specific activities within a facility, such as cooling towers, process use, or landscape water use.
W	
Water audit	An on-site survey of facility water use to measure equipment and management efficiency and generate recommendations to improve efficiency.
Water balance	A chart, table, or diagram that tracks water flow through a building or facility, showing total inflows and total outflows (e.g., consumption, irrigation, evaporation, leaks, and losses).
Water conservation	1. Any beneficial reduction in the water loss, waste, or use. 2. A reduction in water use accomplished by implementation of water conservation or water-efficiency measures. 3. Improved water management practices that reduce or enhance the beneficial use of water.
Water efficiency	A measure of the amount of water used versus the minimum amount required to perform a task. In irrigation, the amount of water beneficially applied divided by the total water applied.
Water footprint	An analysis of the total volume of freshwater that is used directly and indirectly to run and support the business or to produce a product, encompassing water use within an industrial facility, throughout its supply chain, and final disposition of the product.

United States Environmental Protection Agency
www.epa.gov/lean
October 2011
EPA-100-K-11-003