Lean and Environment Training Modules

Version 1.0 – January 2006

Lean and Environment
Training Module 3

Value Stream Mapping

Purpose of This Module

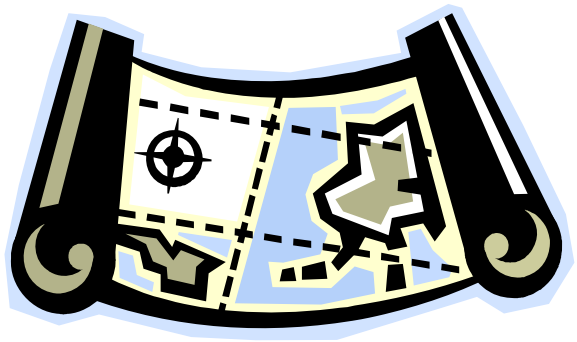
- "Learn to see" environmental waste and material efficiency opportunities in value stream maps (VSMs)
- Identify new opportunities to improve operational and environmental results
- Know when to draw on environmental expertise in Lean events to best achieve the desired future state

What is Value Stream Mapping?

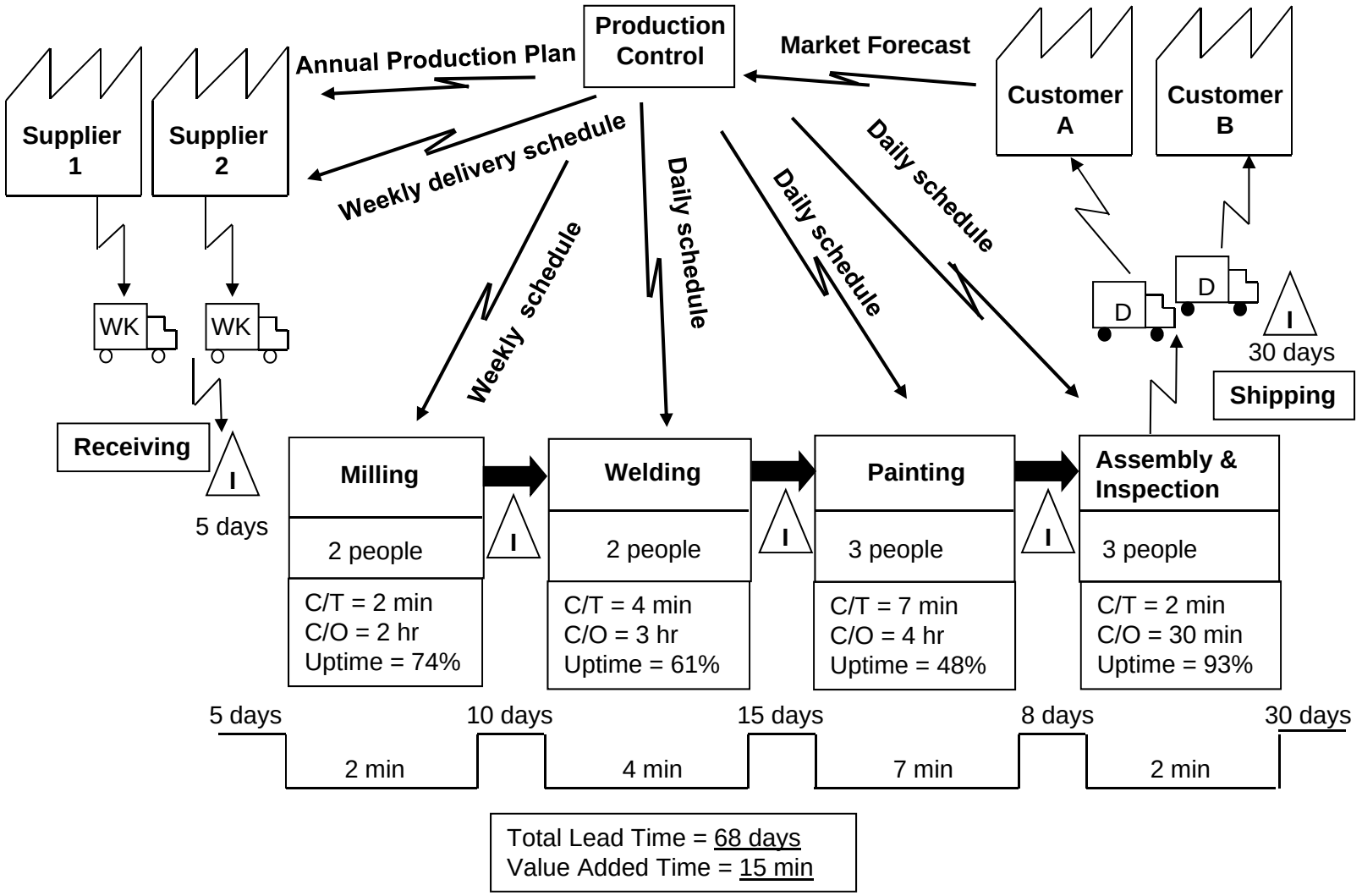
- Value stream mapping is a process-mapping method that enables your organization to:
- Current State Map: Visual representation of existing operations (information and product flows)
  - Identify the largest sources of waste (non-value added activity) in the value stream
- Future State Map: Drawing of Lean flow (vision)
  - Develop implementation plan for Lean activities

Map the Process

- Makes work visible
  - Visibility improves communication and understanding
- Identifies Improvement Opportunities
  - Eliminate the non-value added steps
  - Reduce wasted resources
- Diagnostics
  - Determine the cause of a problem or condition.
- Training and communication



Current State Value Stream Map (Unmodified)



Opportunities to Enhance Value Stream Mapping

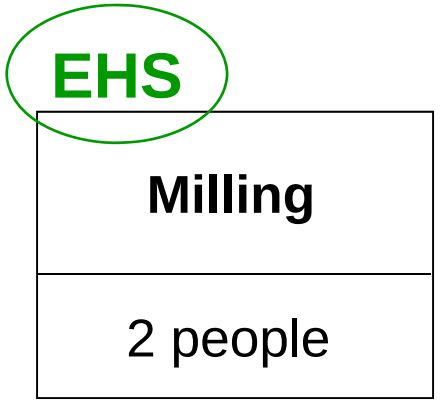
- Classic Value stream mapping can overlook environmental considerations:
  - Raw materials used vs. needed in products and processes
  - Pollution & other environmental wastes in the value stream
  - Flows of information to environmental regulatory agencies
- Making some simple adjustments to your value stream map can help you explicitly address pollution and natural resource wastes:
  - Improving cost reduction opportunities
  - Saving additional time
  - Improving the health and safety of the workplace

Overview of Value Stream Mapping Tools in this Training Module

- A variety of tools & techniques can enhance the Lean and environmental results of value stream mapping
  1. Use icons to identify processes with EHS opportunities
  2. Record environmental data for processes in VSMs
  3. Analyze materials use vs. need in a “materials line” for VSMs
  4. Expand the application of value stream mapping to natural resource flows
  5. Find Lean and environment opportunities in future state VSMs

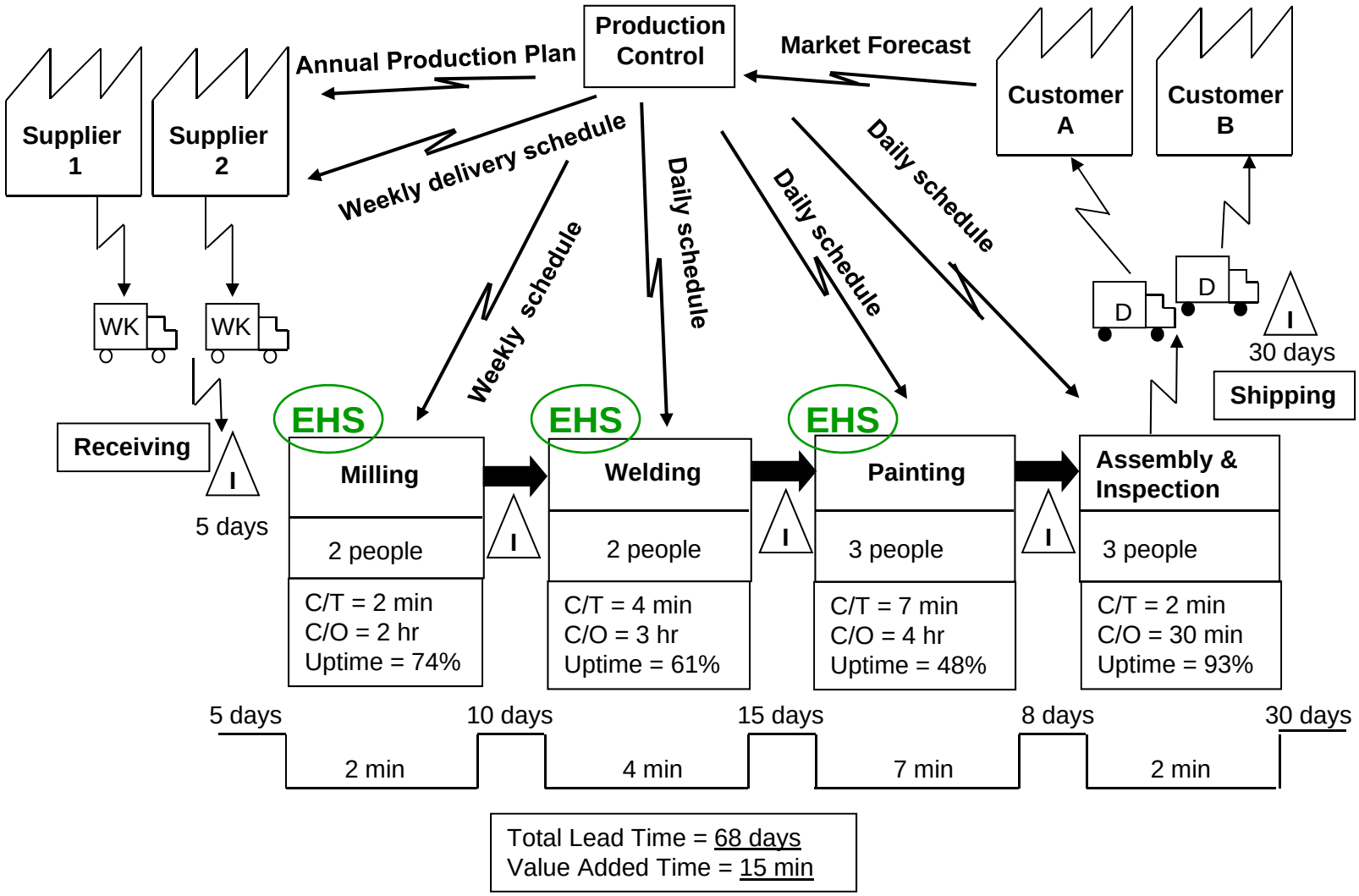
1. Use Icons to Identify Processes with EHS Opportunities

- Use icons or red dots to identify processes with key environmental, health, and safety (EHS) opportunities on value stream maps
- Icons can also highlight where EHS staff expertise will likely be needed



Process Box with EHS Icon

VSM with EHS Process Icons



Where to Put Environmental Icons on VSMs?

- Assess each process for environmental wastes and EHS improvement opportunities
- Look for processes…
  - with high energy, water, and material use
  - with significant solid or hazardous waste generation
  - requiring environmental permits or reporting to environmental agencies
  - with pollution control equipment
  - using toxic chemicals that require personal protective equipment (PPE)

EHS Staff Can Help

- Involve EHS staff when developing VSMs – they can help identify where EHS icons are most needed
  - EHS staff involvement from start to finish is optimal
  - EHS staff involvement on a consultative basis can also be an effective option
- Build on previous environmental assessment work
  - If your organization has an Environmental Management System (EMS), EHS staff should have info on processes' environmental impacts

Common Processes with EHS Wastes and Opportunities

1. Metal casting
2. Chemical and heat treatment of materials
3. Metal fabrication and machining
4. Cleaning and surface preparation
5. Bonding and sealing
6. Welding
7. Metal finishing and plating
8. Painting and coating
9. Waste management
10. Chemical and hazardous materials management

Click here to learn about pollution prevention resources that could apply to these processes

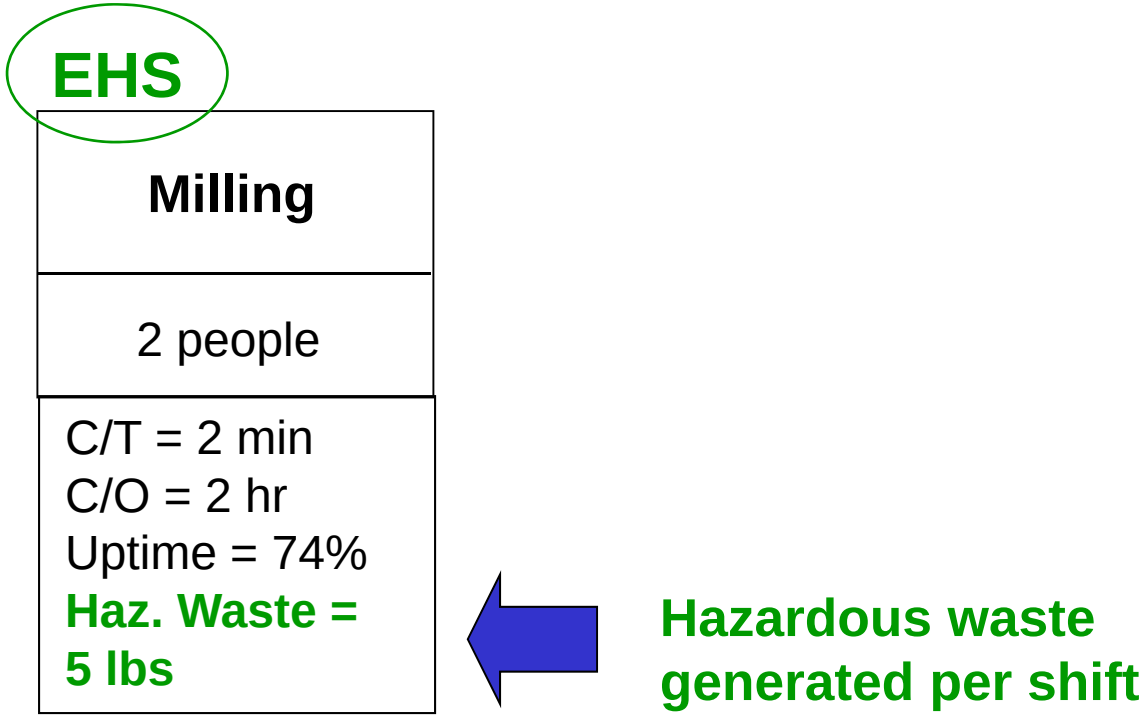
2. Record Environmental Data for Processes in VSMs

- Start by identifying 1 or 2 environmental performance metrics to add to process boxes in VSMs, and consider adding more if appropriate

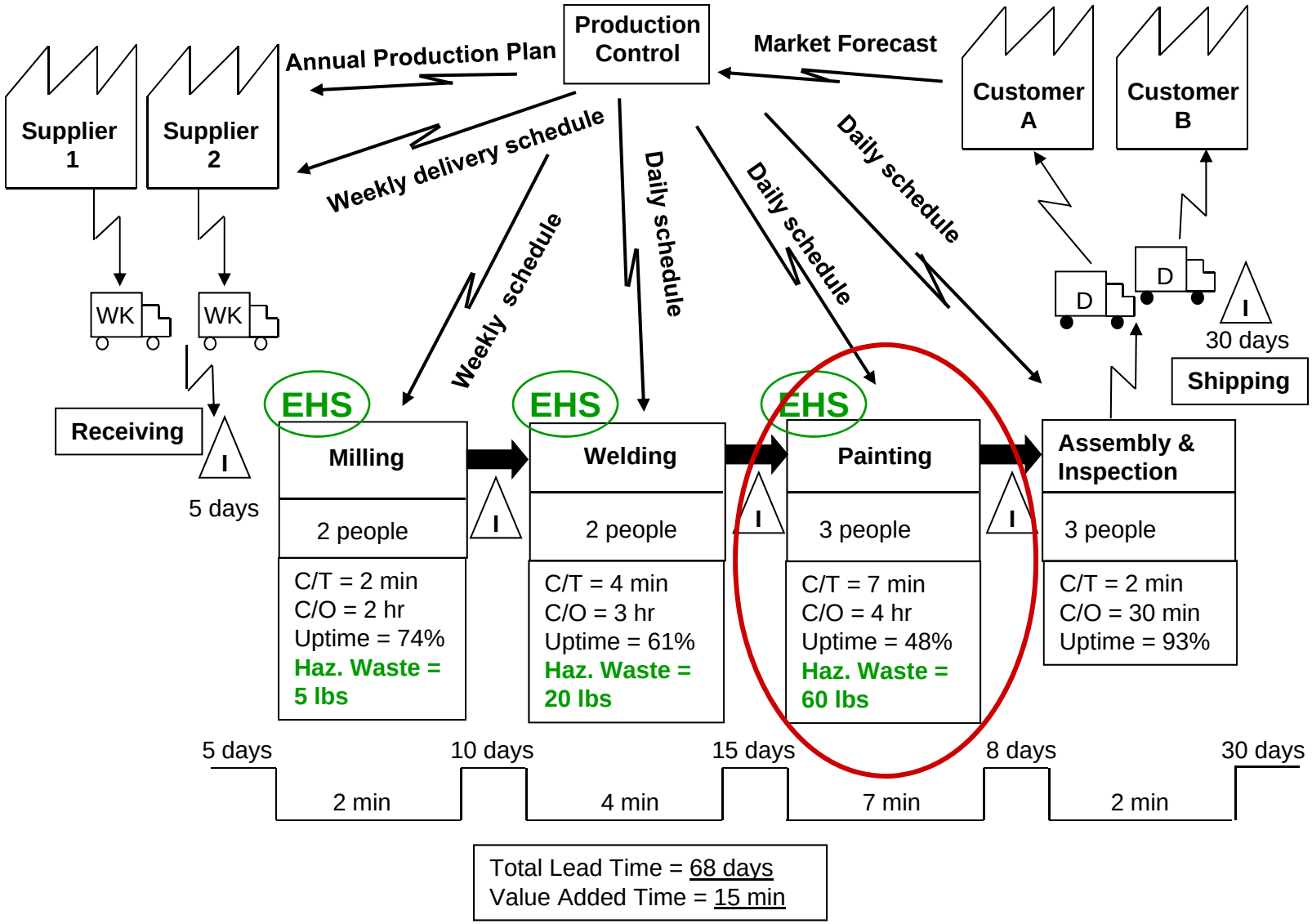
Types of Environmental Metrics	
Energy Use	Air Emissions
Materials Use	Hazardous Waste Generation
Chemical Use	Solid Waste Generation
Water Use	Wastewater Discharges

Adding Environmental Data to VSMs

- Add key environmental data to process boxes on value stream maps



VSM with Environmental Metrics & EHS Icons



How Can Materials Lines Be Useful?

- Identify and quantify the materials used and lost in a process or a facility.
- Provides concise picture of:
  - all materials used in facility
  - how each material is received, handled, stored, used, reused, and lost
- Materials in = Materials out + Materials Accumulated

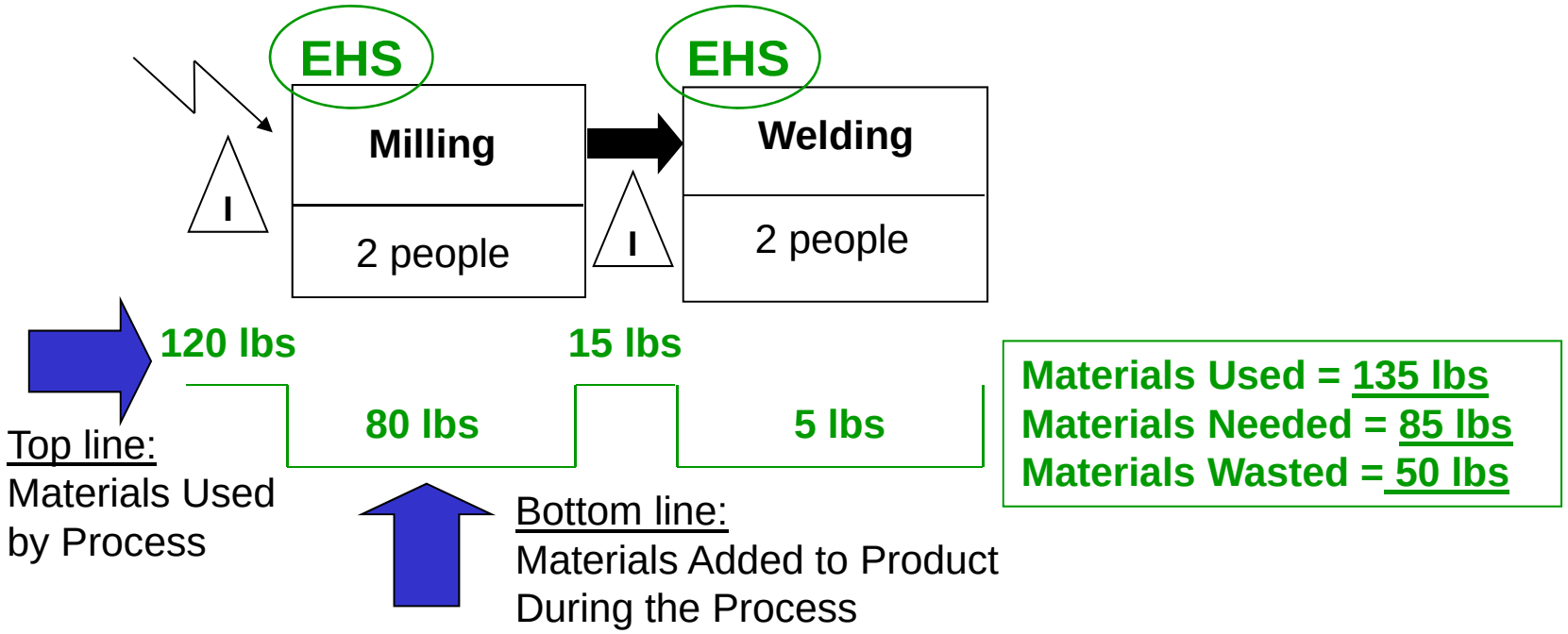
Analyze Materials Use Versus Need in a "Materials Line"

- The "**timeline**" on value stream maps looks at value-added and non-value-added time in the value stream

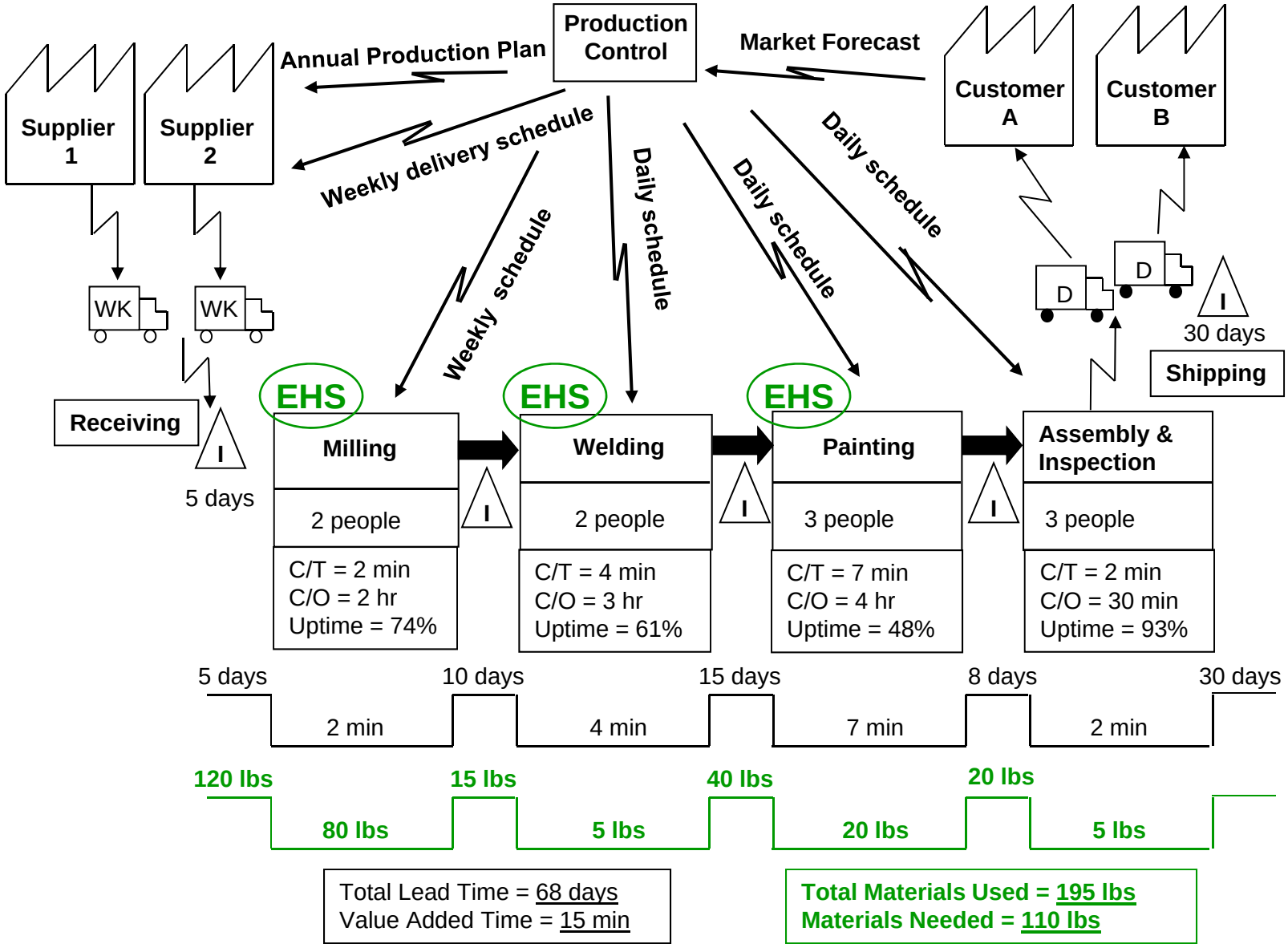
- Add a "**materials line**" to examine:
  - Amount of raw materials used by each process
  - Amount of materials that end up in the product and add value from the customer's perspective

Example Materials Line

- Materials lines can be developed for any major material source used in processes and products



VSM with Materials Line and EHS Icons



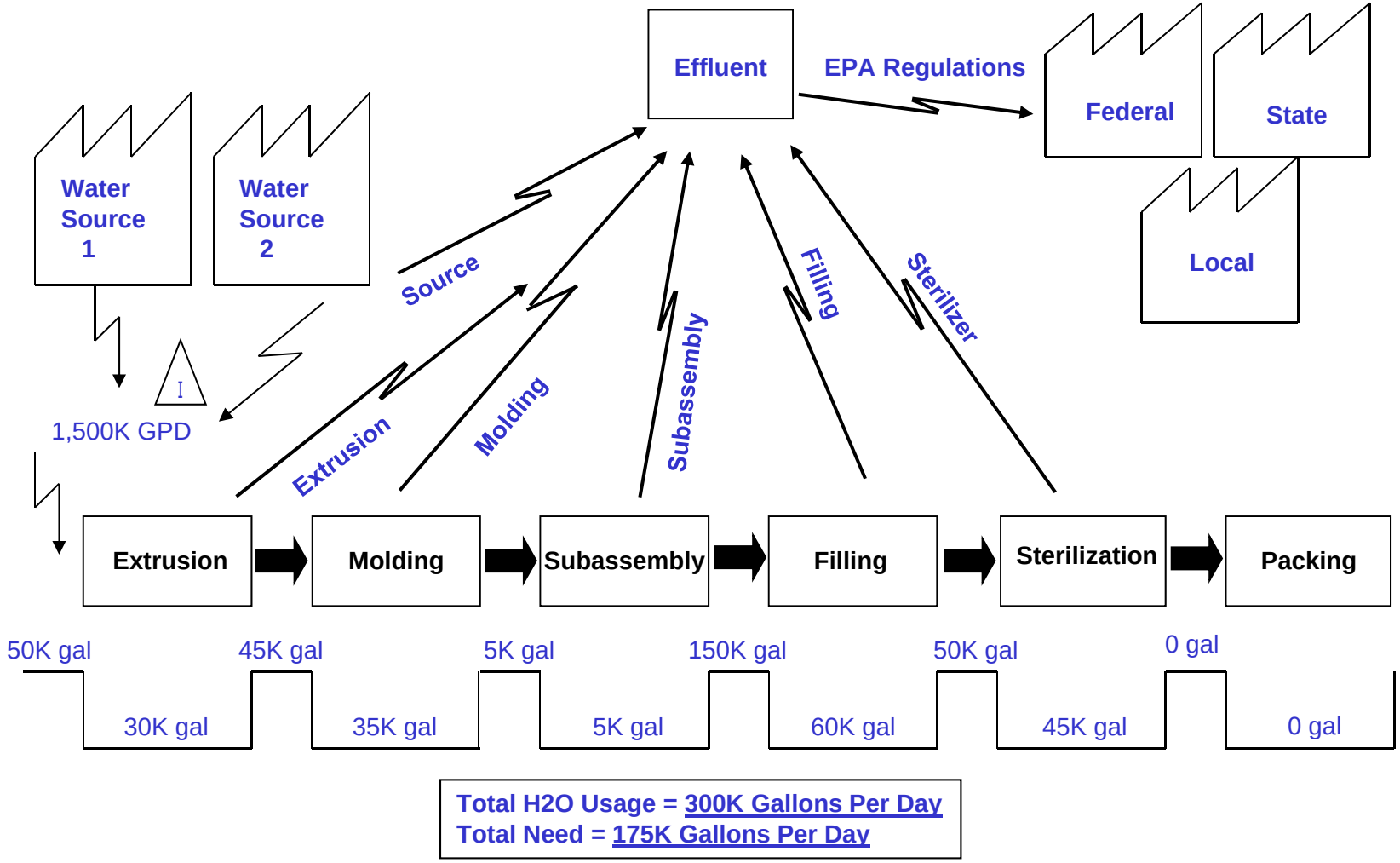
TO CONSIDER

- Which environmental metric(s) would you choose to include in value stream maps at your company?
- Does your company have environmental goals and targets that could be put on value stream maps?
- What processes at your company might have the best opportunities for environmental improvement?

4. Expand the Application of Value Stream Mapping to Natural Resource Flows

- You can also use VSMs to look in more detail at the inputs, outputs, and information flows associated with the use of energy, water, and/or materials
  - Energy/water/materials used vs. needed (as with the “materials line” VSM tool)
  - Environmental waste streams (air emissions, wastewater, hazardous waste, solid waste)
  - Information flows to environmental regulatory agencies (e.g., reporting air emissions)

Water Use VSM



Total H2O Usage = 300K Gallons Per Day
Total Need = 175K Gallons Per Day

Example VSM for Water Use

- This VSM examines water use in the value stream of a product that contains water (e.g., a medical IV bag)
- It includes:
  1. Water use "materials line" summarizing water usage and need for the value stream
  2. Flows of wastewater from processes to the sewer, water treatment tanks, etc.
  3. Information flows to regulatory agencies regarding water use and wastewater discharges

Value Stream Mapping Strategies and Tools

1. Use icons to identify processes with EHS opportunities
2. Record environmental data for processes in VSMs
3. Analyze materials use vs. need in a “materials line” for VSMs
4. Expand the application of value stream mapping to natural resource flows
5. **Find Lean and environment opportunities in future state VSMs**

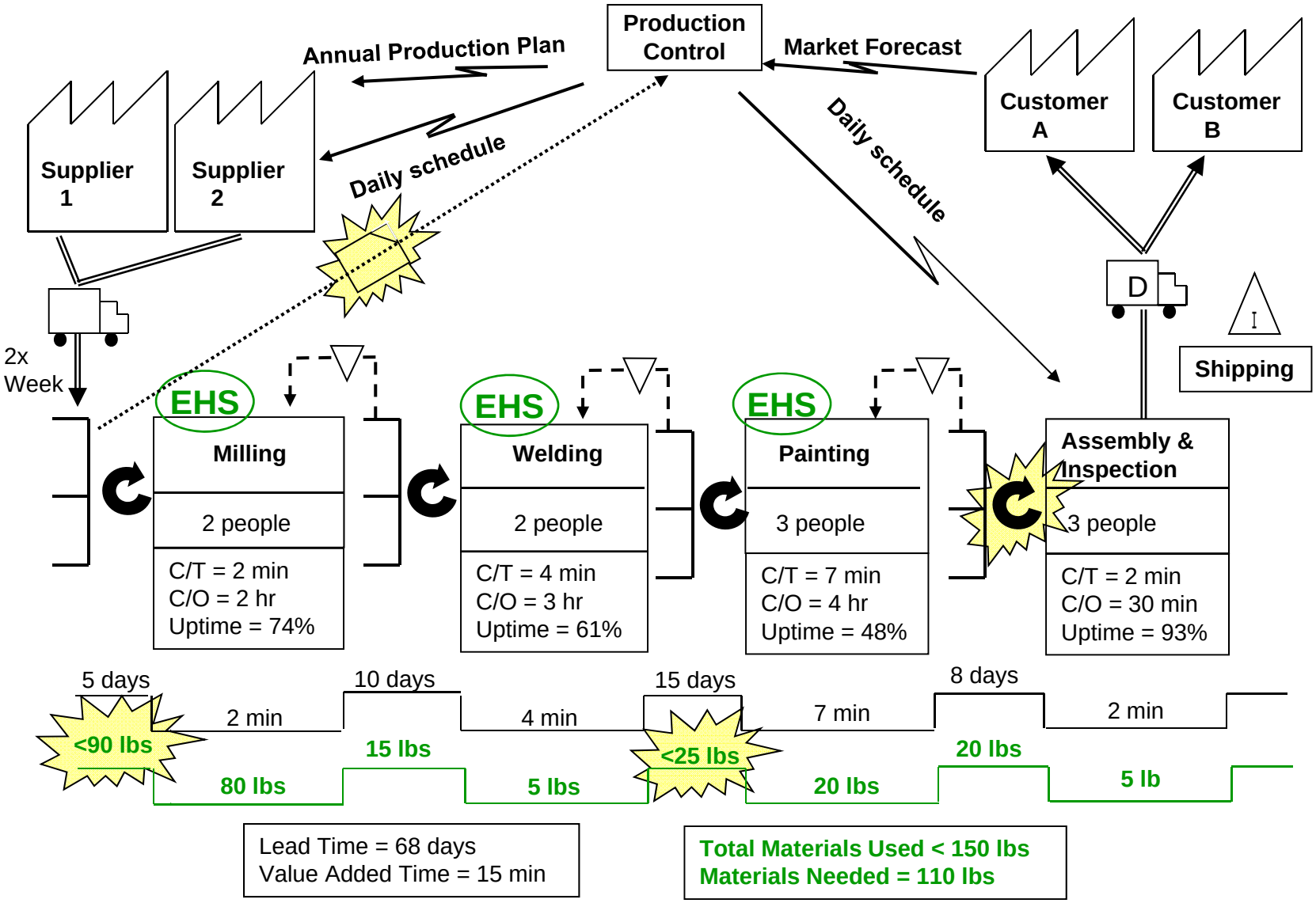
5. Find Lean and Environment Opportunities in Future State VSMs

- Asking simple questions based on the current state VSM can help to envision a less-wasteful future state
- Consider these questions:
  - Where are kaizen events needed to address the biggest areas of environmental wastes? (See the Kaizen Event Training Module)
  - Will any changes be made to the layout of processes marked with an EHS icon, or to the chemicals used by those processes? (These may have regulatory compliance implications)
  - Can one process use the “waste” material from another process instead of using virgin materials?

Questions for the Future State, Continued

- What are appropriate targets for improving environmental performance in the future state?
- What would an *environmentally-preferred future state* look like for the value stream? What if there were:
  - Zero environmental and production wastes?
  - Products and processes that pose no risks to human health or the environment?
  - No need for environmental permits?
- What steps can be taken to get to that future state?

Example Future State VSM



Future State VSMs: Planning for Lean Implementation

- When developing Lean implementation plans in future state VSMs, keep in mind that some processes may require special attention to EHS issues
  - Processes with regulatory requirements
  - Other processes with EHS icons
- Early involvement of EHS staff in planning for Lean events on these processes can help:
  - Anticipate changes needed to environmental compliance practices
  - Bring a fresh perspective and additional resources to Lean waste-reduction activities
  - Prevent harm to worker health and safety

Beyond Value Stream Mapping

- Hierarchical process mapping offers a way to "drill down" from VSMs to find more EHS wastes and process improvement opportunities
  - Uses a tiered approach to examine steps *within* a process in a VSM
  - Helps teams find root causes of waste
  - Includes additional info on resource inputs, non-product outputs, regulatory requirements, & costs
- See the Kaizen Event Training Module for more information about this method

Reflections on Value Stream Mapping Opportunities

- What did you learn from this training module that was particularly useful?
- What questions do you have about the value stream mapping strategies and tools presented?
- What other ideas do you have to improve the environmental performance of your organization with value stream mapping?

EPA Lean and Environment Training Modules

- For more information about EPA's Lean and Environment Training Modules, visit: www.epa.gov/lean
- EPA is interested in learning from organizations' experiences with Lean and environment, and welcomes your comments on this training module
- Please contact EPA by using the form found at http://www.epa.gov/lean/auxfiles/contact.htm

DETAILS

What is Environmental Waste?

- **Environmental waste** is either:
  - an unnecessary use of resources, or
  - a substance released to the air, water, or land that could harm human health or the environment
- Examples of environmental wastes include:
  - Excess (non-value-added) use of energy, water, or materials to meet customer needs
  - Air and water pollution
  - Hazardous wastes, trash, discarded scrap
- See the Identifying Environmental Waste Training Module

DETAILS

More Information on Value Stream Mapping

- In the book *Lean Thinking,* James P. Womack and Daniel T. Jones defined **value stream mapping** as:
  - "Identification of all the specific activities occurring in a value stream for a product or product family"
- Value stream mapping is a manager's tool for understanding how information and materials flow between processes to deliver value to a customer
- This "big-picture," customer-oriented view of an organization's activities allows Lean implementers to identify and prioritize future improvement efforts

DETAILS

Steps in Value Stream Mapping

Typical steps in value stream mapping include:

1. Select a product family
2. Collect data on the current state of the value stream
3. Draw a current state value stream map, identifying waste (non-value-added activity) in the value stream
4. Brainstorm ideas to improve production flow, meet customer demand (takt time), and level product mix
5. Draw a future state value stream map, highlighting targets for Lean improvement efforts
6. Develop a kaizen implementation plan

DETAILS

Value Stream Mapping References

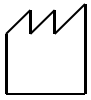
- Rother, Mike and John Shook. *Learning to See: Value-Stream Mapping to Create Value and Eliminate Muda.* Brookline, MA: Lean Enterprise Institute, 2003.

- Tapping, Don, Tom Luyster, and Tom Shuker. *Value Stream Management: Eight Steps to Planning, Mapping, and Sustaining Lean Improvements.* New York: Productivity Press, 2002.

- Womack, James P. and Daniel T. Jones. *Lean Thinking: Banish Waste and Create Wealth in Your Corporation.* Second Edition. 2003.

Key to Symbols on Current State VSM

DETAILS

Milling 2 people C/T = 2 min C/O = 2 hr Uptime = 74%	Production process (with data box)
C/T	Cycle time
C/O	Changeover time
	Inventory
	Truck shipment
	External sources (suppliers, customers, etc.)
	Electronic Information flow
	Movement of production material

DETAILS

Resources for Processes with EHS Wastes and Opportunities

- A wealth of process-specific waste elimination information, detailing techniques & technologies, is available from national and regional "pollution prevention" clearinghouses
- For more information, see:
  - U.S. Environmental Protection Agency Pollution Prevention (P2) website – www.epa.gov/p2
  - Pollution Prevention Resource Exchange – www.p2rx.org
  - U.S. Department of Defense Pollution Prevention Technical Library – p2library.nfesc.navy.mil

DETAILS

EPA's Lean and Environment Basic Environmental Measures (1 of 5)

- EPA has assembled a list of environmental metrics that may be of use to organizations implementing Lean
- The metrics are derived from EPA's Green Supplier Network and Performance Track Program
- The measures include priority chemicals that are of particular concern because of their toxicity, persistence in the environment, and/or their potential to bioaccumulate in organisms at higher levels in the food chain

DETAILS

Environmental Performance Metrics (2 of 5)

Basic Environmental Measures			
Category	**Definition**	**Metric**	**Unit of Measure**
Input Measures			
Energy Use	Any source providing usable power Transportation and non-transportation sources	Energy Used	Specific to energy source such as BTUs or kilowatt hours, % reduction, energy use/unit of product
Land Use	Land covered by buildings, parking lots, and other impervious surfaces Land/habitat conservation	Land Converted, Land Restored or Protected, Area of Impervious Surfaces	Square feet, acres
Materials Use	Materials used (total or specific), including: - Ozone depleting substances (e.g., CFC-11) - Packaging materials Proportion of input materials that were recycled or recovered (vs. virgin materials)	Materials Used, Percent Utilization of Materials, Post-Consumer Recycled Content	Tons/year, pounds/unit of product, % materials utilization
Toxic/Hazardous Chemicals Use	Use of hazardous and toxic chemicals that are regulated or otherwise of concern	Toxic/Hazardous Chemicals Used	Pounds/year, pounds/unit of product, % reduction
Water Use	Incoming raw water, from outside sources, e.g., from municipal water supply or wells, for operations, facility use, and grounds maintenance. NPDES	Volume of Water Used, P2 to reduce Priority Chemicals/Quality Standards/Pretreat Standards	Gallons/year, % reduction, % recycled Pounds Priority Chemicals/year, % reduced, % recycled

DETAILS

Environmental Performance Metrics (3 of 5)

Basic Environmental Measures			
Category	**Definition**	**Metric**	**Unit of Measure**
Non-Product Output Measures			
Air Emissions	The release of any of the following: Air toxics - CAA 112b HAPs (see attachment A) Carbon Monoxide Lead Ozone and its precursors, including: VOCs (volatile organic compounds) NOx (nitrogen oxides) Ozone-depleting substances PM10 (particulate matter) PM2.5 (fine particulate matter) Sulfur Dioxide Greenhouse gases, including Carbon Dioxide	Air Emissions Generated	Pounds/year, Tons/year % reduction
Water Pollution	Quantity of pollutant in wastewater that is discharged to water source. Should include any substances regulated in NPDES permit. May include: Heavy Metals - Cu, Pb, Hexavalent Chromium, Cadmium, Zn, Ni, Hg, Organic Pollutants and Pesticides, Conventional pollutants, e.g., oil and grease, BOD and suspended solids, and Nutrients - N, P Pathogens Sediment from runoff	Mass or Concentration of Regulated Pollutants Discharged	Pounds/year, mg/L or % reduction
Solid Waste	Wastes (liquid or solid) other than RCRA hazardous wastes.	Solid (Non-Hazardous) Waste Generated	Gallons or pounds/year, % reduction, % recycled

DETAILS

Environmental Performance Metrics (4 of 5)

Basic Environmental Measures			
Category	**Definition**	**Metric**	**Unit of Measure**
Downstream/Product Measures			
Product Impacts	Expected lifetime energy and water use Wastes (to air, water, & land) from product use and disposal or recovery	Energy and water used (over product's lifecycle) Waste generated (after the product is used)	Energy - Btu, kWh, MWh Water use - gallons Wastes - pounds, tons
Other Measures			
Money Saved	Money saved in the reduction of materials or other changes in processes	Dollars saved	Dollars saved
Qualitative Measures	Other environmental improvements that cannot be directly or accurately quantified. For example: implementing an EMS or CMS	Savings/environmental benefits from leaning out of permits/DfE/Clean Production/EMS implementation/ Extended Product Responsibility	Not Applicable

DETAILS

Environmental Performance Metrics Resources (5 of 5)

- Companies and other non-governmental organizations have also developed guidance on environmental metrics
  - The Global Reporting Initiative provides guidance for company-wide environmental and sustainability metrics – see www.globalreporting.org
  - The Facility Reporting Initiative provides guidance for facility-wide environmental and sustainability metrics – see www.facilityreporting.org

- While these resources do not focus explicitly on process level environmental metrics, most of the metrics in these frameworks can be considered and applied at process or sub-process levels

DETAILS

Materials Line: Important Considerations

- While material use can typically be determined, it is not always easy to identify what materials are “needed” or “value added” from the customer’s perspective
  - One approach is to count all materials used in a process that are incorporated in the product as “needed”
  - However, it may be possible to meet customers’ need with even fewer materials—this raises important questions for product design

DETAILS

Materials Line: Important Considerations, Continued

- In some cases, materials may play an important role in a process even though they do not directly add value for the customer
- The materials line raises the question: “Is this material needed in the process or is there a better way?”
- For example:
  - Solvents can be useful for cleaning processes even though they often are released to air during the process
  - In some cases, solvents could be replaced by water, compressed air, etc., or the cleaning step can be eliminated by avoiding soiling the part in the first place

Example Future State VSM (1 of 2)

DETAILS

- This future state VSM has kaizen starbursts for:

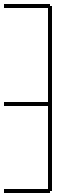
1. Lean Improvements: Converting from a "push" system to a "pull" production system using *kanban* (signals) and supermarkets (controlled inventories of parts)

2. Environmental Improvements: Reducing the amount of materials used by conducting Lean events on the milling and painting processes
   - In this example, the target is to reduce total materials use to less than 150 lbs. per shift

DETAILS

Example Future State VSM (2 of 2)

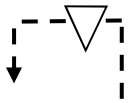
Additional Symbols on the Future State VSM



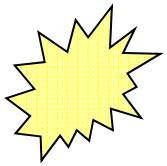
Supermarket (a controlled inventory of parts)

Withdrawal (pull of materials, usually from a supermarket)

Production Kanban (card or device that signals to a process how many of what to produce)



Signal Kanban (shows when a batch of parts is needed)



Kaizen Starburst (identifies improvement needs)