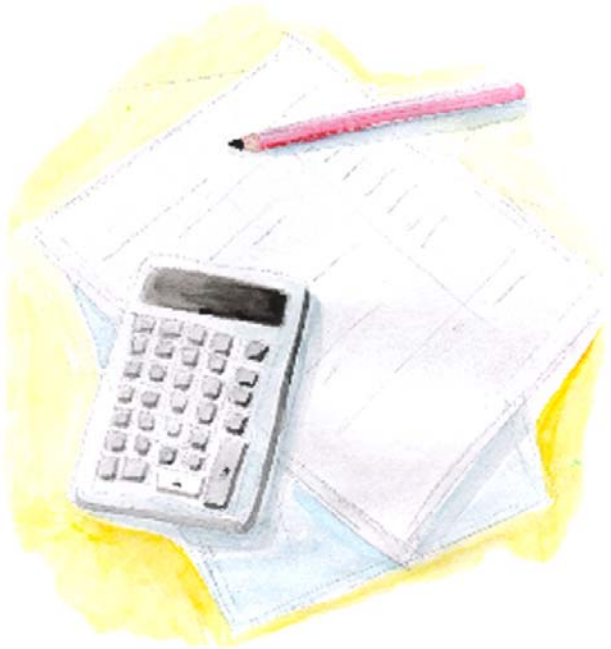
DEPARTMENT OF ECOLOGY
State of Washington

Washington Lean and Environment Project Final Report



Washington State Department of Ecology
Publication Number 07-04-033
Revised August 2008 with 12-Month Review Information

Washington Lean and Environment Project Final Report

Publication Date: August 2007, Revised August 2008 with 12-Month Review Information

Project Conducted by:

Washington State Department of Ecology, Hazardous Waste and Toxics Reduction Program (www.ecy.wa.gov/programs/hwtr)

Washington Manufacturing Services (www.wamfg.org)

Pilot Project Facilities:

Canyon Creek Cabinet Company, Monroe, Washington (www.canyoncreek.com)

Lasco Bathware, Yelm, Washington (www.lascobathware.com)

Columbia Paint & Coatings, Spokane, Washington (www.columbiapaint.com)

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The Washington State Department of Ecology's (Ecology) Hazardous Waste and Toxics Reduction (HWTR) Program and Washington Manufacturing Services (WMS) partnered in a project to provide lean and environmental technical assistance to manufacturing facilities in Washington through three pilot projects. Participating facilities included:

- **Canyon Creek Cabinet Company** (Canyon Creek), a large manufacturer of custom frameless and framed style cabinetry in Monroe.
- **Lasco Bathware** (Lasco), a manufacturer of fiberglass and acrylic bath and shower fixtures in Yelm.
- **Columbia Paint & Coatings** (Columbia Paint), a manufacturer of residential, architectural, and industrial paint and coatings in Spokane.

Ecology provided environmental expertise for the pilot projects, while WMS provided lean manufacturing expertise and management of on-site activities at the facilities. The overall project objectives were to: (1) develop a partnership between Ecology and WMS, (2) evaluate the benefits of deliberately integrating environmental tools into lean practices, and (3) gain the expertise to offer and promote future lean and environment projects to manufacturers statewide. Funding for the project was provided by Ecology, the National Institute of Standards and Technology, and the U.S. Environmental Protection Agency.

Project Activities and Results

Ecology and WMS jointly marketed the pilot projects to manufacturers across Washington and selected facilities based on their ability to meet certain criteria (e.g., demonstrating potential for environmental improvement and securing management buy-in). The pilot projects yielded impressive operational and environmental results at each facility. Cost, time, and environmental savings from the pilot projects are summarized in Table ES-1

Table ES-1. Annual Cost, Time, and Environmental Savings from the Lean and Environment Pilot Projects

Reductions	Canyon Creek		Lasco		Columbia Paint	
	Time and Environmental Savings	Cost Savings	Time and Environmental Savings	Cost Savings	Time and Environmental Savings	Cost Savings
Raw Material and Solid Waste	1,800 wood sheets 10,400 parts 508,000 lbs waste	$376,000	43,200 lbs resin 29,000 lbs overspray[1]	$24,400	49,200 lbs paint solids 18,000 lbs shrink wrap	$109,200
Hazardous Substances and Waste	68,700 lbs purchase 84,400 lbs disposal	$165,600	- - -	- - -	17,600 lbs disposal	$10,000
Air Emissions	55,100 lbs volatile organic compounds	N/A	- - -	- - -	- - -	- - -
Wastewater	- - -	- - -	- - -	- - -	36,900 gallons	(included above)[2]
Energy	20,700 therms	$24,000	126,000 therms	$99,300	- - -	- - -
Labor[3]	39,000 hours	$624,000	2,200 hours	$35,500	2,500 hours	$90,600
Cost Savings Subtotal		*$1,189,600*		*$158,200*		*$209,800*
Total Cost Savings:	$1,557,600 per year					

[1] Estimated potential savings for production of one of Lasco's common models, based on measurements conducted during the kaizen event in 2007.
[2] Cost and material savings associated with the paint solids in wash water are included with raw material savings for the Columbia Paint pilot project.
[3] The labor savings estimates are conservative. Labor hours were reassigned to other value-added activities.

In addition to these savings, other improvements from the pilot projects included:

- Increased production without the need of a Clean Air Act Title V air permit at one facility.
- Reduced total lead time for producing products.
- Increased flexibility and efficiency of production, enabling facilities to be more responsive to customer demands and more competitive in the marketplace.
- Reduced product defects, improved overall workplace organization and ergonomics, and reduced worker exposure levels.
- Enhanced staff morale, improved communication between staff and management, and empowered staff to initiate process improvement activities.

Concurrently with the three pilot projects, WMS and Ecology worked on several separate lean and environment efforts with other manufacturers in Washington and have also further developed the Ecology-WMS partnership.

Key Findings

1. The project confirmed that environmental considerations can be effectively integrated into lean methods to reduce more waste, yield greater cost savings, and increase environmental benefits.
2. The project generated strong, ongoing environmental and operational results.
3. Ecology and WMS have different organizational cultures, but the partners realized the value of overcoming and managing these differences.
4. The partnership added value to individual services offered by Ecology and WMS.
5. Establishing a long-term lean and environment service delivery model is important to the success of the partnership.

Recommendations

The project has potential implications for future lean and environment efforts of Ecology, WMS, and other organizations seeking to combine lean and environmental improvement approaches. Recommendations include:

1. Expand and improve lean and environment service delivery through additional demonstration projects.
2. Continue lean and environment innovation efforts (see textbox).
3. Sustain support for the Ecology-WMS partnership and future lean and environment activities.
4. Develop and implement a coordinated strategy for lean and environment activities in Washington.
5. Extend lean and environment efforts beyond Washington.

Lean and Environment Innovation Areas
(Recommendation #2)

- Environmental "pain" and regulatory issues (i.e., focus on environmentally sensitive processes with substantial costs and/or risks to businesses)
- Product and process design
- Guidance and tools for technical assistance providers
- Links to other environmental and business improvement efforts
- New audiences (local governments, larger manufacturers, etc.)
- Improving agency processes with lean

In conclusion, the Washington Lean and Environment Project was a successful partnership of two technical assistance agencies working together to improve the operational and environmental performance of businesses. Future partnership efforts will likely add to the effectiveness of lean and environmental assistance providers and allow businesses to be more competitive and environmentally sustainable.

I. Introduction and Project Background

In 2006, the Washington State Department of Ecology's (Ecology) Hazardous Waste and Toxics Reduction (HWTR) program and Washington Manufacturing Services (WMS) formed a lean and environment partnership to jointly deliver technical assistance to manufacturing facilities in Washington. The goal was to help businesses improve their operational and environmental performance. This report describes the activities, results, and lessons learned from the Washington Lean and Environment Project. The project consisted of three pilot projects that aimed to integrate lean manufacturing and environmental methods to reduce wastes, increase competitiveness, and improve productivity. Ecology and WMS delivered lean and environment technical assistance to three pilot facilities, including:

- **Canyon Creek Cabinet Company** (Canyon Creek), a large manufacturer of custom frameless and framed style cabinetry in Monroe, Washington.
- **Lasco Bathware** (Lasco), a manufacturer of fiberglass and acrylic bath and shower fixtures in Yelm, Washington.
- **Columbia Paint & Coatings** (Columbia Paint), a manufacturer of residential, architectural, and industrial paint and coatings in Spokane, Washington.

Ecology's HWTR program provided environmental expertise for this project, while WMS provided lean expertise and management of on-site activities at the pilot project facilities. WMS is the state's National Institute of Standards and Technology (NIST) Manufacturing Extension Partnership (MEP) center. WMS provides a variety of services, including lean manufacturing, to help manufacturers become more competitive. Staff from Ecology's Water Quality Program, Solid Waste Program, and Financial Assistance Program also participated in two of the pilot projects. On-site pilot project activities occurred between February 2006 and March 2007.

The objectives of the Washington Lean and Environment Project were to:

- Develop a partnership between Ecology and WMS.
- Evaluate the benefits of deliberately integrating environmental tools into lean practices.
- Gain the expertise to offer and promote future lean and environment projects to manufacturers statewide.

As described later in this report, Ecology and WMS were able to achieve all of these project objectives. The three pilot projects, along with associated partnership activities, demonstrated the value of joint lean and environment technical assistance, while laying the foundation and providing recommendations for future shared work. Case studies for the pilot projects are available on Ecology's Lean and Environment Web site at www.ecy.wa.gov/programs/hwtr/lean.

Lean Manufacturing and Environment Background

Lean production (often called "lean manufacturing," since it originated in automotive and aerospace manufacturing) is a leading business model being adopted and applied by many organizations in the U.S. and other countries. Companies are adopting lean due to competitive pressure to improve product quality, reduce production costs, and increase responsiveness to customer needs.

Environmental agencies such as Ecology and the U.S. Environmental Protection Agency (EPA) have explored the connections between lean production and environmental performance. Research sponsored by EPA confirmed these key observations:[1]

- Lean produces an operational and cultural environment highly conducive to waste minimization, pollution prevention (P2), and sustainability.
- Lean can be produce environmental improvement by addressing its environmental blind spots—environmental risk and life-cycle impacts.
- Lean production and environmental management systems, though essentially different, can be highly compatible.
- Organizations applying lean concepts and methods to environmentally sensitive processes can experience friction with the environmental regulatory framework.[2]
- Environmental agencies have a window of opportunity to work with organizations implementing lean to enhance the environmental benefits associated with lean.

The Washington Lean and Environment Project tested these research findings. It also added to the strategies and tools in EPA's *The Lean and Environment Toolkit* (available at www.epa.gov/lean/toolkit). Both the project and the toolkit provide guidance and examples of how companies can reduce environmental wastes while implementing lean methods.

Project Start Up and Funding

Ecology and WMS jointly conceived the project. Staff from both organizations realized, while visiting the same facility, that they were providing technical assistance to many of the same clients. Recognizing this overlap, Ecology and WMS staff devised a plan to work together on a project that combined lean and environment service delivery. The partnership was formed on the assumption that jointly offering lean and environment technical assistance would improve the overall service delivery of both organizations and provide greater benefits to Washington manufacturers.

In addition to the three facility pilot projects designed to test on-site lean and environment integration, Ecology and WMS plan to deliver two lean and environment workshops and to conduct broader lean training for Ecology staff. Several funding sources supported these partnership activities:

- EPA Pollution Prevention Grant (a 50/50 split of U.S. EPA and Ecology funding)
- EPA's National Center for Environmental Innovation
- National Institute of Standards and Technology
- Individual facility contributions

The overall breakdown of funding sources, amounts, and allocations are outlined in Table 1.

[1] For more information about the relationship of lean production to environmental performance and the environmental regulatory framework, see EPA's Lean Manufacturing and Environment Web site, www.epa.gov/lean.

[2] Organizations can encounter regulatory "friction" (in the form of cost, delays, uncertainty, and/or risk of noncompliance) under the Clean Air Act, the Resource Conservation and Recovery Act, and other environmental regulations when applying lean methods to environmentally sensitive processes. For more information, see: U.S. EPA, *Lean Manufacturing and the Environment: Research on Advanced Manufacturing Systems and the Environment and Recommendations for Leveraging Better Environmental Performance*, October 2003, available at www.epa.gov/lean/leanreport.pdf.

Table 1. Public and Private Funding Sources, Amounts, and Allocation

Public Funding Sources	Amount	Allocation
Ecology[1]	$199,800	Project management, contract administration, case study documentation, on-site services and training, and contractor support[2]
National Institute of Standards and Technology (NIST)	$17,000	WMS lean services
U.S. EPA[3]	$120,000	WMS services, case study documentation, and contractor support
Subtotal	*$336,800*	
Private Funding	**Amount**	**Allocation**
Facility Contributions[4]	$222,300	Capital expenditures
	$73,000	Labor
	$18,000	WMS services
Subtotal	*$313,300*	
Total (Public and Private Sources)	**$650,100**	

[1] *$95,000 were matching funds for a pollution prevention grant, $54,800 for on-site Ecology staff services and training during the pilot projects, and $50,000 from Ecology's "Beyond Waste" pilot project funds.*

[2] *Contractors assisted with case study and final report development, interviews, workshops (conducted in December 2007 and March 2008), and general project support.*

[3] *$95,000 through a pollution prevention grant to Ecology, and $25,000 from the National Center for Environmental Innovation*

[4] *Each pilot facility contributed $6,000 for WMS lean services. Labor and capital expenses include direct project costs to the facility.*

The level of public resources invested in the project is not necessarily representative of the support needed for future Ecology and WMS efforts. Project participants expect future lean and environment facility projects to require significantly less investment of staff and financial resources. Partners plan to train more staff, streamline the communications and management structure, and better define and market value-added roles for Ecology and WMS staff.

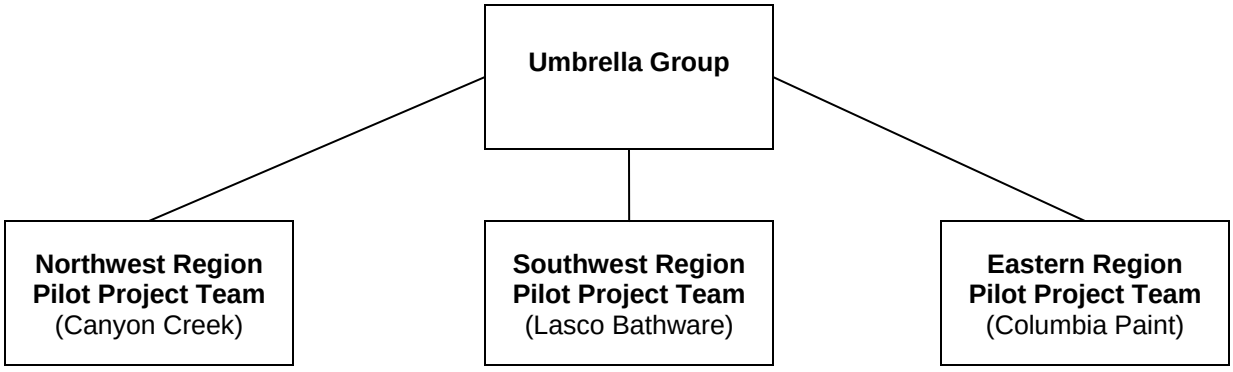
Staffing and Organizational Structure

The Ecology and WMS partnership organized around an "umbrella group" that guided overall project direction and decision-making, and three regional teams that designed, marketed, and conducted the lean and environment pilot projects (see Figure 1). Members of the umbrella group included:

- Two Ecology project leads
- Three Ecology pilot project leads from each of the three participating Ecology regional offices (Northwest, Southwest, and Eastern Regional Offices)
- The WMS president and three WMS regional project managers
- One technical lead from both Ecology and WMS

The individual pilot project teams included Ecology's regional leads and additional Ecology staff, a WMS lean service provider, and a WMS project manager.

Figure 1. Project Organization Chart



In addition, Ross & Associates Environmental Consulting, Ltd. and the Pacific Northwest Pollution Prevention Resource Center (PPRC), through a contract with Ecology, provided general project support to the umbrella group and the regional pilot project teams. Support included writing case studies for the pilot projects and this report.

II. Overview of Project Activities

Marketing and Facility Selection

The umbrella group developed marketing and outreach materials to solicit facility participation in the pilot projects and to guide the pilot project teams. The facility marketing materials described project objectives, benefits to the facility, and the required facility contribution. Ecology emphasized the focus of the pilot projects was technical assistance, not enforcement.

As described in the project marketing flyer, potential benefits for the facility included:

- Lead-time reduction and quality improvement
- Downtime and changeover reduction
- Improved worker health and safety
- Inventory reduction
- Increased floor space available for production
- Reduction in the need for compliance and risk of non-compliance
- Increased productivity and lower costs

WMS and Ecology staff developed a list of candidate facilities based on their collective experience working with manufacturers across the state. Both organizations jointly interviewed interested facilities, with WMS project managers leading the interviews and Ecology available to explain the environmental component. The marketing and facility selection process occurred between February and June 2006.

The Ecology and WMS umbrella group chose pilot facilities that met the selection criteria and provided regional and industrial sector diversity. Based on these criteria, Canyon Creek Cabinet Company, Lasco Bathware, and Columbia Paint & Coatings were chosen as pilot project facilities.

Facility Selection Criteria

Priority facility selection criteria included:

- Sharing project results
- Securing upper management buy-in
- Demonstrating potential for environmental improvement
- Implementing lean events during the pilot project timeframe

Other important qualifications for facilities included:

- "Ripe" (ready) for lean
- Interest in applying lean and environment tools
- Interest in the environment and safety, sustainability, or "green" public relations
- Alignment with other Ecology environmental initiatives
- Willingness to pay the required fee for service
- Possibility for quick decision-making

Any facilities with outstanding penalties or significant regulatory violations were excluded from further consideration.

Lean and Environment Integration Approach

Existing examples of lean and environment integration guided the Washington Lean and Environment Project. Many integration techniques and examples are included on EPA's Lean and Environment Web page (www.epa.gov/lean) and in EPA's 2006 *The Lean and Environment Toolkit.* These served as a reference and guidance during initiation and implementation of the pilot projects.

Ecology and WMS worked with the individual facilities to determine the best lean and environment integration approach. Each pilot project took a slightly different approach based on the facility's needs and goals, and the preferences of WMS and Ecology staff. Examples include:

- Using pollution prevention expertise to identify waste elimination opportunities and toxic material substitutes, finding ways to conserve energy and water, and reducing wastewater generation.
- Expanding the definition of lean wastes to include other wastes, such as "process waste" (a generic term for environmental wastes), in pilot project training and implementation activities.
- Selecting projects based on their potential to reduce environmental wastes, pollution, and exposure.
- Asking leading questions to encourage facility staff to identify environmental wastes and improvement opportunities, especially during the value stream mapping (VSM) workshops. (VSM is a lean method for mapping the flows of information and materials through processes in a "value stream"—all the activities needed to deliver a product or service to the customer.)
- Measuring the costs of environmental waste and pollution during pilot project activities and making them more visible.

Summary of Pilot Project Activities and Results

The activities and results of the Canyon Creek Cabinet Company, Lasco Bathware, and Columbia Paint & Coatings pilot projects are summarized below. (The pilot project descriptions are organized sequentially according to when the on-site pilot project activities concluded.) The full case studies of the pilot projects are available on Ecology's Lean and Environment Web site at www.ecy.wa.gov/programs/hwtr/lean.

Canyon Creek Cabinet Company Pilot Project[3]

Canyon Creek Cabinet Company, a large manufacturer of custom frameless and framed style cabinetry, in Monroe, Washington, was the first pilot project facility. Pilot project activities at Canyon Creek occurred May through August 2006.

Pilot project participants formed teams to address two targeted areas: (1) Canyon Creek's "Millennia" cabinet line, along with plant-wide milling and cutting operations (addressed by the "Woodchuckers Team"), and (2) the finishing department, where products are stained and coated (addressed by the "Toxics Team"). The teams included cross-functional staff from Canyon Creek and four Ecology staff. Each team used the lean value stream mapping method to identify improvement activities, and participated in three, week-long kaizen events to implement lean and environmental changes. (Kaizen events, or "get 'r done" events, are rapid process improvement events that typically last 3-5 days). During value stream mapping, teams conducted additional analysis of the sources and costs of environmental wastes.

The collective efforts of Canyon Creek, Ecology, and WMS to implement lean methods while explicitly addressing environmental wastes produced considerable operational, financial, and environmental benefits. Process improvements reduced lead times, work-in-process (WIP), defects, overproduction, downtime, operator travel time, and material loss and damage. These improvements also reduced the company's hazardous wastes, solid wastes, and volatile organic compound (VOC) emissions.

Cost savings from reductions in environmental wastes are expected to total about $1.2 million per year for process changes implemented as a result of the pilot project.

Table 2. Canyon Creek Pilot Project Annual Cost, Time, Material, and Environmental Savings

Reductions	Woodchuckers Team		Toxics Team	
	Annual Cost Savings	Time, Material, & Environmental Savings	Annual Cost Savings	Time, Material, & Environmental Savings
Raw Material	$110,000[1]	1,800 wood sheets	- - -	- - -
Hazardous Substances	- - -	- - -	$128,500	68,700 lbs purchase
Hazardous Waste	- - -	- - -	$37,100[1]	84,400 lbs disposal
Air Emissions	- - -	- - -		55,100 lbs VOCs
Solid Waste	$58,000	508,000 lbs		
Rejects	- - -	- - -	$208,000[1]	10,400 parts
Energy			$24,000	20,700 therms
Labor[2]	- - -	- - -	$624,000	39,000 hours
Cost Savings Sub-Total	***$168,000***		***$1,021,600***	
Total Cost Savings:	**$1,189,600 per year**			

[1] *These savings were achieved without a capital expenditure request.*
[2] *This is a conservative estimate of labor savings. The additional labor hours were used to fill open positions.*

Canyon Creek expects to save an additional $194,000 in raw material and waste reductions and 2,600 labor hours from the pending investment of three cross-cut saws. The saws are expected to increase the efficiency of wood ripping and reduce the equivalent of up to 37,000 wood sheets per year.

[3] The full Canyon Creek Cabinet Company Lean and Environment Case Study is available on Ecology's Web site at http://www.ecy.wa.gov/pubs/0604024.pdf.

Aside from cost, time, material and environmental savings, there were many operational improvements from the lean and environment pilot project activities at Canyon Creek. Highlights include:

- Increased average production from about 900 cabinets per day to about 1,000 cabinets per day.
- Allowed for up to 70 percent additional production capacity before reaching the Clean Air Act Title V permit threshold for VOCs.
- Greatly reduced number of defective doors scrapped and sent for hog fuel.
- Increased first-pass quality yield rates in two milling departments by 3 and 12 percentage points respectively.
- Reduced lead time in the Millennia product line by 24 percent.
- Reduced floor space needed for work in process by 590 square feet.
- Improved general workplace organization, ergonomics, and reducing exposure levels.
- Eliminated one shift, reassigning all third shift employees to first and second shifts.
- Freed first and second shift staff time to assist with other tasks such as continuous improvement activities and equipment audits.

Post-Pilot Lean and Environment Activities at Canyon Creek

Since pilot project activities concluded in August 2006, Canyon Creek Paint has continued to improve its operational and environmental performance. As part of its ongoing continuous improvement efforts, Canyon Creek has:

- Installed a new finishing line area to enable spraying of miscellaneous parts and items together as a kit without affecting the flow and speed of the main production lines. Finishing the parts for a kit together improves quality and uniformity of finish, and is reducing scrap and defects, along with associated reductions in hazardous substance use and energy use.
- Tested a plural gun system for mixing the top coat and a unicoat system (which is slated for purchase and implementation) that would reduce the facility's hazardous waste stream due to the short pot life associated with pre-mixing.
- Eliminated an alcohol wastewater stream by putting the unicoat product into operation.
- Replaced eight blow-down stations for dust removal between coats by manually removing dust with a tack cloth. This saves on the use of a 40-horsepower compressed air stream.
- Completed and filed a five-year "lean option" pollution prevention plan with Ecology, in lieu of the conventional five-year pollution prevention plan filed by most manufacturers in Washington state.
- Developed a master plan to change the plant layout based on lean principles by the end of 2008.

The close examination of environmental wastes and costs during lean implementation at Canyon Creek led to new opportunities to eliminate waste, improve processes, and reduce costs. WMS and Ecology worked effectively together to deliver powerful results for Canyon Creek's bottom line, environmental performance, and the health and safety of its workers.

Lasco Bathware Pilot Project[4]

Lasco Bathware manufactures fiberglass and acrylic bath and shower fixtures in Yelm, Washington. Lasco participated in the Washington Lean and Environment Project as the second pilot facility. On-site pilot activities occurred May 2006 through January 2007.

Pilot project participants formed teams to address three target areas: (1) Packaging and shipping, (2) fiberglass-reinforced plastic (FRP) spray operations, and (3) acrylic vacuum mold changeover. The teams included cross-functional staff from Lasco, three Ecology staff, and a WMS facilitator. After a "Lean 101" training session, the teams developed current state value stream maps for the FRP and acrylic lines as a way of identifying and prioritizing lean and environmental improvement opportunities. The teams then participated in three kaizen events to implement the process changes identified in the value stream maps.

The collective efforts of Lasco, Ecology, and WMS produced considerable operational, financial, and environmental benefits. Process improvements included:

- Reduced production bottlenecks and established cleaner and more organized work areas.
- Decreased variability in spray operations.
- Reduced energy use and FRP wastes.
- Reassigned over 1,900 annual labor hours to other value-added activities.

These improvements also had a positive effect on the facility as a whole, since they provided better ergonomics, improved internal communications, and fostered a more proactive stance toward continuous improvement among production staff. The project also resulted in cost savings of about $158,000 per year and reductions in environmental, energy, and material wastes, as shown in Table 3.

Table 3. Lasco Pilot Project Annual Cost, Time, Material, and Environmental Savings

Reductions	Annual Cost Savings	Annual Time, Material, & Environmental Savings
Raw Material[1]	$23,000	43,200 lbs resin
Solid Waste[2]	$1,400	29,000 lbs overspray
Energy	$99,300	126,000 therms natural gas
Labor[3]	$34,500	2,200 hours
Total Cost Savings	**$158,200**	

[1] Anticipated savings from installing in-line flow meters for FRP spray gun calibration. As of June 2008, the flow meters had been installed, but were still being adjusted to work properly at the facility.
[2] Estimated potential savings for production of one of Lasco's common models. These estimates are based on measurements for one product line at the production quantity during the kaizen event in 2007.
[3]This is a conservative estimate of labor savings that excludes savings from the flow meter installation. Labor hours were reassigned to other value-added activities.

In addition to these measurable savings, the pilot project also generated other improvements, including:

- Increased weight of spray on the product, resulting in a stronger and higher-quality product.
- Freed staff time to assist with other value-added activities.
- Improved point-of-use storage and layout of acrylic molding area.
- Increased conveyor speed and reduced number of defects from packaging processes.

[4] The full Lasco Bathware Lean and Environment Case Study is available on Ecology's Web site at http://www.ecy.wa.gov/pubs/0704009.pdf.

- Increased transfer efficiency of the FRP resin spray, which reduces overspray waste and may eventually result in less resin use and fewer air emissions.
- Reduced forklift travel, decreasing energy and operator time.
- Enhanced staff communications and morale and generated culture change, especially among production staff.

Post-Pilot Lean and Environment Activities at Lasco

Since pilot project activities concluded in January 2007, Lasco has continued to improve its operational and environmental performance. As part of its ongoing continuous improvement efforts, Lasco has:

- Hired a new plant manager experienced in lean and six sigma who has expanded and matured lean efforts at Lasco.
- Held bi-weekly 15-minute improvement meetings based on topics from the book, *Twenty Keys to Workplace Improvement* by Iwao Kobayashi.
- Implemented a 5S scorecard for each working area that is completed weekly. The facility has steadily improved 5S scores over time and has implemented an estimated 60 percent of employee ideas.
- Added weight variability monitoring (as developed in kaizen event #2) to two additional units with instant visual feedback on spray performance.
- Improved preventive maintenance, leak detection, and cleaning in the mixing room, mold repair room, and spray room.
- Installed new scissor-lift tables for the vacuum-forming area to eliminate the need for manual height adjustments and reduce mold changeover time.
- Eliminated acetone for tool cleaning in a lamination booth, reducing the use and disposal of about 35 gallons of acetone per week. (Lasco also distills and reuses acetone used in other areas of the facility.)
- Installed a newly redesigned spray boom that reduces operator fatigue.
- Revamped the existing vendor-maintained inventory program to provide improved, just-in-time parts management.
- Improved layout in several areas of the plant to reduce travel time and material movement.

Ecology and WMS effectively provided lean and pollution prevention technical assistance to Lasco. This enabled pilot project participants to identify and implement new opportunities to substantially improve production processes, reduce costs, and decrease environmental impacts. Lasco employees were highly engaged in the pilot project, and the combined efforts of all participants empowered staff to seek continued lean and environmental improvement opportunities.

Columbia Paint & Coatings Pilot Project[5]

Columbia Paint & Coatings in Spokane, Washington, manufactures high-quality residential, architectural, and industrial paint and coatings and participated in the project as the third pilot facility. Pilot project activities at Columbia Paint occurred October 2006 through March 2007. In September 2007, Columbia Paint was acquired by Sherwin-Williams, the largest national producer of paint and coatings.

[5] The full Columbia Paint & Coatings Lean and Environment Case Study is available on Ecology's Web site at http://www.ecy.wa.gov/pubs/0704032.pdf.

Pilot project activities included a "Lean 101" training session to introduce lean methods to Columbia Paint staff, a value stream mapping workshop to identify improvement opportunities, and three "get 'r done" events to implement process changes. (A "get 'r done" event is another name for a kaizen event.) The three get 'r done events supported by a WMS facilitator and two Ecology staff were designed to address the following priority areas:

- Develop a production scheduling system driven by customer demand.
- Streamline the quality control process.
- Improve material organization and flow to increase batch-making velocity.

In addition to the planned pilot project activities, Columbia Paint independently conducted several lean and environment activities during the pilot project period, including changes to the plant's layout and improvements to the oil-decanting and shrink-wrapping processes.

The collective efforts of Columbia Paint, Ecology, and WMS yielded considerable operational and environmental benefits. Through project activities, Columbia Paint reduced production lead and cycle times, overproduction, material loss and damage, operator travel time, and downtime. The process improvements also reduced raw material wastes, wastewater discharges, volatile organic compound emissions, and hazardous wastes. As a result of pilot project activities, Columbia Paint now reuses all wash water from white paints and incorporates it into products; the facility also instituted a new raw material tracking code to better quantify cost savings from paint solids recovered in wash water. The new scheduling system allows for better batch coordination, which in turn allows operators to reuse more wastewater into subsequent batches. Cost savings for Columbia Paint are expected to total about $210,000 per year. The cost, time, material, and environmental savings from the project are summarized in Table 4.

Table 4. Columbia Paint Pilot Project Annual Cost, Time, Material, and Environmental Savings

Reductions	Annual Cost Savings	Annual Time, Material, & Environmental Savings
Raw Material	$109,200	49,200 lbs paint solids from wash water 18,000 lbs shrink wrap
Hazardous Waste	$10,000	17,600 lbs
Wastewater	(included above)[1]	36,900 gallons
Labor[2]	$90,600	2,500 hours
Total Cost Savings	$209,800	

[1] *Cost and material savings associated with the paint solids in wash water are included with raw material savings.*

[2] *This is a conservative estimate of labor savings. Hours were reassigned to other value-added activities*

The project also resulted in other operational benefits, including improvements in product quality, customer service, worker health and safety, and staff morale. Highlights include:

- Decreased total lead time for making non-stock products from 6-10 to an average of 5 days.
- Reduced quality control inspection cycle time by 36 percent and decreased overall number of process steps in the quality control process.
- Lessened potential for distressed batches by streamlining and standardizing raw material storage.
- Decreased potential for accidents by reducing forklift traffic congestion, decreasing drum handling, and eliminating safety hazards associated with a conveyer system.
- Reduced worker exposure to ammonia and other volatile organic compounds.
- Freed staff time to focus on value-added tasks such as supporting additional process improvement efforts.

- Enhanced staff morale, improved communication between staff and management, and empowered staff to initiate process improvement activities.

Post-Pilot Lean and Environment Activities at Columbia Paint

Since pilot project activities concluded in March 2007, Columbia Paint has continued to improve its operational and environmental performance. As part of its ongoing continuous improvement efforts, Columbia Paint has:

- Reduced water use by recycling white and off-white wash water to clean tanks instead of using virgin water.
- Saved energy by decreasing the amount of product cycling through the still during the decanting process, and reduced the number of products used in the decanting process from nine to four.
- Made at least three additional rounds of improvements to the job board created in the pilot project to track the "pull" production system as staff gained experience with the new system.
- Extended lean and environment process improvements from the pilot project, including the practices of reusing all white wash water, to the Helena, Montana facility before it was closed. This resulted in the Helena facility having zero wastewater discharges from production operations.
- Taken over all of the production from the Helena facility using only half the labor used in Helena. (Note: The lean process improvements at the Spokane facility may have helped make this production increase possible; however, due to the economic downturn, this cannot be entirely attributed to lean.)
- Implemented several 5S improvement projects to foster housekeeping excellence throughout the facility.
- Developed a list of improvement activities for future get 'r done events.

The combination of lean and environmental objectives contributed to the pilot project's overall success. The pilot project saved Columbia Paint money, improved the facility's responsiveness to customer demands, and increased the efficiency of the facility's production system. Furthermore, the project eliminated an environmental waste stream, improved the health and safety of the workplace, and generated positive momentum for additional lean and environment improvement efforts.

Concurrent Partnership Activities

In support of the overall partnership beyond the pilot projects, Ecology and WMS have engaged in several activities to support and sustain the lean and environment project, including:

- **Lessons Learned Meeting:** Ecology and WMS discussed lessons learned from the three pilot projects and ideas for future lean and environment efforts at a project debrief and strategy meeting in February 2007. (Observations from this meeting are included in this report.)
- **Cross Training:** Ecology and WMS conducted a full day of cross-training in May 2007 on how to recognize environmental "pain" and lean "pain" at facilities. This was intended to enable WMS and Ecology project managers and technical assistance staff to better understand and market each other's expertise to potential clients.
- **Workshops and Presentations:** Ecology, WMS, and PPRC held a series of workshops in December 2007 and March 2008 for Washington businesses and local government agencies to share the results of the lean and environment pilot projects and market future lean and

environment projects to potential candidate facilities. In addition, project participants have presented the case studies at numerous lean and environmental conferences and meetings.

- **Marketing Future Projects:** Ecology and WMS have continued to advertise and market their lean and environment services to prospective clients. These efforts have included marketing more streamlined lean and environment demonstration projects (e.g., less resource-intensive projects that involve Ecology staff more strategically in lean events), lean and environment design projects targeted at process or product design, and engagements involving the EPA and NIST MEP's Green Suppliers Network Program (www.greensuppliers.gov).
- **Strategic Planning:** Ecology, WMS, EPA, PPRC, and Ross & Associates have engaged in planning discussions and meetings to develop a long-term model for lean and environment service delivery in Washington. It is anticipated that the strategies pioneered in Washington could serve as a national model for diffusion of lean and environment activities.

In addition to the three pilot projects, WMS and Ecology did separate lean and environment work with other manufacturers in Washington. As a result of the partnership forged between WMS and Ecology, several opportunities arose to work together at other facilities. The activities, which were not grant-funded, show that the partnership resulted in benefits beyond the pilot projects. Examples of these collaborative technical assistance efforts from 2006–07 include the following.

- **Pro CNC (Bellingham, Washington):** While providing lean services to Pro CNC—a full service CNC (computer numerical control) precision machining facility—WMS identified an environmental challenge the facility faced that could benefit from Ecology's technical expertise. WMS referred Pro CNC to Ecology staff to evaluate the environmental impacts of using small metal finishing baths to fit into Pro CNC's production cells.
- **Wilcox Farms (Roy, Washington):** A WMS consultant working with Wilcox Farms to improve its egg production operation identified an opportunity to address an environmental challenge in the context of lean. Wilcox Farms and WMS invited Ecology staff to participate in a one-day problem-solving session focused on balancing chicken manure oversupply with demand for manure products. Ecology participated in the session, lending P2 and regulatory expertise to improve manure management.
- **Tyee Aircraft (Everett, Washington):** During a lean consulting project with a Tyee Aircraft facility, WMS suggested that the facility invite an Ecology staff person to visit the facility and provide free environmental technical assistance. The purpose of the referral was to identify environmental improvement opportunities, such as lower-toxicity cleaners, to complement their lean efforts.

The pilot projects and these other partnership activities have laid the groundwork for Ecology and WMS to work together on future lean and environment efforts.

III. Findings and Lessons Learned

Key Findings from the Washington Lean and Environment Project

1. The project has shown that environmental considerations can be effectively integrated into lean methods to reduce more waste, yield greater cost savings, and increase environmental benefits.

This project tested the concept that lean and pollution prevention methods are complementary. During the initial stages of the project, Ecology and WMS reviewed the U.S. EPA's *Lean and Environment Toolkit* to identify ways to integrate environmental considerations into lean. Participants then developed and adapted a lean and environment integration strategy for each pilot project. The pilot project experience demonstrated that there are a variety of approaches for merging lean and environmental concepts.

- The Canyon Creek pilot project team explicitly built environmental considerations into the design of the project. In particular, participants selected and dedicated a team for each of the three kaizen events on the finishing process because of the potential to reduce the use and disposal of hazardous materials (although the finishing process kaizen activities encompassed more than environmental work).
- Columbia Paint's pilot project team chose improvement projects based on the company's business priorities (e.g., focusing on the larger volume latex paints instead of oil-based paints), but let environmental opportunities "bubble up" during lean implementation.
- Ecology and WMS adapted their lean and environment integration strategy in the Lasco pilot project over time to meet the needs of Lasco while achieving the project's overall objectives (e.g., WMS and Ecology negotiated with Lasco to increase the focus on environmental outcomes for the second kaizen event, and used design-of-experiment[6] and six sigma[7] tools).

While each lean and environment integration strategy differed and was tailored to the specific facility, all were effective in achieving the objectives of the project.

In all three pilot projects, participants successfully used lean events as a platform for identifying and implementing environmental improvement opportunities. The value stream mapping method was particularly useful for identifying large sources of waste (including both lean wastes and environmental wastes) and in prioritizing future process improvement efforts. For example, it was during the value stream mapping workshop that line workers at Columbia Paint realized they could reuse all white wash water rather than disposing it. This resulted in an immediate reduction in the disposal of white wash water. Furthermore, Lasco acknowledged that a shrink-wrap heating oven could be eliminated (resulting in significant energy and cost savings) after the value stream mapping workshop.

Ecology supplemented the analytic tools used in lean with pollution prevention tools—such as process mapping, root cause analysis, and environmental cost accounting—as well as technology-specific pollution prevention expertise (e.g., demonstrating laser spray techniques at Lasco). WMS and Ecology integrated "process waste" (i.e., environmental wastes such as air pollutant emissions, solid and hazardous wastes, wastewater, and excess energy use) into the Lasco and Columbia Paint Lean 101 training sessions and the value stream mapping workshops. This lessened the distinction between lean and the environment

[6] "Design-of-experiment" refers to a structured, organized method for determining the relationship between factors affecting a process and the output of that process.

[7] "Six sigma" is an improvement methodology and collection of statistical tools that aim to reduce defects and other forms of process variation.

and will help ensure that future improvement efforts at the companies will address all types of production and process wastes.

2. The Washington Lean and Environment Project generated strong and ongoing environmental and operational results.

The project resulted in a variety of impressive, tangible results for the environment, worker health and safety, and the competitiveness of the participating facilities (see textbox). Ecology and WMS followed up with the facilities six months and 12 months after the last kaizen event to see whether these results were sustained and/or improved upon. All three facilities sustained the gains made during the pilot projects, although some attention to follow up and additional training was needed to prevent back sliding. For at least one facility, Columbia Paint, the pilot project caused the facility to better track environmental savings; the actual annual environmental cost savings for Columbia Paint were much higher than the estimates presented in the initial case study. (This report incorporates results from the 12-month reviews.)

Environmental and Operational Benefits from the Washington Lean and Environment Project

Collectively, the three lean and environment pilot projects:

- Saved $1.6 million annually in labor, raw material, and other costs.*
- Eliminated 55,100 pounds of volatile organic compound (VOC) emissions, and allowed one facility to increase production without needing a State Title V air permit.
- Saved 36,900 gallons of wastewater by reusing a waste stream at a facility.
- Reduced the use of hazardous substances by 68,700 pounds.
- Eliminated 102,000 pounds of hazardous waste.
- Cut solid waste by over 580,000 pounds.
- Saved 146,700 therms of natural gas.
- Reduced total lead times for producing products.
- Increased flexibility and efficiency of production, enabling facilities to be more responsive to customer demands and more competitive in the marketplace.
- Improved product quality and reduced defects.
- Improved safety and ergonomics, and reduced the potential for accidents.
- Increased staff morale and improved communication between management and staff.

* Note: Labor savings did not result in any layoffs; employees were reassigned to other value-added tasks.

In addition to the benefits from the lean and environment pilot project activities, the project enabled facilities to independently identify and implement lean and environmental improvement opportunities without Ecology or WMS support. The pilot projects built the capacity of the facilities to implement lean methods, fostered a continual improvement organizational culture, and focused employees on eliminating all types of waste. For example, Columbia Paint independently improved its shrink wrapping and oil decanting processes, as well as rearranged the plant layout to support the new pull production system. Furthermore, all three pilot facilities continued and expanded their lean and environmental improvement efforts since end of the pilot projects, as described in the textboxes on post-pilot project activities above.

3. While Ecology and WMS have different organizational cultures, the partners have realized the value of overcoming and managing these differences.

Many of the challenges faced during the project related to differences in organizational cultures, objectives, and operational methods of Ecology and WMS. WMS tends to be more client-focused than Ecology, while Ecology must consider the regulatory context and environmental implications of the agency's work with facilities. Even though Ecology's toxics reduction staff are technical assistance officers with no enforcement authority, the perception of Ecology as a regulator may limit the willingness of facilities to allow Ecology staff to participate in improvement efforts.

WMS and Ecology have different models for service delivery, as well as different marketing and project management practices. For example, WMS charges direct fees for its technical services, while Ecology provides "free" pollution prevention technical assistance to facilities (toxics reduction staff's professional services are funded by hazardous waste fees paid by companies statewide). Lean service providers working for WMS spend nearly all of their time providing on-site services to clients, so WMS participants in this project found it difficult to deal with the extent of e-mail, phone communications, and meetings with Ecology. Ecology staff, on the other hand, expressed some frustration with the difficulty of communicating with lean service providers at times during the project, and felt a greater need for precise data on the cost and environmental savings from the pilot projects.

Despite these differences, Ecology and WMS worked successfully together, and participants adapted their approaches to better meet the needs and objectives of both organizations and the pilot facilities. Ecology offered technical assistance and suggestions within the framework of lean implementation, while WMS adapted its lean service delivery to incorporate environmental considerations and accommodate Ecology's interests in increased data analysis and reporting. Working together, Ecology and WMS were able to deliver more comprehensive technical assistance services to clients and, as a result, achieved better results for both business and the environment. Lean methods and processes yielded significant environmental gains and the focus on environmental wastes led to opportunities to reduce labor and raw material costs as well as decrease health and safety hazards. If implemented sequentially or in isolation, neither improvement approach would likely have been as effective.

4. The partnership added value to the individual services offered by Ecology and WMS.

WMS and Ecology recognize that they both offer better services through this lean and environment partnership. For Ecology, lean provides a window of opportunity to introduce pollution prevention technologies and techniques when companies are committed to making major operational changes to support lean implementation. In addition, pollution prevention is a natural extension of lean's focus on waste elimination, continuous improvement, and employee involvement. Ecology staff in the Canyon Creek pilot project observed, "This is the way pollution prevention is supposed to work." For WMS, the involvement of Ecology allows WMS to provide additional technical services to help clients reduce environmental risks and costs, regulatory compliance burdens, and environmental impacts. Recognizing this added value, lean service providers from WMS have invited Ecology to assist with lean projects at other Washington facilities (as described in the previous section).

Ecology and WMS have found their skills and services to be complementary. For example, WMS places more emphasis on marketing and sales than Ecology, and may be more successful in reaching new clients. Ecology staff, on the other hand, may be better poised to assist facilities with follow-up from events, since the engagement of WMS lean service providers is focused on short-term lean event facilitation. In addition, Ecology staff can provide more specific technical expertise on technology alternatives and regulatory requirements associated with certain types of processes, while WMS staff can provide overall

process expertise on facilitating lean events. The partnership has also allowed both WMS and Ecology to gain increased access to clients.

5. Establishing a long-term lean and environment service delivery model is important to the success of the partnership.

Recognizing the value of joint lean and environment service delivery, Ecology and WMS have committed to continuing the partnership established through this project. While relationships established through the pilot projects stimulated some cross-organizational "pull" for lean or environmental expertise, it will be useful to develop a long-term model for joint services. Building a coordinated infrastructure and holding additional demonstration projects will help facilitate long-term engagement of WMS and Ecology.

Through this partnership, Ecology and WMS have recognized that there are multiple ways to integrate lean and environment, and that a flexible service delivery model is necessary for the future. While some techniques have proven successful and can be replicated (e.g., the incorporation of "process waste" into the Lean 101 training presentation), it will continue to be important for WMS and Ecology to tailor their services to address the unique needs of each facility. In addition to flexibility, Ecology and WMS recognize the need for streamlining the management aspects of the partnership (e.g., reduce the extent of communication during the planning stage of projects) and to think more strategically about how and when Ecology staff participate in lean events at facilities. Thus far, Ecology's participation has been most valuable during value stream mapping events and in the planning phase of kaizen events that focus on environmentally sensitive processes.

Tactical Lessons Learned from the Pilot Projects

Along with overall findings from the project, Ecology and WMS participants in the three pilot projects identified a number of specific, tactical lessons learned relating to lean and environment implementation efforts. Highlights of these lessons learned are summarized below.

Marketing and Outreach

- The combination of lean and environment was a hard sell, even with financial support for environmental services. Often a perception around subsidized services raises a red flag.
- Environmental services require a different sell than lean. Ecology will need to learn to better speak the language of business and productivity, and also to translate environmental benefits into more obvious business and cost benefits. Facilities should be able to understand the benefits of Ecology's services and the value of addressing environmental wastes though lean implementation.
- For future marketing and sales efforts, consider using terminology other than "environment" and explicitly counter the perception that Ecology's toxics reduction staff is there to enforce compliance. As an example, Ecology and WMS marketed the March 2008 workshops as "lean and green" to counter the negative perceptions around the word "environment."
- Some businesses perceive WMS' services to be expensive, so it could be beneficial to address this issue by clearly conveying the value-added services that WMS offers.

Communications and Management

- It is important to ensure that the facility, WMS, and Ecology have a common vision for the desired outcomes of a project. Participants should document a scope of work that sets clear expectations (especially the environmental improvement requirements) at the outset of a project.

- It will be useful to explore options for better qualifying clients before signing contracts (such as conducting a walk through of the facility to identify the magnitude of environmental improvement opportunities before initiating a project with multiple kaizen events).
- Future Ecology-WMS efforts should use a model that is non-intrusive, efficient, and draws on the strengths of each organization.
- Recognizing that frequent data requests can be disruptive to clients, Ecology and WMS should coordinate and streamline future communication with clients, while still obtaining the information necessary to document project results.
- Establishing ongoing communication (e.g., conference calls or meetings) among the Ecology-WMS staff is useful for setting clear project objectives and sharing lessons learned during the pilot project period as well as during the transition to more streamlined projects.

Lean and Environment Integration Strategy and Tools

- The high-level integration of environmental issues as "process waste" in the Lean 101 training and value stream maps worked well, particularly when the level of detail of environmental data was similar to that used for lean metrics (e.g., as in the Columbia Paint pilot project).
- The lean and environment value stream maps were helpful in enabling project teams to see environmental wastes and causal factors. Value stream maps offer a more effective, systematic view of the facility's activities while P2 process maps identify additional waste sources and improvement opportunities that are not typically included in value stream maps.
- It is important to remain flexible with projects, recognizing that every client is different and there is no set way to do things. Important aspects of flexibility include:
  - Adjusting the schedule, sequence, and/or scope of kaizen events as conditions change during the project.
  - Switching tools or techniques (e.g., the Lasco project team used a six sigma and design-of-experiment approach in one event).
  - Focusing some kaizen events on the facility's largest areas of "pain," while targeting other events on processes that could have a higher impact on environmental performance.

Roles and Relationships

- It was useful for Ecology and WMS staff to define each person's role in the project before approaching candidate facilities in order to present a united front. In one pilot project, participants developed a charter to set roles for the facility, WMS, and Ecology.
- Support from senior management and the involvement of a cross-functional group of staff are critical to the success of a project.
  - Management involvement speeds-up decision making, while lack thereof can stall projects.
  - Involving cross-functional facility staff facilitates broad organizational diffusion of lean and environment and lends new perspectives to a team.
  - Consider including informal as well as formal leaders from the facility in lean events.
- Ecology's level of participation should vary by event or project, depending on the need for environmental expertise, since too much participation can undermine facility ownership during lean

events, particularly if Ecology staff facilitate small group work (when these roles would otherwise have been assumed by facility personnel).

- While there is some value for Ecology participating in non-environmentally focused events, Ecology staff can offer the greatest service in events that address environmental issues.

Measurement and Reporting

- It is important to respect the client's agenda and to work from a result-oriented view. The long-term ramifications for companies should be considered when measuring the impacts of the project (e.g., reductions in overtime labor).
- While it may be appropriate to identify "soft" costs and savings (benefits), it may not be necessary or useful to push for a detailed calculation of these benefits. Doing so can take significant effort and potentially undermine the credibility and the facility's ownership of the results.
- It may be useful to develop guidance and/or additional tools related to measuring lean and environmental results, including (a) calculating cost savings, (b) measuring different types of wastes, and (c) addressing common errors. For example, a metric for measuring material efficiency could be developed similar to lean metrics such as the ratio of value added time to non-value added time.
    - It is important to consider how much data is really needed, why, and for whom. It may be better to focus on tools that will meet customer needs, rather than the reporting needs of Ecology or WMS.
- The report-out presentations and debrief sessions involving the facility, Ecology, WMS, and Ecology's contractors (Ross & Associates and PPRC) on the final day of events were helpful for:
    - Gaining a common understanding of project activities and results.
    - Sharing suggestions and feedback for future lean and environment activities.
    - Celebrating the accomplishments of project teams.

Collectively, the three pilot projects demonstrated the usefulness of combining lean and environmental technical assistance, while offering insights into adjustments needed to develop and improve upon a long-term program model.

IV. Recommendations

The Washington Lean and Environment Project has numerous potential implications for future lean and environment efforts of Ecology and WMS, as well as for other organizations seeking to combine lean and environmental improvement approaches. Accordingly, lean service providers, environmental agencies, and P2 technical assistance providers may wish to consider the following recommendations.

Recommendation 1: Expand and improve lean and environment service delivery through additional demonstration projects.

The project confirmed the value of combining lean and pollution prevention technical assistance, while highlighting adjustments that will be useful to future lean and environment engagements with facilities. Additional demonstration projects would allow WMS and Ecology to refine their service delivery techniques (e.g., reaching new audiences and potential clients, reducing the level of investment of public resources in each project). These demonstration projects would serve a vital role in testing potential components and features of long-term model of joint Ecology-WMS service delivery. Furthermore, they

would help make lean and environment efforts mainstream at each organization (also see recommendation 3). In the short-term, grant funding can support demonstration projects; however, in the long term, joint services should be marketed at their full value. Potential objectives for future projects include:

- Build a critical mass of "success stories" from lean and environment demonstration projects.
- Explore and strengthen lean and environment integration techniques.
- Develop and test streamlined models for joint lean and environment technical assistance delivery (e.g., be strategic with regard to the participation of Ecology staff in lean events, standardize and streamline the types of data collected in projects, etc.).
- Define better and market value-added services provided by Ecology (or other environmental agencies) in the context of lean, and address the misperception that "free" services are substandard.
- Increase awareness and involvement of staff at Ecology and WMS in lean and environment efforts.
- Involve other Ecology media programs (e.g., water quality, air quality, and solid waste) in the demonstration projects.
- Diversify the industry participation in the lean and environment projects (e.g., work with both large and small facilities).

Recommendation 2: Continue lean and environment innovation efforts.

Along with additional demonstration projects, it would be worthwhile for Ecology, WMS, and other lean and P2 organizations to expand the lean and environment innovation efforts of this project. The three pilot projects show a range of strategies and techniques for lean and P2 integration. There are opportunities to experiment with new methods, apply lean and environmental methods to new issues, reach new audiences, and develop new tools. Specific areas in which additional innovation may be helpful include:

- Explore projects more focused on addressing sources of environmental "pain" (substantial costs and/or business risks) and regulatory friction areas (e.g., companies facing potential additional regulatory compliance obligations).
- Develop additional guidance and tools for other technical assistance agencies seeking to integrate lean and environment (e.g., develop a model program guide as a complement to EPA's *The Lean and Environment Toolkit*).
- Incorporate environmental considerations and tools into lean product and process design methods (e.g., as in Ecology and WMS' work on lean and environment design projects).
- Link lean and environment efforts to other environmental and business improvement efforts in the state and region (e.g., climate change action plans, Puget Sound and Spokane River restoration efforts, etc.).
- Use industry's energy reduction efforts to highlight the opportunities and synergies around lean and energy reduction. EPA's *Lean and Energy Toolkit* offers suggestions for integrating these two initiatives.

The Next Frontier: Lean and Green Design

One promising innovation area is lean and environmental product and process design:

- Green design concepts (such as Design for Environment, Design for Disassembly and Recovery, and Cradle to Cradle) could be a natural extension of lean design methods (such as 3P, Design for Manufacturing and Assembly, and Quality Function Deployment).
- Ultimately, the goal is to encourage both better manufacturing (how we make things) and smarter manufacturing (what we make).
- Lean manufacturing practices, supplemented by P2 concepts, can be used for both aims.

- Explore new ways to apply lean to environmental agency processes, including Ecology's pollution prevention work, to provide better service to clients.

Recommendation 3: Provide continued support for Ecology-WMS partnership and future lean and environment innovation activities.

Additional financial and staff resources will be needed to support continued lean and environment innovation as well as develop a long-term model for joint Ecology and WMS service delivery. Furthermore, staff training and capacity building efforts should continue. A concerted, sustained effort will be needed to move lean and environment service delivery from the pilot stage to the point of mainstream implementation and integration into the routine operations of Ecology and WMS.[8] The partners recognize the value of working jointly together, and have started to outline a framework for continued interactions.

To sustain momentum, build upon individual relationships forged through initial pilot projects, and develop the lean and environment service area, it will be important for Ecology and WMS to jointly engage in additional lean and environment implementation efforts and associated outreach. Some of these efforts have begun, as described in the Concurrent Partnership Activities section above; however, Ecology and WMS could potentially engage in much more lean and environment activity. It may be helpful to seek continued support from EPA and NIST, and to reach out to other entities—such as the State legislature and the Association of Washington Businesses—to support the next phase of innovation and diffusion.

Recommendation 4: Develop and implement a coordinated strategy for lean and environment activities in Washington.

There are a wide range of opportunities for additional lean and environment activities in Washington. Because resources will likely be limited, it will be important to think about an overall vision and strategy for lean and environment efforts in Washington, and then to use that strategy to define short-term and long-term priorities. Although a lengthy strategic plan is not needed, it could be beneficial for Ecology and WMS to work with EPA, PPRC, and other potential partners to agree on the central components of a statewide lean and environment strategy. Additionally, it will be helpful to clarify the roles that each organization would have in advancing that strategy and to develop an action plan for implementing the highest priority activities over the next few years. This strategy-development process has begun, but additional work and follow through is needed.

Key components of a lean and environment strategy include:

- A long-term vision for lean and environment in Washington.
- Clear roles for each partner organization in advancing the vision.
- Annual objectives with performance measures for each partner organization.
- Shared priorities for lean and environment projects and services.
- Coordinated and strategic marketing, outreach, and partnership development efforts.
- Sufficient support infrastructure, including staff and financial resources, training, and streamlined coordination and communication mechanisms.

[8] Research shows that there are several steps involved in the transition of an innovation from project conception to the adoption, adaptation, and incorporation of the new practice into an organization's routine operations [Everett M. Rogers, *Diffusion of Innovations,* Fourth Edition, (New York: The Free Press, 1995)].

A successful strategy will be aligned with each organization's objectives, useful for prioritizing resource investments, and be focused, actionable, and measurable.

Recommendation 5: Extend lean and environment efforts beyond Washington.

Recommendations for Other State Pollution Prevention Programs and Lean Providers

1. **Keep an eye on the prize:** The potential for mutual gain from lean and P2 partnerships is significant. Focus on how integration of lean and environment benefits the client facility.
2. **Navigate differences:** Be conscious of and strategize for potential friction between "government culture" and "manufacturing culture."
3. **Measure what's important:** Find a balance between metrics that serve the government versus metrics that serve the client.
4. **Just do it!** Lean and environment integration is best learned by *doing*. Find ways to conduct a small project even if little or no grant funding is available.
5. **Establish relationships:** Create partnerships and teams that work well together. Once trust has been established and value demonstrated, the relationships will generate their own momentum.

Environmental agencies, manufacturing assistance organizations, and independent pollution prevention assistance providers and independent lean providers, can learn from and adapt strategies and techniques pioneered in this project as well as those identified in national lean and environment efforts (such as EPA's Lean and Environment Initiative and the EPA and NIST MEP supported Green Suppliers Network). Combining lean and environmental technical assistance services can provide greater value and results for client facilities, as well as enhance the effectiveness of both environmental agencies and lean service providers. EPA, NIST and its MEP network, and national or regional P2 agencies (e.g., the National Pollution Prevention Roundtable and regional P2 assistance centers in the Pollution Prevention Resource Exchange [P2Rx] network[9]) could play an important role in supporting outreach about the Washington Lean and Environment Project and the transfer of knowledge to organizations outside Washington. Efforts in other states could capitalize on lessons learned from the Washington Project (see textbox), as well as adapt the service delivery approach based on specific technical assistance agencies involved and challenges facing local manufacturers.

In conclusion, the Washington Lean and Environment Project represented a successful collaboration of two technical assistance organizations that effectively worked together to improve the operational and environmental performance of Washington facilities. Furthermore, the partnership also built the capacity and initiative at those facilities for additional performance gains. Future efforts to innovate with lean and environment service delivery should continue to enhance the effectiveness of lean and P2 assistance providers and enable businesses to be more competitive and environmentally sustainable.

[9] P2Rx is a national network of regional information centers and resources on pollution prevention including breaking news, research and publications, and regional and national networking opportunities.

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