Final Report

Creation of an Industry Best Management Practice for Adoption of a Closed Chain of Custody for Herbicide Use in the Utility Vegetation Management Industry

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Executive Summary

A detailed study of the potential for adoption of practices intended to improve supply chain logistics related to herbicide use in the Utility Vegetation Management (UVM) industry was conducted. It includes an analysis of the financial implications of adopting "closed chain of custody" Best Management Practices (BMP).

The UVM industry makes extensive use of herbicides. The Utility Arborist Association (UAA) has previously published a BMP defining fieldwork practices consistent with Integrated Vegetation Management (IVM). However, limited attention has been focused on the logistical aspects of shipping, storing, mixing and handling herbicides, as well as management of the waste stream, including rinsates and empty containers.

The UVM industry has traditionally purchased herbicides in concentrated form, supplied in disposable one-way containers, to prepare mixes on job sites. The central strategy of this best practice proposal is to adopt the use of custom blends supplied in returnable recyclable closed supply containers. There are sound operational reasons for converting to this new BMP methodology. Financial analysis demonstrated that there is also a financial incentive to adopt the new BMP.

This report describes the process used by the UAA in establishing the new BMP. The project involved six steps. The first three tasks were investigative in nature and included an Internet-based survey of UAA members, process benchmarking case studies of five early adopters, and detailed financial analysis. The fourth task involved a collaborative process to develop a set of best practices. The final two tasks as originally proposed included supporting implementation and communicating the new BMP to the utility industry. These tasks have not yet been funded. They are recommended as essential steps to facilitate adoption of the new BMP across the UVM industry.

The new BMP defines an end-to-end strategy for managing the herbicide chain of custody from manufacturer to custom blender, distributor, utility owner, and applicator.

Financial analysis was conducted at the industry-wide level and considered four discrete application types:

1. The use of ready-to-use formulations in Low Volume Basal applications.
2. The use of dilute concentrate blends in Low Volume Foliar applications.
3. The use of dilute concentrate blends in Hydraulic (High) Volume Foliar applications.
4. The use of dilute concentrate blends in Aerial applications.

Four discrete element of the “Closed Chain of Custody” concept were evaluated:

1. The use of returnable reusable (RR) supply containers.
2. The use of a closed system interlock on RR containers and application equipment.
3. The use of improved means of tracking supply containers.
4. The use of custom blends containing the required active ingredient and adjuvants.

While the project found that the new BMP can be adopted at no premium cost to the industry, costs and benefits will vary for individual stakeholders. Anecdotal evidence of the benefits of many of the practices within the BMP were identified in discussion with stakeholder groups; e.g. crew personnel that had used custom blends in reusable closed containers were reluctant to return to the use of open one-way containers, and applicators that had incorporated the practices in their operations brought them to work on other utility systems.

Finally, the new BMP will reduce the risks of mixing errors, spills, and applicator exposure. Adoption of the new BMP is also a demonstration of environmental stewardship.

Introduction

The Utility Vegetation Management (UVM) industry makes extensive use of herbicide applications in maintaining vegetation on utility rights-of-way (ROW). Herbicides are used to maintain utility ROW free of tall growing trees that pose a threat to the reliability of energy delivery systems, and to preserve access. Applications of both water-based foliar and oil-based basal stem applications are common practice. Advances in chemistry and applications methods have significantly reduced the volume of mixed herbicide solution applied. Considerable progress has been made in developing application methods and formulations that mitigate potentially adverse environmental impacts of UVM practices. These advances are addressed in a Best Management Practice (BMP) reference related to Integrated Vegetation Management that was published by the Utility Arborist Association (UAA) in 2007.

Conventional practice has typically involved the use of concentrated herbicides provided in non-returnable containers. This requires handling open containers of concentrate on job sites, as herbicides are measured and mixed in spray tanks. Advances in application techniques and formulations have made it practical for the UVM industry to consider the adoption of ready-to-use and dilute concentrates provided in closed delivery systems. Advances in information technology have created an opportunity for increasing prescriptive applications and improving recordkeeping.

History

The use of closed, reusable containers in the UVM industry can be traced back to the pioneering efforts of West Penn Power (now a part of Allegheny Power) and its service providers in the mid-1990's. The concept was initially developed as a means of improving inventory management. Applicators subsequently recognized the potential for productivity gains.

The concept has since gone through considerable refinement, and has become established in vegetation management programs at some leading utilities. It has also been adopted by several innovative applicators. However, it has been slow to be adopted across the broader UVM industry. Reasons for this include perceptions of increased cost, complexity, general inertia, and reluctance to change.

Early adopters faced a number of challenges in developing the current system, which is centered on the use of custom blends provided in returnable refillable closed supply containers. The litany of problems encountered and resolved includes:

- The inability to draw down the container, sometimes leaving more than a gallon of custom blend in the "empty" closed container. This was due to internal sumps that either leaked or were too short. This problem has been addressed by

making improvements to the sump tubes and the inclusion of a basin-like sump in the container bottom
  - The instability of some initial custom blends. Improvements in product chemistry, emulsifiers, and diluents have largely resolved this problem.
  - Cracks and leaks in returnable refillable closed supply containers. This problem was addressed by improvements in container design specifications and assembly.
  - Ergonomic challenges. Earlier versions of returnable refillable closed supply containers in the 15-gallon size (± 150lbs), which is commonly used, did not include any handles. They now do.
  - Some active ingredients were known to crystallize and compromise seals and pumps. This issue has largely been resolved by making changes in gasket materials, in the types of valves and transfer pumps used, and in work practices.
  - Premium product pricing. Initially the pricing for bulk products supplied in custom blends was higher than that for products supplied as package goods in one-way disposable containers. The market has adjusted such that bulk pricing (and as such custom blends) is more cost-competitive than with package goods.

Evolution of closed systems in the UVM industry continues. It has become common practice at some utilities and with some applicators. UAA first formally recognized the potential of closed systems and the use of returnable reusable containers in early 2009, and applied for an EPA PRIA2 grant. While the grant proposal was not funded, it elevated a sense of opportunity. Conceptual discussions were held with Dow AgroSciences (DAS) during UAA's Annual Meeting. Subsequently a Memorandum of Understanding between UAA and DAS was executed and UAA received project funding in the form of a directed grant. DAS provided a leading contribution sufficient to fund a basic project. Additional funding will be required to support implementation of the new BMP.

UAA undertook this project in an effort to establish a proactive strategy for incorporating regulatory trends into the art and practice of UVM. The following regulatory developments were considered in developing this BMP:

- 2006 – New container regulations and guidance on custom blend formulations.
- 2007 – New labeling requirements including more specific references to appropriate container disposal.
- 2009 – Proposed recycling initiative, which is currently tabled.
- 2011 – Proposed new regulations related to use of reusable containers.

Purpose of the Project

The purpose of the project was to conduct a thorough evaluation of the benefits and cost of an end-to-end strategy for managing the chain of custody of herbicides from herbicide producer to distributor, custom blender, applicator and utility. The project included both general and specific assessments of current practices and detailed financial analyses. Once the concept of a “Closed Chain of Custody” was shown to be economically feasible, the project then focused on establishing practices consistent with the use of returnable, reusable closed supply containers.

UAA’s Motivation

This project demonstrates UAA’s proactive leadership in advance of new regulations regarding the use of returnable reusable containers. It is also consistent with contemporary thinking regarding the management of quality by designing the potential for errors out of, and quality into, UVM processes. Clearly a closed system reduces the worker and public exposure to concentrated herbicides, and is an opportunity to demonstrate a commitment to environmental stewardship.

The Concept of a “Closed Chain of Custody”

The concept of a “Closed Chain of Custody” as used in this project is focused on the end-to-end supply chain, and includes the logistical aspects of herbicide shipping, distribution, storage and mixing. The chain extends to management of the waste stream, including rinsates and empty containers.

There are four important elements to the “Closed Chain of Custody” as defined in this project:

1. The use of returnable reusable (RR) supply containers
2. The use of a closed system interlock on RR containers and application equipment
3. The use of an improved means of tracking supply containers
4. The use of custom blends containing the required active ingredient and adjuvants

Project Team

UAA retained the services of BioCompliance Consulting, Inc., to complete the project. John W. Goodfellow was principal investigator. BioCompliance retained the services of Arkan Kayihan to support development of the financial models that were used to assess the costs and benefits associated with the new BMP.

Method

Development of the new BMP as initially proposed involved six steps. The first three tasks were investigative in nature and included:

1. An Internet-based survey of UAA members
2. Process benchmarking studies of five early adopters
3. Detailed financial analysis

The fourth task involved a collaborative process to develop a set of best practices. This task drew upon the first three tasks in developing a first draft of potential best practices. The draft BMP was validated using Delphi Analysis techniques. This involved an initial review by the UAA Oversight Committee and other subject matter experts. The draft BMP was revised and circulated for review by a larger group of practitioners, and a final revised draft BMP was produced.

The final two project tasks envisioned for the project include implementation and communicating the new BMP to the utility industry. These last two tasks deal with delivery and full adoption of the new BMP into common use in the UVM industry. These two were not funded and have yet to be completed.

Survey of UAA Membership

The first task involved conducting a survey of UVM industry stakeholders. This was accomplished by conducting an Internet-based survey of UAA member. The survey was conducted in October 2009, and achieved a response rate of approximately 7%. The survey respondents from each important stakeholder group with standing on the new BMP were represented, as can be seen in Figure 1.

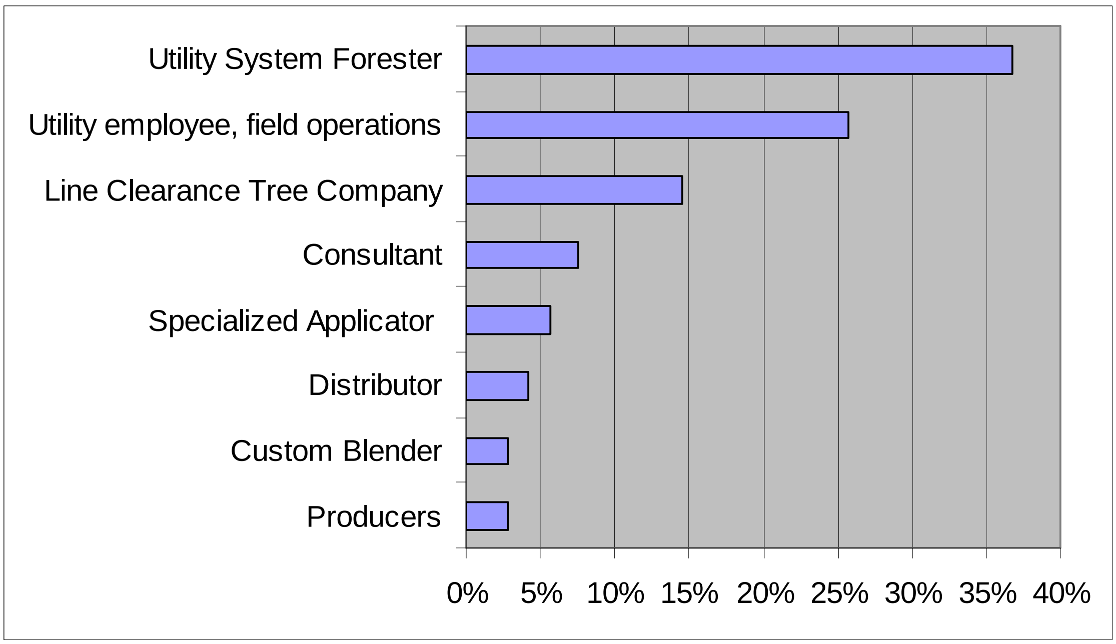

Figure 1. Stakeholder groups responding to survey of UAA members. Note the strong participation by utility employees, particularly System Foresters, who are key decision makers.

The survey focused on determining current practices, experience, and perceptions within the industry as related to herbicide handling and supply chain logistics.

Slightly more than half (55%) of respondents indicate that they were using some form of returnable reusable closed containers in their operations, with 15 gallons being the most common size of RR container. The most common size of one-way disposable container cited was 2.5 gallons.

Only a third (32%) of survey respondents indicated that they were currently using any form of container tracking system. However, the use of an automated tracking system for applications (40%) and purchases (44%) was more common. In contrast, as can be seen in Figure 2, respondents recognized the potential value in having better access to tracking information and documentation.

NOTE: An ordinal scale of five rankings was used to score perception:

- High Value
- Medium Value
- Low Value
- No Value
- Negative Value

The results reported in Figure 2, Figure 3, and Figure 5 are intended to focus on the perception of strong positive and negative perceptions, and intentionally exclude “Low” and “No” value ratings.

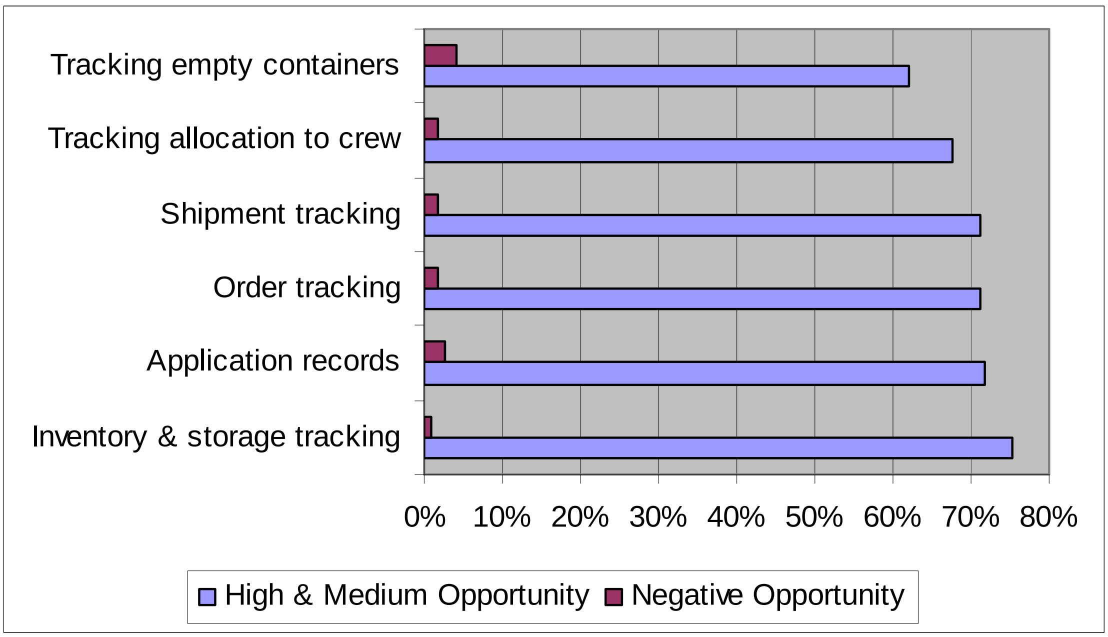

Figure 2. Perceived value of documentation at steps along the supply chain.

Respondents to the survey were also asked their perception of value of requiring closed connections at various transfer points along the supply chain (Figure 3). The expected value of a closed connection was thought to be highest for a closed valve on the supply container, and diminishes as the transfer points get closer to the application equipment. The stronger negative sentiment should also be noted.

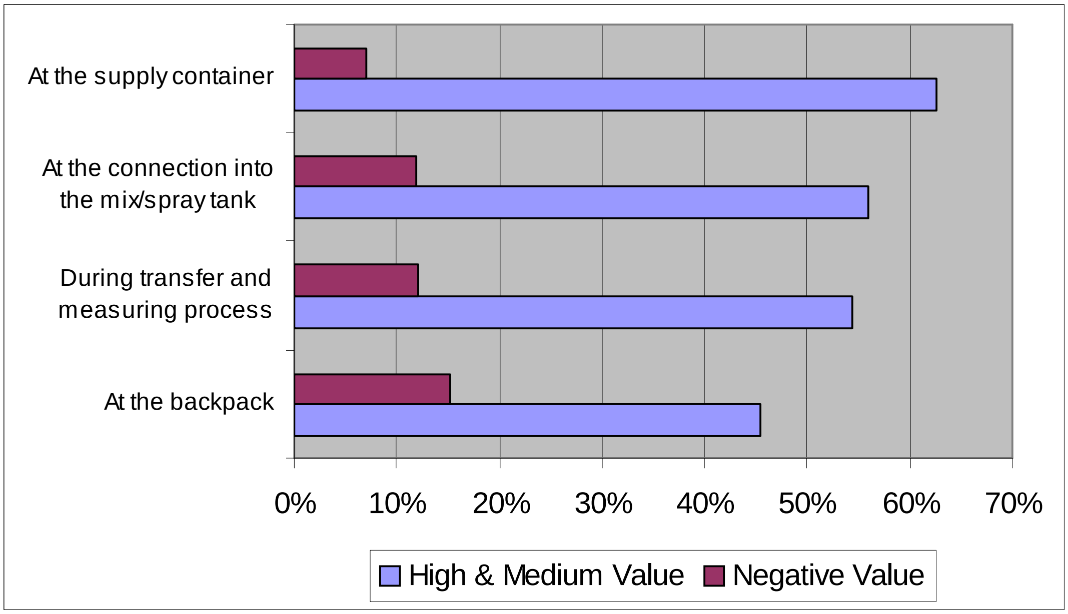

Figure 3. Perceived value of closed connections at transfer points.

The survey respondents were asked to rank their perception of the effectiveness of a closed chain of custody system in avoiding a variety of potential errors. This can be thought of as a question related to avoided cost. The results are presented in Figure 4 below. The greatest opportunities involve a reduction in risk due to the use of returnable reusable containers and closed interconnections. Survey respondents saw less opportunity to reduce risk of tracking- and documentation-related errors.

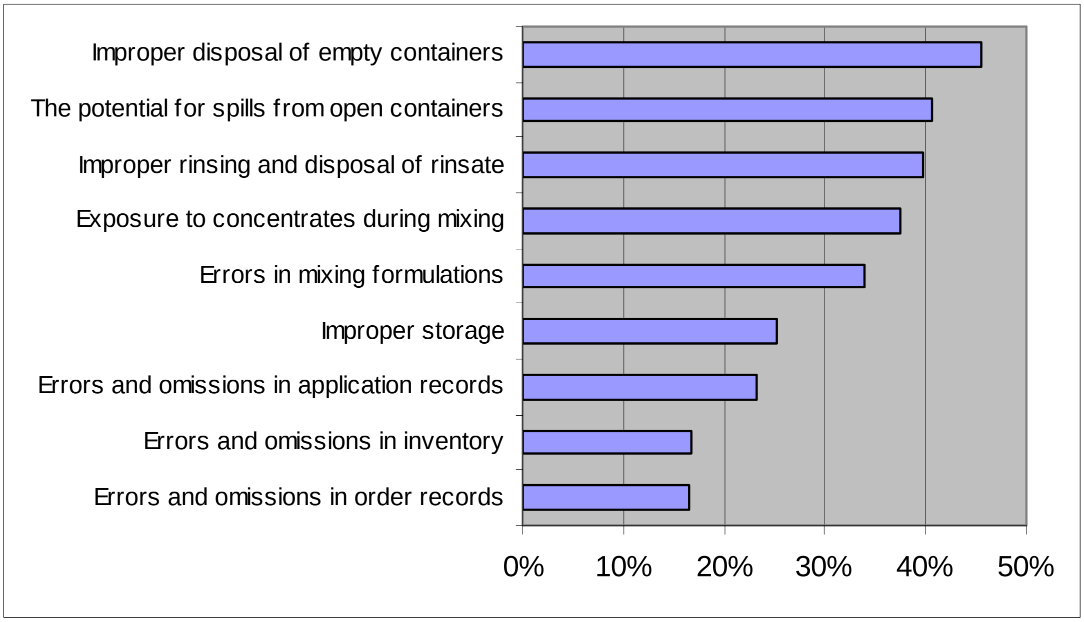

Figure 4. Perceived opportunity to reduce risk (avoided cost) due to avoidable errors. Data reported are percentage of respondents that ranked the issue as "High" value in avoiding adverse occurrences.

Survey respondents were also asked to rank their perception of the benefits of adopting a closed chain of custody. These results are presented in Figure 5. Many of what are often referred to as "soft benefits" such as safety, environmental stewardship, and quality scored higher than direct benefits such as cost accounting and productivity. It is also worth noting that there was very little negative "pushback".

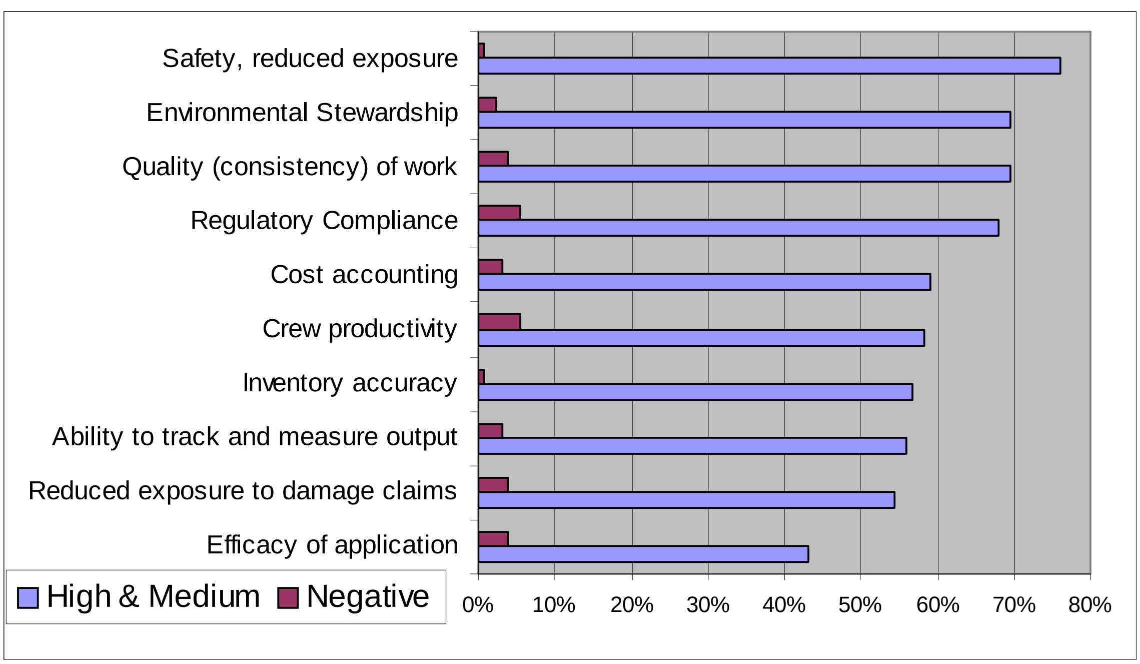

Figure 5. Perceived opportunity for improvements (benefits).

Finding from the Internet survey established a baseline of the “as is” situation. It also identified areas of interest and challenge. Results from the survey were used to guide the design of the project.

Process Benchmarking

The second project task was to conduct process-benchmarking studies of some existing operations that were successfully using variants of the “closed chain of custody” process in their vegetation management operations.   A search was conducted and ten potential case studies were identified. The pool of potential candidates was screened and a five were chosen for detailed study including vegetation management programs at Allegheny Power, Duke Energy, Duquesne Light Company, Northeastern Rural Services, and Oklahoma Gas and Electric. These five case studies represent regional and industry variations such as differences between large and small UVM programs at investor-owned and public sector utilities (Table 1).

Table 1. Stakeholders that participated in process benchmarking studies.

Utility	Applicator(s)	Custom Blender	Distributor
Allegheny Power	Asplundh Tree	ArborChem	ArborChem
Duke Energy	SE Woodlands Superior Forestry	Aqumix	CWC Chemical
Duquesne Light Company	Asplundh Tree Hazlet Tree Lewis Tree Nelson Tree	ArborChem Aqumix	ArborChem, CWC Chemical
Northeastern Rural Electric Cooperative	Northeastern Rural Services	Aqumix	Red River Specialties
Oklahoma Gas and Electric	Townsend Tree Service	Eco-Pak, LLC	Townsend Chemical Division

The purpose and focus of each study was to understand and define the end-to-end process at each site, from producer to distributor, custom blender, applicator, applications on the utility ROW, to the back haul of empty returnable reusable containers. The work included interviewing key stakeholders in the process including distributors, custom blender, applicator, and utility personnel. One-on-one interviews were conducted during site visits in January 2009, and involved the use of a structured series of detailed questions.

Process Environment

The process begins with the producer of herbicides used in UVM, and concludes with the herbicide application and the fate of supply containers. There are three important attributes of the process environment that need to be considered.

Business Environment

A commercial relationship exists between the process stakeholders. The utility is the asset owner and in most cases the asset manager, the asset being the ROW that requires maintenance. The utility provides the financial input to the process that sets the process in motion. Transactions between all other stakeholders make use of this initial investment as products are purchased, distributed, blended and applied.

Utilities commonly contract with applicators to provide UVM services involving the use of herbicides. There are two general types of applicators in the UVM market. Traditional line clearance tree removal and pruning companies often provide herbicide application services to their utility clients as part of a comprehensive UVM offering. Typically this group of applicators can draw on existing tree crew personnel in staffing spray crews, and their crews tend to be made up of fewer workers (2-3/crew). The other group can be thought of as specialized applicators whose primary business focus is the application of herbicide. The specialized applicators typically provide services to the UVM and forest industries, and often field crews composed of more workers (5-10/crew).

There are currently a limited number of producers of herbicides serving the UVM market. There are many distributors selling herbicides to the UVM industry. The majority of sales are made to applicators. However in a limited number of cases, utilities buy herbicides and provide them to applicators.

There currently are three dominant providers of custom blends, two of which offer services to the full UVM market. The third significant custom blender operates as a business unit within a large UVM contractor and provides captive intra-company services to business units engaged in herbicide applications. The capital cost to establish a registered custom blend facility and fleets of RR Closed Supply Containers is a barrier to entry by other potential service providers.

Regulatory Environment

The UVM program operates in a regulated business environment, and is subject to federal and state statutes related to cost, reliability, and environmental responsibility. Owner-operators of the bulk transmission system (a.k.a. “the Grid”) are subject to reliability-related UVM requirements established by FERC/NERC FAC-003. EPA is responsible for regulating herbicides at the federal level.

UVM operations are also subject to state-level regulatory requirements. Most notably, utilities are quasi-monopolies regulated by state regulatory commissions. The primary focus of these regulators is the management of costs as they relate to utility rates, and levels of service. Some state commissions have extended their reach into UVM operations. States are also mandated to regulate herbicides within their jurisdiction.

Physical Environment

UVM operations by their very nature are geographically dispersed. Application crews are highly mobile and typically operate from remote locations for significant periods of time. This is not a "bricks and mortar" business. Application crews often report to work at the job site rather than to a central office.

Process Flow for Herbicide Use in UVM

Findings from each of the five process benchmarking studies were evaluated and used in developing a process flow diagram. Both a traditional and a Closed Chain of Custody-like variant were identified in each benchmarking case study. This is a demonstration of the continuing need for some herbicides being supplied as "package goods" in one-way disposable containers.

There were similarities in the basic use of Custom Blends in RR Closed Supply Containers between benchmarking study partners. This made it relatively easy to produce a common Closed Chain of Custody process. Figure 6 is a visual depiction of both the traditional and Closed Chain of Custody processes in one diagram. The traditional process, based on one-way disposable containers, is depicted largely on the left side of the figure. The right side of the figure includes the use of Custom Blends in R/R Closed Supply Containers. There are obvious differences in the two approaches, most notably in the lower portion of Figure 6. The traditional approach is linear and terminates at the lower left, whereas the Closed Chain of Custody process cycles back as containers return to the Custom Blender for refilling.

It is equally important to identify what is not depicted in Figure 6. There are two important aspects of the process related to herbicide use in the UVM industry. The first is the physical process describing the logistical steps involved in moving herbicides from producer to applicator, their use, and in the case of the proposed BMP, the return of empty R/R Closed Supply Containers. Figure 6 is a reasonably accurate depiction of many of the important physical steps in this process. What is missing in this depiction of the physical process is the management of inventory from the time the applicator receives a shipment to when it is assigned to a crew and used on a job.

The second aspect of the process related to herbicide use in UVM can be described as the accounting process. This describes ownership responsibilities for the herbicides from the time they are produced through to application. For example, while quantities of concentrated products are stored in bulk tanks at the custom blender's site, the producer of the herbicide typically owns this inventory.

The process benchmarking studies were an opportunity to gather data on work practices, application methods and formulations, equipment, and cost structures. These data were used in designing the financial model and in developing potential practices that were being considered for inclusion in the new BMP.

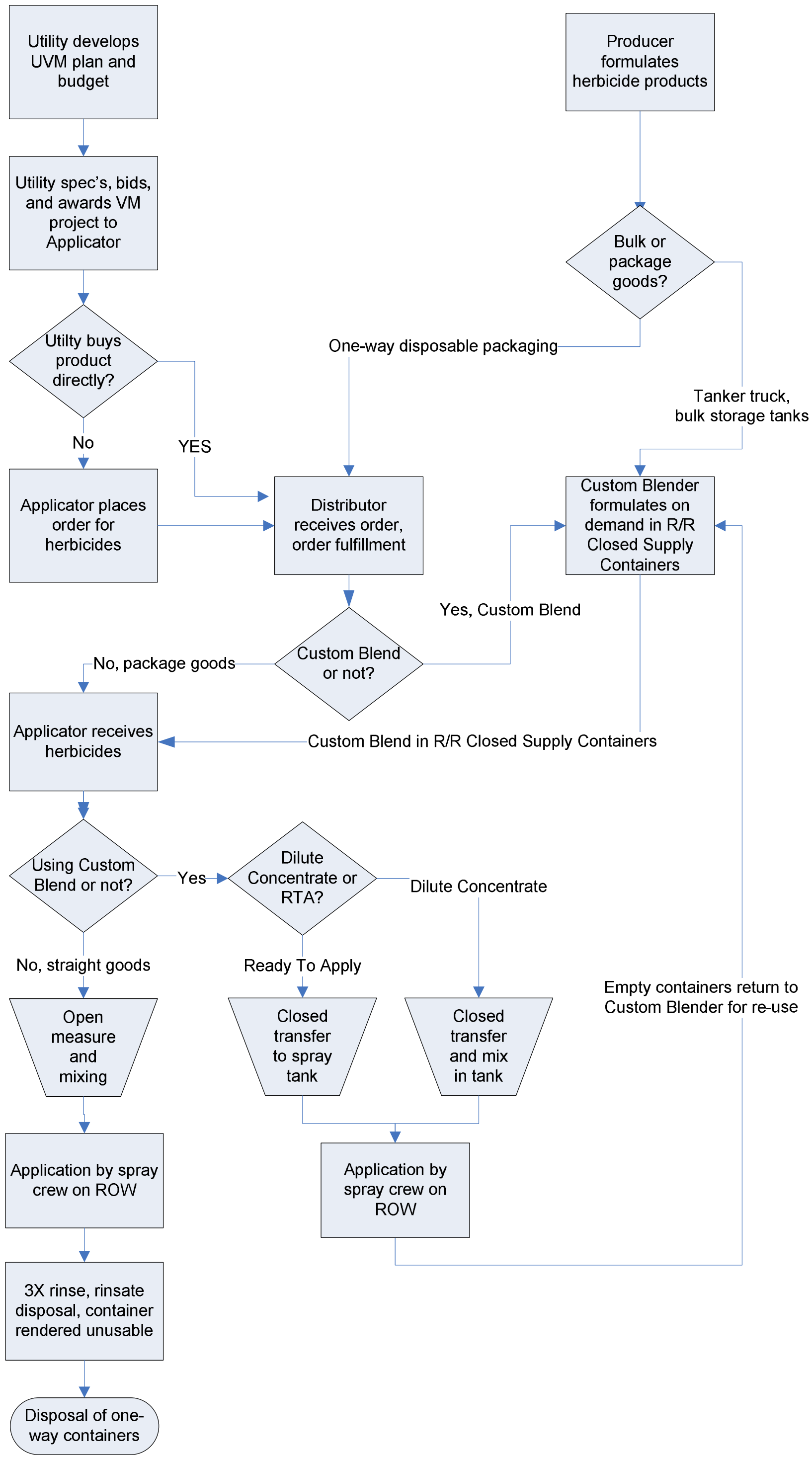

Figure 6. Process flow diagram depicting both the traditional use of package goods in one-way disposable containers and custom blends in RR closed supply containers.

Financial Analysis

Although there are several good operational reasons for adopting the new BMP, a significant change in practice requires solid financial justification if it is to be embraced by the UVM industry. The purpose of the financial analysis task was to determine the financial implication for the UVM industry in adopting the proposed BMP. This section of the report describes the approach taken to financial analysis, the methodology, and results behind the model.

Approach

Financial analysis of the economic implications of implementing the new BMP can be broken down into four elements:

1. The use of RR supply containers.
2. The use of closed system interlocks on RR containers and application equipment.
3. The use of an improved means of tracking supply containers.
4. The use of custom blends containing the required active ingredient and adjuvants.

The economics for each initiative are examined and calculated, when appropriate, for the aggregate of all stakeholders (Utilities, Distributors, Customer Blenders and Applicators) into a supply chain-wide five year Net Present Value (NPV). The key reference metric is the cost differential of a mixed ready-to-apply gallon in a spray tank. This calculation is made by comparing the traditional use of “package goods” in open one-way containers to the corresponding element in the BMP.

The economic drivers include hard and soft benefits and costs. Even if values for the drivers are not available, or, more frequently, not applicable or relevant to the scale of costs/benefits being examined, they are still included in the equations for documentation purposes. These full equations are translated into one-time and yearly costs and benefits to calculate a five-year NPV per applied gallon of herbicide for each of the three initiatives.

Economic Models and Variables

Data used in the financial analyses are based on the results from an Internet survey of UAA membership and interviews with producers, distributors, customer blenders, applicators and utility owners. The analysis was run for each of four application types based on herbicide formulations and rates that are representative of UVM industry practice.

1. The use of ready-to-use (R2U) formulations in Low Volume Basal applications.
2. The use of dilute concentrate blends in Low Volume Foliar applications.
3. The use of dilute concentrate blends in Hydraulic (High) Volume Foliar applications.
4. The use of dilute concentrate blends in Aerial applications.

The herbicide formulations used in this analysis are presented in Appendix C.

There are several variables and assumptions used in this economic analysis. A concerted effort was made to be conservative so as not to inflate benefits from migrating to a BMP. Three important study factors are:

- Yearly cost of capital is 9%
- Average R/R container lifecycle is 5 years or 30 turns
- 15 gal R/R and 2.5 gal disposable container sizes

The cost of capital is an average taken from various asset owners, distributors and customer blenders. The average container lifecycle was based on interviews with customer blenders. These first two factors, cost of capital and container lifespan, are critical in determining the appropriate NPV horizon and discount factor. The container sizes are based on the survey results for the most common sizes used in the industry. Other assumptions are discussed in detail in the corresponding initiative sections and in the relevant appendices.

Economics of using Dilute Concentrates in Reusable Returnable Supply Containers

There are no incremental revenue streams created by a change from disposable (D) containers to RR containers, so the benefit comes from reducing costs. The potential RR container benefit equation takes the following form:

Potential RR Container benefit = $- Cost_{RR} + Cost_{D}$

The comparison between RR and D is normalized by examining usage and active ingredient equivalence. For example, it takes multiple 2.5 gallon disposable containers to match the active ingredients in a 15 gallon RR container. This equivalent active ingredient ratio is application dependent and is taken into consideration. As a RR container can be used about 30 times over its lifespan, we calculated the equivalent number of disposable containers to match the active ingredient value over 30 RR turns.

The core economic drivers behind the costs of $Cost_{RR}$ and $Cost_{D}$ include the following:

- The cost of the containers
- The cost of outbound shipping, and in the case of returnable containers, the return shipping cost
- The cost of handling concentrates and custom blend on-site
- Cost of processing and ultimately disposing of containers at end of life.

$Cost_{RR}$ is broken down explicitly as follows:

$$Cost_{RR} = a + (b + c) + d*a + \lambda 1\,(e + f + g) - \Omega$$

where:

a = RR container unit cost
b = end-of-life RR container processing cost

$$= \frac{\text{blender wage (\$)}}{\text{hour}} * \frac{\text{processing time (min)}}{\text{RR container}} / 60$$

c = end-of-life disposal cost of RR container
d = RR container damage/replacement rate (per year)
λ_1 = number of times the RR container can be used before end of life
e = outbound and return shipping cost

$$= \frac{\text{shipping cost}}{\text{gal}} * \frac{\text{gal}}{\text{RR container}}$$

f = on-site handling cost of custom blend in RR container

$$= \# \text{ crew} * \frac{\frac{\text{applied gal}}{\text{RR cont}}}{\frac{\text{applied gal}}{\text{tank}}} * \frac{\text{min (disp) / tank}}{\text{crew member}} * \frac{\text{applicator wage}}{\text{hr}} / 60$$

= 0 (for R2U formulations)

g = post-use blender container prep for refilling and reuse

$$= \frac{\text{blender wage (\$)}}{\text{hour}} * \frac{\text{processing time (min)}}{\text{RR container}} / 60$$

Ω = Green PR or Goodwill benefit

The values of each variable related to the use of RR containers can be found in the appendices.

In order to effectively compare RR to D containers, the active ingredient equivalence is calculated across the lifetime of one RR container. An equivalent factor is calculated for each application type using the following formula:

Active ingredient in one 15 gallon RR container = Active ingredient in **ω** 2.5 gallon D containers

$$\omega = \text{active ingredient ratio (\%)}_{\text{RR container}} * \frac{\frac{\text{gal}}{\text{RR container}}}{\frac{\text{gal}}{\text{disp container}}}$$

for example, the calculation for dilute concentrate used in volume foliar applications is

$$\omega = 78\% * \frac{15 \text{ gal}}{2.5 \text{ gal}} = 4.7$$

Therefore, it takes 4.7 D containers to match the effectiveness of one RR container of dilute concentrate for this application type[1]. Given the lifespan of a RR container, 141 D containers (30*4.7) would need to be processed and disposed of to match the equivalent active ingredient potency of one RR container being used thirty times. This is the basis of Cost_D, which is broken down explicitly as follows:

Cost_D = $\omega * \lambda_1 (i + j + k + l + m + n + o)$

where:

ω = equivalent disposable container ratio

[1] Custom blends in the form of Ready to Apply mixes would increase the equivalency to 6.

(to match the active ingredients of a RR container)

$$= \text{active ingredient ratio (\%)}_{\text{RR container}} * \frac{\frac{\text{gal}}{\text{RR container}}}{\frac{\text{gal}}{\text{disp container}}}$$

i = disposable container unit cost

j = disposable container outbound shipping cost

$$= \frac{\text{shipping cost}}{\text{gal}} * \frac{\text{gal}}{\text{disp container}} * 0.67 \text{ (no return cost factor)}$$

k = on-site mixing cost

$$= \# \text{ crew} * \frac{\frac{\text{applied gal}}{\text{disp cont}}}{\frac{\text{applied gal}}{\text{tank}}} * \frac{\text{min (RR) / tank}}{\text{crew member}} * \frac{\text{applicator wage}}{\text{hr}} / 60$$

$$= \# \text{ crew} * \frac{\left(\frac{\text{applied gal}}{\text{RR cont}} / \omega\right)}{\frac{\text{applied gal}}{\text{tank}}} * \frac{\text{min (RR) / tank}}{\text{crew member}} * \frac{\text{applicator wage}}{\text{hr}} / 60$$

= 0 (for R2U formulations)

l = post-use triple rinse

$$= \frac{\text{applicator wage (\$)}}{\text{hour}} * \frac{\text{processing time (min)}}{\text{disp container}} / 60$$

m = post-use rendering unusable = included in 'l'

n = disposal transport cost

o = disposal fee

Disposable containers require triple rinsing, an action to render them unusable, and disposal which increases the processing cost associated with each container. The effect of this increased labor effort plays a significant role in the overall NPV.

The values of each variable related to the use of disposable containers can be found in the appendices.

Economics of Using Closed Connections

The benefit of migrating to a closed system is the difference between the initial capital outlay and the potential realizable benefit from migration. Benefits are realized in the increased accuracy in completing herbicides transfers, a reduction in applicator exposure, and diminished risk of adverse regulatory and civil attention due to leaks and spills. The combination of all-inclusive dilute concentrates formulated for a specific applicator's use, and the use of closed interlocks allow for tighter control in transferring and diluting formulations to the correct concentration on-site. Greater accuracy results in a reduction of the risk of too low a level of active ingredient and the resulting need for rework. Too much active ingredient results in wasted concentrate, and the potential for applications that exceed the labeled rate. .

The common reference and unit of measure for this analysis is based on a spray rig. Application equipment is capable of using a certain amount of applied gallons per season. This depends of the type of application. To maintain consistency across all elements of the financial model, a five-year horizon was used with upgrade costs applied immediately. Upgrade costs include the cost of all closed interlock valves, seals, hoses and pumps required to retrofit a spray rig. Upgrade costs also include the cost of providing container closure, on an equivalent container uses per rig per year. For example, if a spray rig can apply 900 gal/yr, 56 15-gallon RR containers need to be fitted for a closed system. The assumption that all RR containers need to be upgraded, rather than a portion of them as they are cycled throughout the season, was a deliberate effort to be conservative in the calculation of benefits from this initiative. Another conservative assumption was made regarding the ability to capture all of the theoretical benefit. Instead of assuming the calculation was 100% accurate or could mitigate all liability, *the assumption was made that only 20% of the accuracy or litigation reduction benefits are captured.* These captured benefits were also spread out on an annual basis, based on applied gallon spread per year, over a five-year period.

In summary, the core economic drivers behind the closed system economics are the

- Cost of outfitting application equipment and RR supply containers
- Reduction in liability expense
- Reduction in the need to retreat due to an under-rate application
- Reduction in wasted herbicide

and the benefit is broken down explicitly as follows:

$$\text{Closed system benefit} = -[\alpha * A1 * (1-Ar_1) + (A2+A3)*(1-Ar_2)] - f*(A1 + A2 + A3) + a*(\sum Bj + C + D) - E$$

where units are in terms of \$ / rig, and:

α = RR containers / rig (per yr)

$$= \frac{\frac{\text{applied gal}}{\text{rig}}}{\frac{\text{applied gal}}{\text{RR container}}}$$

A = cost of the closed system

1 = Container interlock (valve + sump + assembly + seal + label)

2 = Rig setup (valve + installation)

3 = Rig setup (pumps)

Ar_1 = RR container CC rebate (provided by Producer of herbicide) (%)

Ar_2 = rig CC rebate (provided by Dow AgroSciences) (%)

f = yearly valve failure rate

a = estimated reduction in waste across B, C, D from using a closed system (%)

B = liability (per rig per year)

1 = applicator exposure (health)

2 = inspection/spills (regulatory)

3 = spills (civil and regulatory)

4 = claim defense costs

C = formulation accuracy quality too low (only for dilute concentrate)

$$= \frac{\text{inefficiency (\$)}}{\text{RR container}} = \text{conc. too light (\%)} * (\text{labor} + \text{concentrate})$$

$$= \text{conc. too light (\%)} * \left(\begin{array}{l} \text{\# workers} * \frac{\text{worker hrs}}{\text{day}} * \frac{\text{labor cost}}{\text{hr}} * \frac{\text{days}}{\text{season}} \\ + \frac{\frac{\text{applied gal}}{\text{rig}}}{\frac{\text{applied gal}}{\text{RR container}}} * \frac{\text{DC gal}}{\text{RR container}} * \frac{\text{cost}}{\text{DC gal}} \end{array} \right)$$

D = formulation accuracy quality too high (only for dilute concentrate)

$$= \text{conc. too high (\%)} * \left(\begin{array}{l} \text{conc. overage (\%)} * \frac{\frac{\text{applied gal}}{\text{rig}}}{\frac{\text{applied gal}}{\text{RR container}}} \\ * \frac{\text{DC gal}}{\text{RR container}} * \frac{\text{cost}}{\text{DC gal}} \end{array} \right)$$

E = rebuild (every five years for model consistency)

The values of each variable related to the inclusion of closed interlock connections can be found in the appendices.

Economics of Using Improved Container Tracking

The benefits of adopting a container tracking system come from reducing the following sources of cost: excess stored inventory, inventory shortages and shrinkage. Excess inventory has an associated cost of committed capital. This is capital that could be used for other projects or be reinvested at an appropriate rate of return. Excess inventory and the related capital cost is due to three root causes examined by this study: contingency inventory, excess concentrate, and over-prediction.

Contingency inventory refers to a “rainy day” stock of inventory that is kept in reserve in case of an unforeseen event. Tracking should help applicator managers feel more confident in looking at historical averages to predict necessary reserve inventory rather than ordering to cover anecdotal incidents. Excess concentrate refers to the open containers of concentrate that contain partial quantities left over from making prior formulations. Tracking usage and current inventory of these concentrates will allow for proper ordering to meet application recipe-dictated ratios and amounts, thereby allowing applicators to order more exactly in the future rather than build up a stockpile in the warehouse. Shrinkage is a retail term that refers to misallocated and misappropriated inventory. Container tracking at the blender/distributor to applicator levels should help reconcile and reduce lost and stolen inventory.

Some custom blenders already offer tracking systems as a ‘Software as a Service’ (SaaS) to applicators. SaaS allows applicators to use the tracking software over the web, rather than having to install servers and maintain software at their end. The cost of the tracking benefit is charged by the software provider on a per-container basis and is incorporated into the tracking economics model.

A conservative assumption was made of the ability to capture all of the theoretical benefit by reducing excess inventory, stored inventory, or shrinkage. *An estimate of only 20-50% of the potential benefit of each theoretical benefit is assumed to be attainable, depending on the area of improvement.* These area dependent benefit capture rates are explicitly listed in section 5.5. Again, these captured benefits are also spread out on a yearly basis, based on applied gallon spread per year, over a five-year period.

In summary, the core economic drivers behind the closed system economics are the

- Benefits in inventory optimization
- Cost of using the tracking SaaS

and the benefit is broken down explicitly as follows:

Tracking benefit = $\mu * \sum a_i * X_i + a_4 * Y + * \sum a_i * Z_i - \alpha * (W_1 + n * W_2)$

where:

$\mu * \sum a_i * X$

$$= \mu * \left(\text{excess inv (days)} * \frac{\frac{\text{applied gal}}{\text{rig (season)}}}{\frac{\text{days}}{\text{season}}} * \frac{\frac{\text{DC gal}}{\text{RR container}} * \frac{\text{cost}}{\text{DC gal}}}{\frac{\text{applied gal}}{\text{RR container}}} * \sum_{n=1}^{3} a_n X_n \right)$$

μ = cost of capital
a_{1-3} = estimated improvements in X from tracking (%)
X = too much inventory on-hand ($\sum X = 1$)
1 = contingency inventory (%)
2 = excess concentrate (%)
3 = need over-prediction (%)

a_4 = estimated improvements in Y from tracking (%)
Y = too little inventory on-hand, causing a rush order

$$= \text{rush order (days inv)} * \frac{\frac{\text{applied gal}}{\text{rig (season)}}}{\frac{\text{days}}{\text{season}}} * \frac{\frac{\text{DC gal}}{\text{RR container}}}{\frac{\text{applied gal}}{\text{RR container}}} * b * \frac{\text{shipping cost}}{\text{gal}}$$

b = expedited shipping premium

$$\sum a_i * Z_i = c * \frac{\frac{\text{applied gal}}{\text{rig}}}{\frac{\text{applied gal}}{\text{RR container}}} * \frac{\text{DC gal}}{\text{RR container}} * \frac{\text{cost}}{\text{DC gal}} * \sum_{n=5}^{6} a_n Z_n$$

Z = shrinkage ($\sum Z = 1$)
1 = misallocated inventory (%)
2 = misappropriated inventory (%)
a_{5-6} = estimated improvements in Y from tracking (%)
c = typical shrinkage rate/yr

$\alpha * (W_1 + n * W_2)$ = tracking cost

α = RR containers / rig (per yr)
W_1 = cost per container
n = number of locations per location
W_2 = scan cost per container per location

The values of each variable, as related to the adoption of an improved container tracking system, can be found in the appendices.

Cost of Application-Ready Mixes

There is a price differential from using application-ready mixes versus using concentrates and mixing later. This differential is incorporated as either a benefit or cost, depending on the situation, and was calculated using price quotes for all active ingredients, adjuvants, and diluents necessary to create each representative tank mix for each of the four application types found in the UVM industry. A comparison of bulk, custom blend, and package good pricing was then made. The price quotes used in the analysis are not included in this report, to respect the proprietary nature of these data.

Results of Financial Analysis

The 5-year NPV analysis was performed and the results were normalized to units of NPV per applied gallon of herbicide. Summarized results of the complete financial analysis are presented in Table 2 below.

Table 2. CCC BPM 5-year NPV Results per Applied Gallon. The column on the far right summarizes the full scope of the new BMP: use of custom blends in RR closed supply containers, and includes container tracking.

Application type	RR Supply Containers	Closed System connections	RR Closed Supply Container	Tracking	Custom Blend	All CCC BMP elements
RTA, Low Vol. Basal	$1.13	$(0.64)	**$0.49**	$0.07	$0.25	**$0.81**
DC, Low Vol. Foliar	$0.08	$0.00	**$0.08**	$0.00	($0.04)	**$0.04**
DC, High Vol. Foliar	$0.04	$(0.01)	**$0.03**	$0.00	$0.01	**$0.04**
DC, Aerial	$0.12	$(0.05)	**$0.07**	$0.02	$0.42	**$0.51**

Adoption of RR containers is net positive across all four applications types. This is due to the two main contributing factors including the avoided cost of proper disposal of one-way containers, and incremental improvement in crew productivity related to efficiency of transfer and mixing of herbicides. The primary differences in RR NPV values between application types are a function of dilution ratios.

Using conservative capital outlay estimates, closed system economics for the dilute concentrates are nearly net zero. There is a large benefit from accurate mixing, but it is countered by the initial capital outlay to fit the rigs and RR containers with closed connection interlock valves. Benefits from implementing the closed system for ready-to-apply applications have the greatest negative NPV (cost) as the concentrate is already pre-mixed; therefore, there is no improved dilution accuracy benefit as a result of the migration. However, when RR containers and the use closed connections, as they are in current form of the RR Closed Supply Containers that are commercially available to the Utility Vegetation Management (UVM) industry, the benefits are net positive.

Tracking benefits are net positive across all application types.

A comparison of market pricing[2] of package goods and their custom blend equivalents revealed that the purchase cost of formulations as custom blends is less expensive

[2] Cost estimate based on Q1 2010.

except in the case of low-volume foliar applications. Note that these values are not reported as 5 year NPV's.

In summary the adoption of the BMP has been shown to result in savings to the UVM industry. The column on the far right of Table 2 presents the results for use of custom blends in RR closed supply containers, and includes container tracking. When all elements are considered together, the results are net positive.

Sensitivity Analysis

A sensitivity analysis was performed on model variables across all applications to examine their respective impacts on total NPV. Relative sensitivity was examined in bandwidths from 75 to 125% of original values used. The variables examined, with their original values, are:

- Expected number of round trips a RR container makes over its service life (30)
- Shipping costs per gallon ($2/gal)
- Benefit capture rates from using closed systems (20%)
- The initial amount of excess stored inventory before tracking improvements (20 days)

Overall sensitivity results show that total NPV is positive regardless of the range of variables examined. This demonstrates robustness in the BMP initiative for producing overall positive NPV.

RR Container Round Trips

The financial analysis was completed using the assumption that a RR closed supply container would be used at the allowable maximum number of turns (30). The results for adjusting number of RR lifetime turns is shown below in Figure 7, with the original variable amount highlighted on the x-axis in red.

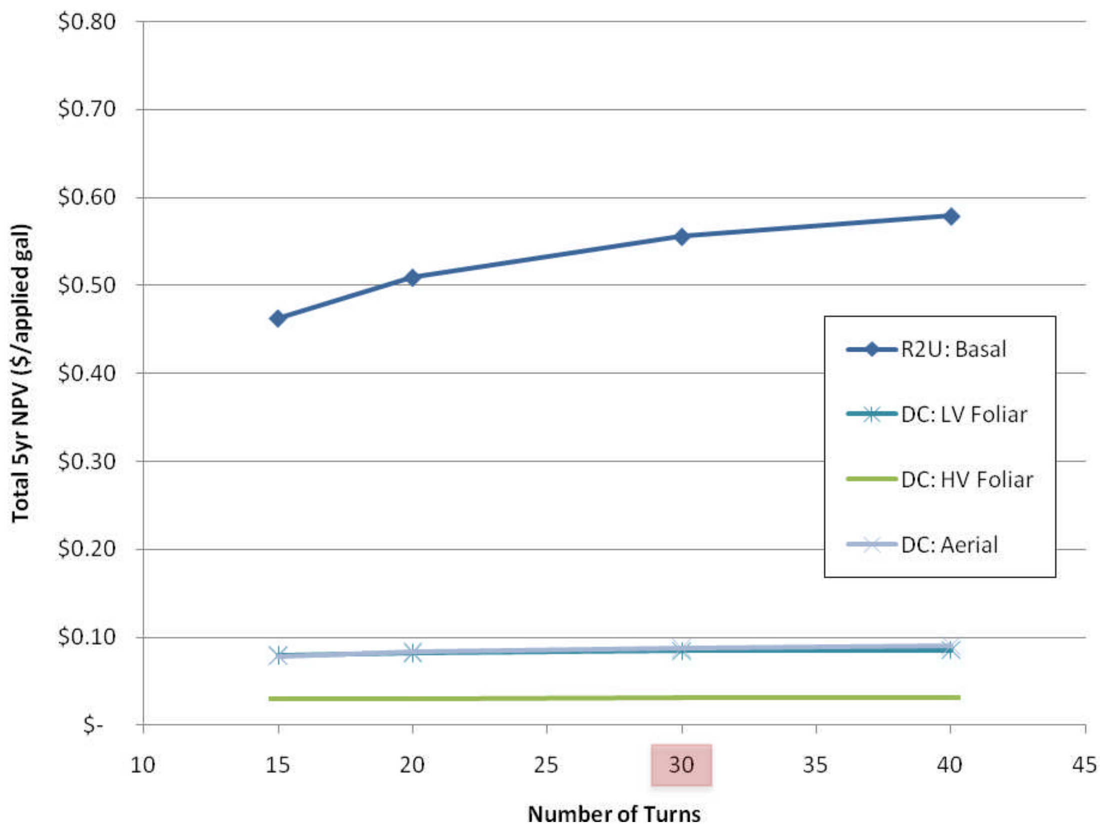

Figure 7. Sensitivity of projected benefit to varying number of times a RR container is refilled. A value of 30 turns was used in the detailed financial analysis.

The graph in Figure 7 shows that as the number of turns decrease, the NPV decreases as well. This follows logically, as each RR container becomes less effective in delivering as much herbicide over its lifetime and the blender is required to purchase a new container. Also note that forty turns are included for illustrative purposes only, as the planned service life is the lesser of 5 years or 30 turns.

Shipping Cost

The financial analysis was completed using an average shipping cost of $2 per gallon. Sensitivity analysis was conducted adjusting the cost of shipping. Results are presented below in Figure 8, with the original variable amount highlighted on the x-axis in red.

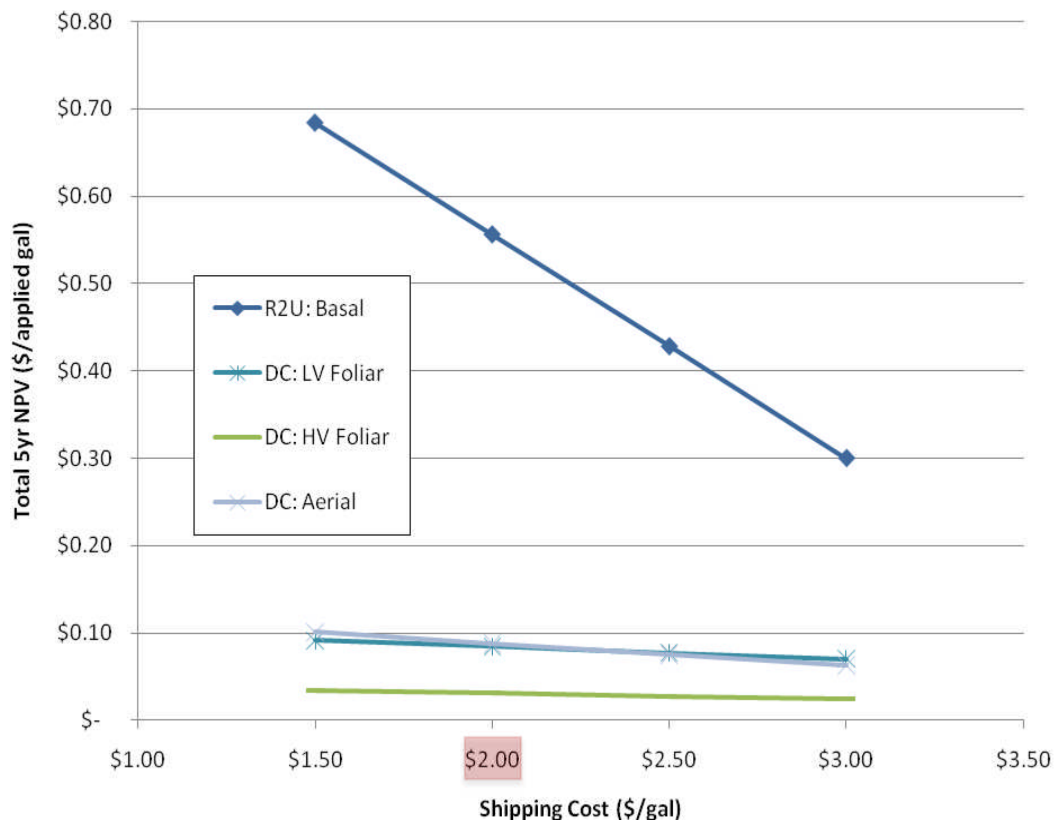

Figure 8. Sensitivity of projected benefit to the shipping cost. A value of $2.00/gallon was used in the detailed financial analysis.

Figure 8 graphically shows that as the shipping cost increases, the NPV decreases. Disposable containers only need to be shipped one-way to the job site and thus are less affected by a price increase. As a result, there is a larger reduction in NPV for RR containers as shipping costs increase, as compared to disposable containers. The range of shipping costs examined in this sensitivity analysis are consistent with those reported by custom blenders. The analysis shows that the projected 5 yr NPV benefit for basal applications involving ready-to-apply formulations is very sensitive to shipping cost.

Benefit Capture Rate for Closed Connections

The financial analysis included a discount factor used to adjust down the sum of total potential benefits, as a form of practical reality check. The results for adjusting the realizable benefit for installing closed interlocks on RR supply containers and application equipment are shown below in Figure 3, with the original variable amount highlighted on the x-axis in red.

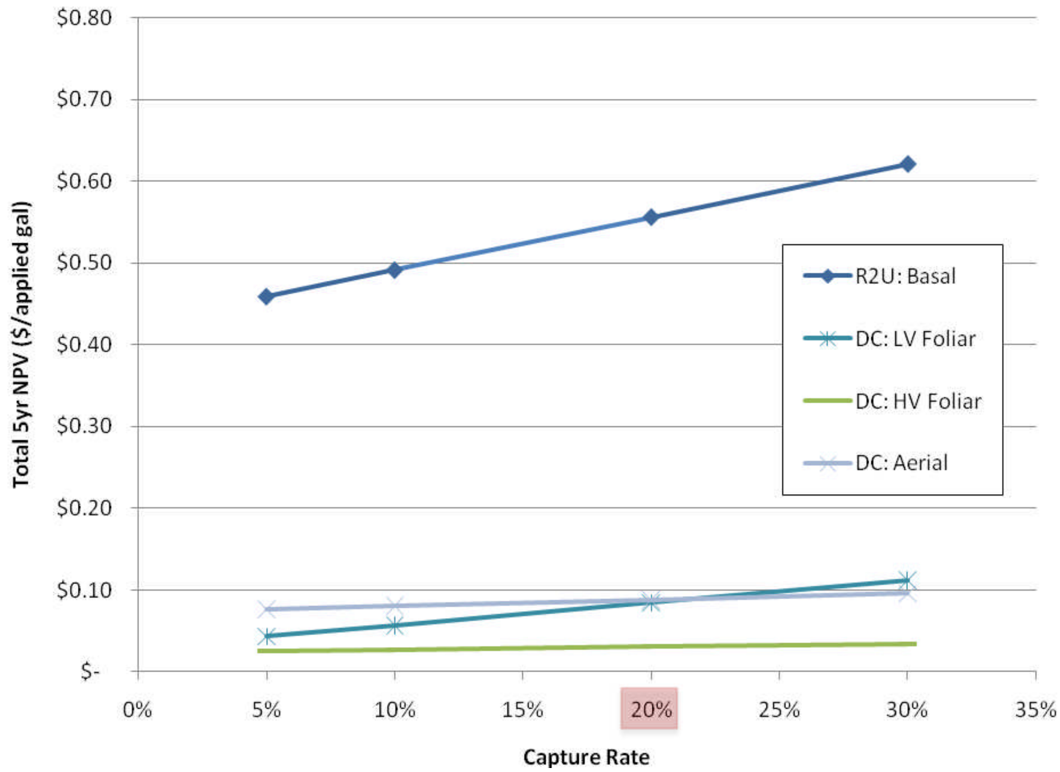

Figure 9. Sensitivity of projected benefit to various assumptions for capturing the potential value of closed connections on RR Supply Containers and spray rigs.

The graph shows that NPV increases along with increasing benefit capture rate. The dilute concentrates show greater sensitivity to this change as they gain more benefit from mixing accuracy. From an absolute dollar perspective, R2U: Basal still shows benefit improvement as a result of reduced likelihood of adverse events such as leaks and spill.

Level of Traditional On-hand Inventory

The financial analysis included an assumption that applicators traditionally had carried the equivalent of 20 days excess inventory. The results of the sensitivity analysis of the projected benefit to differing assumptions of excess inventory are shown below in Figure 10 with the original variable amount highlighted on the x-axis in red.

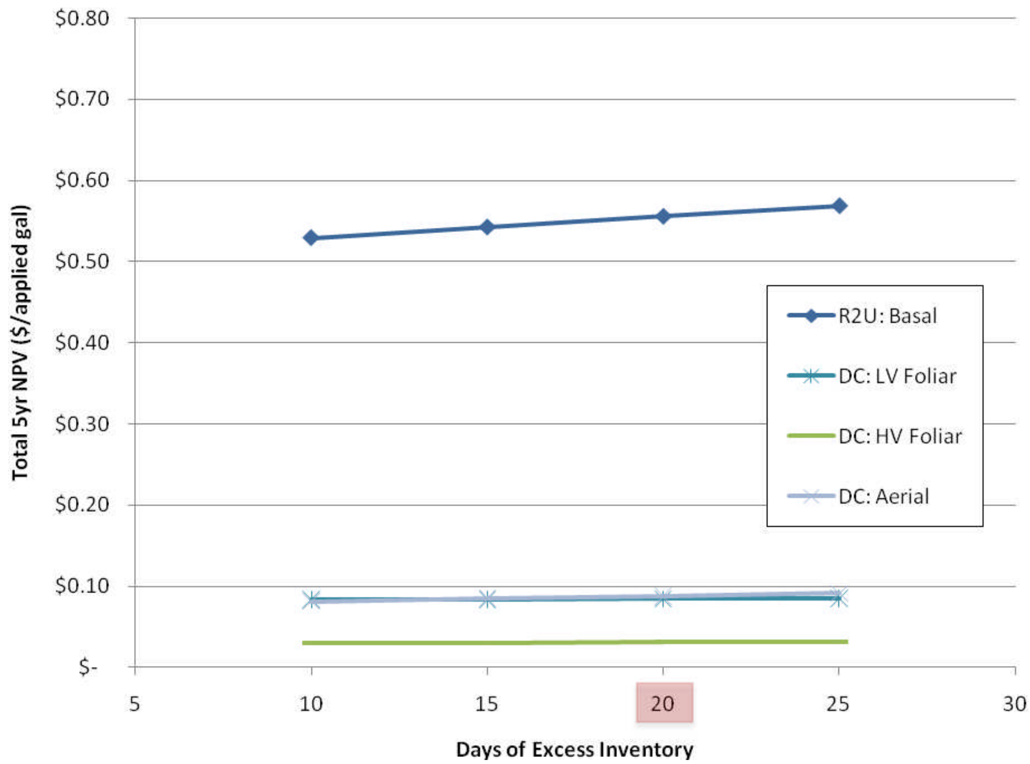

Figure 10. Sensitivity of projected benefit to various assumptions of level of excess inventory. An assumption of 20 days of unnecessary inventory was included in the detailed financial analysis.

The graph shows that NPV increases along with increasing starting inventory. This is logical: as there is more potential excess inventory that can be reduced, DC: Aerial has the greatest relative sensitivity (on a change per starting value ratio) as it has the most expensive cost per gallon of dilute concentrate, at $87/gal. The more expensive the product, the more valuable the inventory and the greater benefit can be captured by reducing stored inventory.

Development of Best Management Practices

The survey of current UVM industry practices and the process benchmarking studies that were completed as Tasks I and II of this project served to define the useful scope of the new BMP. It became clear that the new BMP would need to address the following sub-processes and topics:

- ✓ Use of RR closed supply containers
- ✓ Use of reusable service containers
- ✓ Use of closed connections at transfer points
- ✓ Use of custom blends
- ✓ Means of closed measuring and mixing
- ✓ Container tracking and record keeping
- ✓ Inventory management
- ✓ Return and refilling of empty RR supply containers
- ✓ Decommissioning of RR supply containers
- ✓ Use of open one-way disposable containers

Examples of approaches to each of these items were identified at process benchmarking partner sites. The operational practicality and financial implications of each were assessed. An initial draft of the BMP was then created and prepared for validation.

Validation of the draft BMP was completed using Delphi Analysis techniques. The Delphi Method involves a structured process used to collect and distill the knowledge of groups of subject matter experts and stakeholders. It is an iterative process involving feedback and refinement. The method recognizes the value of human experience and judgment, and structures these into a useful form.

In this specific application two Delphi groups were used. A small group of subject matter experts participated in an initial review of the draft BMP. One-on-one discussions were also conducted with some key stakeholders. The initial draft was substantially revised based on this first round of review. The draft BMP was then vetted and validated by a larger group of informed stakeholders. This group included:

- ✓ All stakeholder participants in the five process benchmarking studies.
- ✓ All persons who self-identified during the Internet survey as being willing to participate in a review.
- ✓ Members of the UAA Research Committee
- ✓ All persons who had provided comments during the review of UAA's Integrated Vegetation Management BMP

The resulting BMP is intended to establish an overall construct, and establishes expectations while allowing commercial variations in specific methods. The actual BMP is included as Appendix B to this report.

Implementation & Communications

As initially envisioned, the project was to have included the development of implementation materials and a communications strategy for advancing the adoption of the new BMP by the UVM industry. Unfortunately these two tasks did not receive initial funding support. It is strongly recommended that UAA commit to the development of implementation materials and a communications strategy.

Implementation resources for use by various stakeholder groups might include items such as a checklist, FAQ, and training materials. The new BMP should be actively promoted in trade publications, at UVM industry meetings, and potentially in workshops designed to introduce the new BMP.

Conclusions

Financial analysis conducted as part of this project demonstrates that the new BMP can be adopted at no additional cost to the UVM industry. To be clear: the analysis was conducted at the UVM industry level. It is likely that at least in the short term there will be inequity in costs and benefits between various stakeholders to the process, as some bear costs in excess of any direct benefit they might receive. However, in an efficient marketplace any initial unintended cross-subsidization will be reconciled, as costs and benefits true up.

The new BMP can easily be adopted by utilities by incorporating it by reference in procurement specifications.

Our analysis demonstrated that adoption of the BMP can reduce risks of mixing errors and spills, and applicator exposure. Adopting the BMP is a demonstration of good environmental stewardship.

Perhaps the strongest evidence for adoption is anecdotal. Application crews that have used custom blends in RR closed supply containers like the practice, and are reluctant to return to open containers. Applicators that use them have brought the practice to work on utility systems where they have not been used.

Appendix A: White Paper

Business Case for Adoption of Closed Chain of Custody Best Management Practices

Introduction

This white paper provides the financial justification for migrating to a closed chain of custody best practice methodology. Currently in the vegetation management industry, disposable one-way containers are used to ship herbicide concentrates and prepare mixes on job sites. The best practice proposal is to migrate to the use of custom blends supplied in returnable/recyclable containers that have interlocks (improved liquid transfer mechanisms) and tracking technology. Although there are sound systematic reasons for migrating to this new best practice methodology, the financial analysis demonstrates that there is also a financial incentive to migrate. This report provides an analytical financial analysis to justify a migration.

Solution Overview

Financial analysis of the economic implications of implementing the new CCC BPM can be broken down into four elements:

5. The use of returnable reusable (RR) supply containers.
6. The use of a closed system interlocks.
7. The use of an improved means of tracking supply containers.
8. The use of custom blends versus concentrates.

The financial analysis was conducted in a way such that the cost of implementation, and financial justification, for each element can be considered as a separate initiative.

Solution Details

The economics for each initiative are examined and calculated, when appropriate, for the aggregate of all stakeholders (Utilities, Distributors, Customer Blenders, and Applicators) into a supply chain-wide five year Net Present Value (NPV). The key reference metric is the cost differential of a mixed ready to apply gallon in a spray tank. This is a calculation made by comparing the traditional use of “package goods” in open one-way containers to the corresponding element in the CCC BMP.

Data used in the financial analysis are based on the results from an Internet survey of UAA membership and interviews from Asset Owners, Distributors, Customer Blenders and Applicators. The analysis was run for each of four application types based on herbicide formulations and rates that are representative of UVM industry practice. A detailed presentation of the financial analysis will be included in the UAA CCC BMP project report.

Solution Benefits

The 5-year NPV, given a yearly cost of capital of 9%[3], is presented individually, and in composite in the table below for each of the four aspects of the CCC BMP:

CCC BPM 5-year NPV Results per Applied Gallon

Application type	RR Supply Containers	Closed Systems	RR Closed Supply Container	Tracking	Custom Blend	All CCC BMP elements
RTA: LV Basal	$1.13	$(0.64)	**$0.49**	$0.07	$0.25	**$0.81**
DC: LV Foliar	$0.08	$0.00	**$0.08**	$0.00	($0.04)	**$0.04**
DC: HV Foliar	$0.04	$(0.01)	**$0.03**	$0.00	$0.01	**$0.04**
DC: Aerial	$0.12	$(0.05)	**$0.07**	$0.02	$0.42	**$0.51**

The migration to RR supply containers is net positive across all four applications types. This is due to the two main contributing factors including the avoided cost of proper disposal of one-way containers, and incremental improvement in crew productivity related to efficiency of transfer and mixing of herbicides.

The adoption of closed connections comes at a premium. There is an immediate benefit from more accurate herbicide mixing, thereby reducing waste as well as spillage-induced liability, but it is countered by the initial capital cost to fit the rigs and RR containers. However when combined in current form of the RR Closed Supply Containers available to the Utility Vegetation Management (UVM) industry, the benefits are net positive.

Improvements in tracking are economically positive, primarily due to better inventory management. There are also savings in the purchase cost of formulations as custom blends except in the case of low-volume foliar applications. When all elements of the CCC BMP are considered together, the results are net positive, as reported in the right most column of the table above.

Summary

The financial impact of the CCC BMP for all application types is positive. Adoption of these practices by the UVM industry can therefore be financially justified. The burden of capital outlay is most intensive for custom blenders in establishing a fleet of RR Closed Supply Containers. The capital outlay for applicators is offset by rebates from Producers. Tracking system improvements are a result of increased information technology and could be adopted in a phased approach.

In addition, there are several soft benefits from migrating to the CCC BPM that are not included in these results, such as enhanced branding (Green PR) by demonstrating environmental stewardship. These benefits accrue to the utility through customer and regulator perception.

[3] The cost of capital is an average taken from various asset owners, distributors, and customer blenders.

Appendix B: Closed Chain of Custody BMP

Utility Arborist Association
Best Management Practices for a:

Closed Chain of Custody for Herbicide Use in the Utility Vegetation Management Industry

May 18, 2010

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- Northeastern Rural Services
- Oklahoma Gas and Electric
- CWC Chemical
- Red River Supply
- ArborChem
- Aqumix
- Eco-Pac LLC
- Asplundh Tree Expert Co.
- Hazlet Tree Service
- Lewis Tree Service
- Nelson Tree Service
- Progressive Solutions
- Southeast Woodlands
- Superior Forestry
- Townsend Tree Service
- Townsend Chemical LLC

The Utility Arborist Association received funding from Dow AgroSciences for the purpose of supporting this project: Closed Chain of Custody for Herbicide Use in the Utility Vegetation Management Industry
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Forward

Vegetation is a leading cause of interruptions to the reliable supply of electric power to consumers and businesses. Electric utilities maintain incompatible vegetation that may grow into conflict with overhead transmission and distribution lines using a variety of field-tested techniques and tools. In 2007 the Utility Arborist Association (UAA) published a Best Management Practice (BMP) that defines contemporary Integrated Vegetation Management (IVM) as practiced the electric utilities use to prevent vegetation from causing power outages.

The Utility Vegetation Management (UVM) industry makes extensive use of herbicide applications in maintaining vegetation on utility rights-of-way (ROW). Herbicides are used to maintain utility ROW free of incompatible tall growing tree species that endanger public safety, pose a threat to the reliability of the energy delivery systems, and to help with access for utility lines inspection, maintenance, and for personnel making emergency restoration and repairs. Considerable progress has been made in developing application methods and herbicide formulations that mitigate potentially adverse environmental impacts of UVM practices to the environment in which these products are applied. Advances in chemistry and application methods have significantly reduced the volume of mixed herbicide solutions applied. Applications of both water-based foliar and oil-based basal stem applications are common practices.

Traditionally the herbicides used in UVM have been supplied in concentrated forms in non-returnable containers. This requires handling open containers of concentrate on job sites, as herbicides are measured and mixed in spray tanks. Advances such as low volume application techniques and the herbicide formulations being prescribed have made it practical for the UVM industry to consider the adoption of ready-to-use and dilute concentrates in closed delivery systems, as yet another adoption of practices that further protect the applicator and the environment. Not only are these safety measures enhanced, but also businesses can save time and money by switching to these types of products.

This BMP is intended to establish an end-to-end strategy for managing the chain of custody for herbicides from Producer to Custom Blender, Distributor, and Applicator to the Utility. The concept of a “Closed Chain of Custody” as used in this project is focused on the end-to-end “Supply Chain”, and includes the logistical aspects of herbicide shipping, distribution, storage and mixing. It also addresses management of the waste stream and the return of empty containers for refilling and reuse as part of reducing plastic containers as part of the waste stream.

There are three important elements to the “Closed Chain of Custody” as defined in this Best Management Practice:

1. The use of supply containers that are returned, refilled, and reused – the container cycle.
2. The use of closed connections at the transfer points between supply container, mix tank, and application equipment- the integrity cycle.
3. The use of a container tracking system establishing an auditable record documenting movement of herbicides and containers – the documentation cycle.

Table of Contents

Note: The page numbers listed above pertain to the BMP as a stand alone document, and not those reflected in this Final Report.

Glossary of Terms

The following terms are used extensively in defining the requirements of this Best Management Practice.

Adjuvant - Any additive to the herbicide formulation or mixture that is intended to enhance efficacy or application characteristics including emulsifiers, surfactants, drift control agents, and dyes.

Applicator - The person or company who is responsible for making the actual application of herbicides to utility rights-of-way (ROW). In most cases Applicators purchases herbicides from Distributors. The Applicator typically is under contract with the Utility. Alternatively, the Applicator may be an in-house organization within the Utility.

> ***Important note:*** *There is a regulatory distinction between "Applicator" and "Mixer/loader". These terms have different meaning with respect to regulatory statute and the way the human health assessments are conducted. In the UVM industry the same personnel typically mix, load, and apply herbicides. It should be recognized that much of this BMP addresses "Mixer/Loader" practices.*

Best Management Practice (BMP) –This document establishes contemporary policies, procedures, and practices for use in the utility vegetation management industry in managing transportation logistics, herbicide transfer and applications, and the use and fate of containers.

Closed Connection – A means of connecting and transferring herbicides between containers in which there is no open access to the mixture being transferred. Closed connections typically involve use of mechanical interlocks and valves.

Closed System – An end-to-end process that eliminates the need for open access to herbicides and adjuvants through the preparation of ready to apply the mixtures.

Chain of Custody – An end-to-end process of documented ownership responsibilities for herbicides and adjuvants from production through application, and the fate of containers and waste products.

Custom Blend – A herbicide blend of registered active ingredients, adjuvants, and diluents that is created on demand for a specific Applicator and specific project. Custom Blends can be Dilute Concentrates or Ready To Apply mixes. Custom Blends are typically provided in Returnable Reusable Closed Supply Containers.

Custom Blender - The stakeholder who is responsible for creating and supplying Custom Blends to Applicators. Custom Blenders manage a fleet of Returnable Reusable Closed Supply Container used in supplying Custom Blends to Applicators. A Custom Blender providing Custom Blends to the open marketplace is a "repackagers" per the regulatory definition in the Federal Insecticide Fungicide and Rodenticide Act (FIFRA), and is recognized as a Registered Establishment. A custom blending operation owned by an Applicator that supplies Custom Blends for the exclusive use of the Applicator's own crews may not be a Registered Establishment.

Diluents – A medium such as water or oil used to dilute the concentrations of active ingredients in an herbicide mixture.

Dilute Concentrate – A Custom Blend containing a combination of registered active ingredients, adjuvants, and diluents produced for a specific Applicator and project. Dilute Concentrates are further diluted by the Applicator in preparing the required application mixture and rate in their mix or spray tank.

Distributor - The stakeholder to the process who is responsible for receiving orders for herbicides from Applicators, and sometimes directly from Utilities. Distributors may provide registered herbicide products in one-way disposable containers to Applicators or supply Custom Blends through a relationship with a Custom Blender.

Emulsifier - A substance that promotes the suspension of one liquid in another.

Mix Tank - A tank used by an Applicator to prepare the required mixture and rate for an application-ready mixture. This tank is used as an intermediary tank typically used to supply ready to apply formulations to the supply tank which is part of the application equipment.

Mixer/Loader – See note under definition of "Applicator".

Product – A registered herbicide product delivered by the Producer. Registered herbicide Products are supported by their own product chemistry documentation, and are labeled for specific uses.

***Producer* -** The stakeholder to the process who formulates registered active ingredients. Producers provide Distributors with registered products for sale, and also maintain bulk quantities of products with Custom Blenders for storage and use in Custom Blends.

Ready to Apply (RTA) - RTA formulations are created on demand by Custom Blenders and are intended for use by a specific Applicator on a project. They contain active ingredients, adjuvants, dilutants, and are supplied as an application-ready formulation. They are supplied as mixtures of registered products diluted to the required concentration as required by an Applicator for a project.

Ready to Use (RTU) - RTU formulations are labeled products that are registered for a specific use and are diluted, unique formulations. Their registration is supported by their own product chemistry documentation packages and thus can only come from producers. They contain active ingredients, adjuvants, dilutants, and are supplied as an application-ready formulation.

***Returnable Reusable Supply Container* -** A durable container with open access to contents that is intended for repeated use as a Supply Container. These containers may be used by Custom Blenders to supply Custom Blends to Applicators. Regulations for reusable containers include the requirement that they be fitted with a tamper evident seal.

Returnable Reusable Closed Supply Container – A durable container fitted with a closed interlock valve that is intended for repeated use as a Supply Container. These containers are commonly used by Custom Blenders to supply Custom Blends to Applicators. Regulations for reusable containers include the requirement that they be fitted with a tamper evident seal.

Rinsate – The product of triple rinsing supply containers as part of the preparation for their disposal or recycling.

Service Container - A reusable container used by an Applicator within their operations to transport small quantities of herbicides from Supply Containers or mix tanks to remote crew locations. Service containers are not shipped by common carrier.

***Spray Tank* –** The application equipment supply tank that contains a herbicide mixture at the rate and concentration required for applications. Mixing and dilution may be accomplished in the Spray Tank or in an intermediary Mix Tank.

Supply Container – A container in which herbicides are provided to Applicators. Custom Blends of Dilute Concentrates and Ready to Apply herbicides may be provided in Returnable Reusable (R/R) Closed Supply Containers. Registered straight goods and Ready to Use products are typically provided in one-way disposable package good containers or returnable reusable mini-bulk containers. It is also possible for a registered herbicide concentrate to be provide in Returnable Reusable (R/R) Closed Supply Containers.

Surfactant - A material that improves the emulsifying, dispersing, spreading, wetting or other properties of a liquid by modifying its surface characteristics.

Utility Owner - The stakeholder to the process who is the asset owner and in most cases the asset manager, the asset being the right-of-way corridor being maintained. The Utility typically retains the services of a commercial Applicator by written contract that establishes specific work performance standards that must be complied with.

Purpose of this Best Management Practice

The Utility Arborist Association believes that this BMP is a demonstration of pro-active industry self-regulation and a clear demonstration of the UAA's commitment to environmental stewardship. The BMP aligns with the United States Environmental Protection Agency's (EPA) interest in promoting the use of closed systems and container recycling. A number of benefits to the UVM industry, government, and utilities are realized by the adoption of this BMP as part of normal operations.

Maintaining closed connections at transfer points throughout the transportation, filling, and application system as herbicides move from Supply Containers to mix tanks and application equipment reduces mixer/handler and applicator exposure to herbicides. The use of custom blends of dilute concentrates and ready to apply formulations reduces potential exposure to concentrated herbicide products.

The use of all-inclusive custom blends of dilute concentrates reduces the likelihood of errors in measuring the proper quantity and during mixing operations. It also assures integrity of the intended formulations including active ingredients, diluents, and adjuvants by reducing the likelihood of unauthorized changes in rates and/or substitutions. When dilute concentrates are supplied in volumes that match spray tank requirements, the need for measuring can be eliminated, just as they are in the case of ready to apply formulations.

Improvements in crew productivity and the cost effectiveness of vegetation maintenance are available through the adoption of the policies, proceedures, and practices in this BMP. The use of custom blends reduces the time required to prepare a ready to apply mix. The use of returnable reusable containers eliminates the need for the crew to triple rinse and dispose of empty containers. In contrast, reusable containers must be collected and returned. These practices enable the crew to spend more time making applications and reduce down time.

This BMP creates favorable environmental benefits and is a demonstration of commitment to environmental stewardship. The use of returnable reusable supply containers reduces the volume of the waste stream associated with UVM operations. There is a reduction in the number of one-way containers that must be disposed in a landfill. Secondly, there is a reduction in the volume of rinsate generated by a spray crew because returnable reusable supply containers eliminate the need for triple rinsing of empty containers before refilling. The volume of rinsate generated by the use of conventional open one-way disposable containers is significant, though it can be reused as part of the diluent in the next batch of mix being prepared.

Provisions within this BMP also are an effective means of risk mitigation. The use of closed connections at transfer points may reduce the likelihood of leaks and spills during handling, mixing and loading operations. The use of robust returnable reusable supply containers reduces the likelihood of damage resulting in a leaking container. There is also a reduction in the risk of unintended regulatory non-compliance, either due to application of off-label rates or improper disposal of rinsates and empty containers.

Introduction

This BMP is the fourth to be produced by the Utility Arborist Association. The other references that are published by UAA include:

- *"BMP Utility Pruning of Trees"*, 2004
- "*BMP Integrated Vegetation Management"*, 2007
- "*BMP Western Hazard Tree Mitigation", 2009*

This BMP establishes an end-to-end strategy for managing the Chain of Custody for herbicides used in UVM programs from Producer to Distributor, Custom Blender, Applicator, Utility owner of transmission and distribution ROW. It also includes the return and reuse of empty containers. It is intended to provide Utility asset owners with a useful resource that can be incorporated by reference in procurement of vegetation maintenance services that involve the application of herbicides. This BMP is intended to increase the level of professionalism and environmental stewardship demonstrated by UVM programs.

Intended Scope

The BMP is intended for use in dedicated herbicide application programs and operations typically involving specialized crews. This includes herbicide application to all aspects of UVM including transmission and distribution ROW, substations, storage yards and related industrial sites. Several elements of the BMP may also apply to line clearance tree pruning crews making occasional use of herbicides such as cut stump treatment and incidental basal application.

There are three important elements to the "Closed Chain of Custody" as defined in this BMP:

1. The use of Supply Containers that are returned, refilled, and reused.
2. The use of Closed Connections at the transfer points between supply container, mix tank, and application equipment
3. The use of a container tracking system that establishes an auditable record documenting movement of herbicides and containers.

Regulatory Compliance

This BMP was developed by the UAA in an effort to establish a proactive strategy for incorporating regulatory trend in to the art and practice of UVM. The following regulatory developments were considered in developing this BMP:

- 2006 – New container regulations and guidance on custom formulations.
- 2007 – New labeling requirements including more specific references to appropriate container disposal.
- 2009 – Proposed recycling initiative, which is currently tabled.
- 2011 – New regulations related to use of reusable containers.

The provisions of this BMP are intended to be compliant with current federal and state regulatory requirements.

Applicators shall conform to all label instructions of the registered herbicides being applied. This includes, but may not be limited to transport, handling, mixing, application, and disposal.

Regulations change; if the BMP is found to be inconsistent with current regulations, the regulatory requirements supersede the BMP's stated practices.

Safety

Safety is a paramount objective of this BMP. Elements of this BMP are expected to enhance safety within the Applicator's work environment. The use of closed connections and all-inclusive custom blends reduces applicator exposure to concentrated herbicides. However, the need for the personal protective equipment required on the herbicide labels is unchanged.

The use of a closed system significantly reduces most exposure-related risk. However care should be taken when connecting and disconnecting closed connections with Supply Containers that may have become pressurized when exposed to direct sunlight or due to changing temperatures.

An Applicator's health risk related to herbicide use is a function of the toxicity, frequency, and duration of exposure. The toxicity of the herbicides commonly used in UVM is low relative to other pesticides. The use of the Closed System should further reduce risk by reducing the likelihood of adverse applicator exposure. Lessening any exposure is always a worthwhile goal.

Increased accuracy in the rates of active ingredients in the herbicide mixtures being applied will enhance the safety of the general public and the environment from UVM applications. The use of a closed system should reduce the likelihood of leaks and spills during handling, transferring, and mixing processes. The use of Custom Blends decreases the likelihood of errors in mixing and application.

Use of Returnable Reusable Supply Containers

This BMP promotes the use of Returnable Reusable (R/R) Supply Containers that are returnable, reusable, and ultimately recyclable. There are inherent advantages associated with the use of R/R Supply Containers. R/R Supply Containers are filled by Custom Blenders and are the vessels in which custom blends are provided to the Applicator.

R/R Supply Containers meet UN/DOT Class II requirements. They have an expected service life of 5 years or 30 return cycles. They are typically made of recyclable translucent chemical resistant plastics, although some limited use of steel containers has occurred in the UVM industry. At the end of their service life they are recycled.

As required under the returnable container regulation, effective August 2011, each R/R Supply Container must have a unique identification number and a tamper-evident seal.

Each R/R Supply Container is labeled per regulatory requirements, including EPA product registration numbers and labels for all registered herbicide products contained within. Labeling also includes:

- The concentrations of all ingredients including active ingredients, diluents, and adjuvants.
- A reference to the specific lot or batch contained therein.
- Mixing/dilution instructions specific to the spray tank size in which it will be used. This may be expressed in either the graduated units on the Supply Container or as a ratio.
- The Utility and Applicator. The regulation requires designation of the “Owner”. In this case the Utility is the Owner and the Applicator is an Owner’s Agent.

Each R/R Supply Container is graduated with English and metric unit scales of sufficient detail to allow accurate determination of volume of liquid content. Containers should be sufficiently translucent to allow the user to determine the level (volume) of liquid contents.

When practical, the preferred R/R Supply Container should be of a size that facilitates the use of a 1:1 ratio of container contents to intended mix or spray tank volume. This can also be accomplished by use of Service Containers.

Use of Reusable Service Containers

The BMP recognizes the need for and use of Service Containers. Service Containers are intended to be reusable and refilled by the applicator, and are used to provide small quantities of herbicide solutions from larger containers to crews. Service containers are used within an Applicator's operations for intra-company transport of herbicides. If someone other than the Applicator transports these herbicides the container is not a service container, and is subject to UN/DOT class II container and hazardous waste regulations.

Service Containers may be used as an intermediary vessel facilitating the goal of a 1:1 ratio between containers containing custom blend and mix or spray tank. The intent is to eliminate the need for measuring by spray crews in the field.

Service Containers should be durable enough to survive repeated refilling and use over their intended service life.

The reuse of a one-way disposable container as a "service container" is inconsistent with federal regulations and this BMP. Any container that comes from producer as a package good container is labeled "do not reuse", and must be disposed whenever it is emptied and tripled-rinsed.

Service Containers typically have 2.5 gallon and 5 gallon capacities.

Use of Closed Connections at Transfer Points

This BMP is intended to promote the use of closed interlock valve connections at each transfer point where herbicide is being moved from one container to another container or tank, including application equipment supply. There are advantages with the use of R/R Closed Supply Containers.

There should be a closed connection fitting or valve on each R/R Closed Supply Container. A closed connection involves a positive interlock valve or fitting. It is a mechanical, leak-proof connection.

The R/R Closed Supply Container should be filled through a closed connection at the Custom Blender. The integrity of the closed connection should be inspected at regular intervals and maintained at all times. Effective in August 2011 a tamper-evident seal must be maintained on all R/R Supply Containers, as required under the returnable container regulations. This is typically accomplished by affixing the seal to the closed connection valve.

There should be a closed connection between Supply Container and the Applicator's equipment. This includes maintaining a closed connection:

- Between Supply Container and Spray Tank associated with application equipment.
- Between Supply Container and any Mix Tank used as an intermediate tank used to supply application equipment Spray Tanks.
- Between an Mix Tank, if used, and the application equipment Spray Tank.

The preferred practice includes a closed connection between the mix tank (or in the case of Ready to Apply formulation the Supply Container) and backpack or other small spray equipment receiving an application-ready mixture.

If Service Containers are used to supply spray crews in the field, the preferred method is that they should be fitted with a closed connection valve or fitting that is used for filling. Transfers of herbicides into the Service Container should be made through a closed connection. However, transfer from the Service Container to application equipment may be done via an open pour since, at this time, there is no practical means of use of a closed container for drawing out the contents of a Service Container. The use of closed connections for filling of Service Containers used to supply line clearance tree crews making incidental use of herbicides is a preferred practice.

The addition of supplemental adjuvants such as surfactants and drift control agents may be added to the mix or spray tank on an as-needed basis through an open (non-closed) connection. It also may be necessary to increase the rate of active ingredients in a spray mixture to achieve the desired level of control on a specific site and/or hard to control target species. When this becomes necessary the supplemental active ingredient may be added to the mix or spray tank through an open connection.

Products that do not go into solution but occur as suspensions in the spray mix such as dry flowables may be added to the mix or spray tank through an open connection.

Adding supplemental additions to the mix or spray tank through an open connection should occur on the ROW job site.

Measuring Quantities of Custom Blends

The intent of this BMP is to reduce or eliminate the need for field measurement of quantities of the individual herbicides and adjuvants contained in the specific spray mix.

Custom Blends supplied in the form of Ready to Apply formulations do not require measuring and mixing prior to use.

The preferred method is to use Custom Blends in R/R Closed Supply Containers with capacities and at concentrations that result in a 1:1 ratio of a Supply Container volume to Mix Tank or Spray Tank volume. This eliminates the need to do any measuring because the entire contents of the Supply Container are added to the mix tank or spray tank. This can also be accomplished by using a Service Container.

There are two reasons why it may not be possible or practical to achieve the preferred 1:1 ratio of Service Container volume to mix or spray tank volume:

1. Supply Container Contains More: It may be necessary to use a partial quantity of the volume of Custom Blend contained in a R/R Closed Supply Container. This occurs when the custom blend is supplied at concentrations or volumes higher than that which would result in a 1:1 ratio of contents of the Supply Container to mix or spray tank. In this case, the amount of Dilute Concentrate required to make up a full tank of application-eady mixture should be measured in full units, and the units should be consistent with the graduated markings on the supply container. If the quantities required are less than full units as marked on the R/R Closed Supply Container, it may be

necessary to use a Service Container or other intermediate tank with finer unit gradations.

2. Less Than Full Spray Tank Required: It may be necessary to mix in quantities smaller than that of a full mix or spray tank. This will result in the need for less than a full R/R Closed Supply Container of Dilute Concentrate. In this case the amount of Dilute Concentrate required should be measured in whole unit volumes consistent with the graduated unit markings on the supply container. If the quantities required are less than full units as marked on the Supply Container, it may be necessary to use a Service Container or other intermediate tank with finer unit gradations. The volume of any existing spray mixture in the spray or mix tank should be determined. The volume of diluents being added to the partial tank should be determined by measurement. It is important to accurately measure not only the active ingredients, but also the quantity of diluents (water, oil) being added to the mix or spray tank.

Closed System Measuring

The intent of this BMP is to maintain closed connections between Supply Containers and Applicator equipment during the process of measuring quantities of Dilute Concentrates. This reduces applicator exposure and chance of spills.

The preferred method is to maintain a closed system during the measuring process as a Concentrate or Dilute Concentrate is transferred from R/R Closed Supply Container to mix or spray tank. This can be accomplished through the use of:

- The use of intermediate fixed volume transfer vessels of known volume such as cone tanks with volumetric measures of sufficient detail to allow the applicator to determine whole unit quantities.
- The use of graduated/calibrated flow transfer pumps or flow meters.
- Translucent graduated Supply Containers and mix/spray tanks, which allow the applicator to determine liquid levels and the volumes of herbicide, diluent, and adjuvant being transferred.

Herbicide Formulations Being Supplied

The full benefit of R/R Closed Supply Containers is more likely realized with Utilities and Applicators focusing on a few basic core mixes for their specific programs and projects. The intent of the BMP is to encourage increased standardization within individual operations. This BMP also acknowledges the need for an adaptive IVM strategy that anticipates the need to make changes in application-ready mixtures at the time of application due to changing weather and/or site conditions.

The use of Ready to Use Products and Ready to Apply Custom Blends are preferred for Low Volume Basal including cut surface applications.

The use of Dilute Concentrates is preferred for Low Volume Foliar, High Volume (Hydraulic) Foliar, and Aerial applications.

There will be a continued need for some use of concentrated forms of herbicides. These products are commonly referred to as “package goods” and are typically provided in one-way disposable containers. This may typically occur when the Applicator is treating small projects of limited scope and scale, or when the mixture in the R&R container will not effectively control an unexpected brush species.

The intent of this BMP is that the herbicide formulations being supplied are as complete and all-inclusive as possible. As such, Custom Blended Dilute Concentrates should:

- Contain all active ingredients that will remain in stable solution.
- Contain all necessary adjuvants intended to enhance stability and efficacy of the mixture.

Drift control agents may be added to the mix/spray tank at the time of use on an as-needed basis. Additional Surfactants may be added to the tank at the time of mixing to address unique efficacy concerns; i.e., late season applications or drought conditions. Additional active ingredients may be added on occasion to address site- or species-specific concerns.

Some forms of concentrates such as dry flowables that do not stay in suspension may have to be added to the tank at the time of mixing.

Paraffin-oil based foliar mix carriers (e.g. “Thinvert”) act as both a surfactant and drift control agent. These formulations require additional field agitation to assure that the carrier and active ingredients are optimum suspension.

The stability of the Custom Blend Dilute Concentrate formulations being supplied should be well established and/or demonstrated; uniform color and no layering visible.

Dilute Concentrates are intended for use in a timely manner, and should not be held in inventory for longer than a spray season. A dilute concentrate should generally be expected to remain stable for two years.

Closed packaging of dry flowables in small volumes that match individual spray or mix tank volume requirements is desirable.

This BMP acknowledges that some herbicide formulations used in the UVM industry are in granular of other dry forms that cannot be incorporated in to Custom Blends. A longer-term goal for the industry would be to develop a means of formulating dry flowables that would stay suspended in a Dilute Concentrate form and be able to be included in R/R Closed Supply Containers.

Mixing

The addition of Concentrates and Dilute Concentrates to the spray tank should occur on the ROW job site. Filling of spray equipment fro Supply Containers containing RTU and RTA formulations should also occur only on the job site.

Mixing should not be done at any location where water being used as a diluent is acquired. Mixing should only be done on the job site, and at least 100 feet away from water crossings and wetlands.

Label instructions establish mixing requirements. In general the proper order of adding components is:

1. Half fill tank with diluents (water or basal oil)
2. Add Concentrate or Dilute Concentrate to the tank.
3. Add any supplemental adjuvants (e.g. surfactant, drift control agent, etc).
4. Add remainder of diluents to correct final fill volume.

Maintain a visible air gap between a water supply line and mix/spray tank. The use of an anti siphon check valve is a preferred practice when acquiring water.

Tracking and Record Keeping

This BMP is intended to create an auditable record documenting the movement of herbicides and containers through the Chain of Custody from Producer, through

Distributor, Custom Blender, Utility, Applicator, and return of empty containers to Custom Blender.

Tracking data should be maintained in a reasonably timely manner. The R/R Closed Supply Container should be tracked by its unique identification number. It would be preferable that the status of the contents (full, empty, partial) should also be tracked.

The following hand-off points along the supply chain may be useful in tracking the movement of R/R Closed Supply Containers and their contents, documenting the Chain of Custody for herbicides used in UVM:

- The order placed by an Applicator with a Distributor.
- Distributor refers order to Custom Blender
- Blending, filling and shipment of Supply Containers by the Custom Blender
- Tracking the status of a shipment may be available through a common carrier.
- Applicator receipt of shipment and placement in Applicator inventory.
- Allocation to a crew and/or job.
- Record of application made on job site.
- Status of empty container stored by Applicator
- Backhaul return of empty Returnable/Reusable Supply Containers to the Custom Blender.

The preferred method is that the tracking system be in the form of an electronic record that can be accessed remotely, such as an Internet-based system.

The industry's continued development of emerging information technologies such as use of bar coding, scanners, and other field-enabled technology represents emerging practices is encouraged. This would include automation of application records and the ability to tie the Supply Container and its contents to GIS coordinates of the application site. A geospatial record of application type indicating changes from general to wetland approved products for use near streams, lakes and seeps would aid in compliance with recent interpretation of Clean Water Act regulations as interpreted by the 6th Circuit Court. Ideally application data capability will include documentation related to temperature, relative humidity, wind speed and direction, and precipitation.

The Utility should have access to tracking data and documentation. Other stakeholders should have access to data, as appropriate to their needs. No open access to commercial/competitive information, nor is access by he general public to the data is intended. This BMP does not require or encourage the tracking of commercial information such as cost and pricing information.

Routine summary reports should be available. The tracking system should also have interactive lookup capability, and allow interrogation.

Inventory Management

This BMP is intended to create a system that allows an applicator to reduce the quantity of herbicide stored in inventory at any given time. This applies to herbicides in R/R Closed Supply Containers and in traditional one-way disposable containers.

The preferred practice is to adopt a "just-in-time" approach to inventory management where sufficient inventory is available on-site to provide for immediate and short-term needs. General guidelines include:

- Store no more than three weeks' supply on hand at any given time to meet anticipated demand.
- Store no more than 1/2 of the estimated job requirement on hand at any given time, unless it will be used within a few days.

Regulations related to custom blends prohibit Custom Blenders from producing Dilute Concentrates on a speculative basis. Dilute Concentrates are only produced when ordered for a specific Owner (Utility or Applicator as Owner's Agent) and purpose, and are shipped soon thereafter. Common carriers are typically able to provide reasonably accurate and reliable estimates of shipping times. The stability of some Custom Blends deteriorates over time. These factors should be considered when placing orders, and support a move to "just in time" inventory management.

It is recommended that users minimize the number of Supply Containers of Dilute Concentrates - such as foliar mixes - that are carried over dormant seasons when foliar applications are not possible. Likewise, the user should minimize the number of Supply Containers of Ready to Apply basal mixes during periods when no basal or cut surface applications are being made. The same should be true of concentrated packaged goods in one-way disposable containers. They should not be carried in inventory for long periods of time.

Minimize the number of partially full containers. The recommendation applies to both R/R Closed Supply Containers and one-way disposable containers.

The inventory of herbicides should be held in secure storage with access restricted to authorized, qualified personnel. This applies both to a permanent storage at a central location and any inventory in transit and assigned to specific crews and projects. Herbicide inventory should not be accessible by the general public. These requirements apply equally to full, partially full, and empty containers.

R/R Closed Supply Containers should not be stored for long periods of time in direct sunlight. Intense sunlight may compromise container integrity and the chemical stability of container contents.

Adequate inventory controls including processes and maintenance of documentation should be in place.

The unique ID numbers assigned to Returnable/Reusable Supply Containers can be used to maintain inventory records and may include status of contents (e.g., full, partial, empty).

Applicator Handling of Empty R/R Closed Supply Containers

This BMP is intended to promote a reasonable standard of care for R/R Closed Supply Containers, and to facilitate their timely return to the Custom Blender for refilling and reuse, or at the end of their life recycling.

Care should be taken to minimize container damage, wear and tear.

It is important to maintain integrity of container closure if it is to be reused. No additional openings should be made, such as puncturing or removal of the closed interlock valve.

It is important to preserve the integrity of any tamper-evident seals.

R/R Closed Supply Containers cannot be refilled by Applicators or Distributors, nor are they to be used for any other purposes.

Empty R/R Closed Supply Containers must be returned Custom Blenders within 30 days. The goal of a timely return of empties is less than 30-day turn, with a target not to exceed 60 days. Empty containers may be held by the Applicator until a full pallet of containers is accumulated for shipment. Empty R/R Closed Supply Containers should not be stored for long periods of time in direct sunlight.

Applicators should designate key contacts and job/drop locations for staging empty containers of all types.

Refilling Returnable Reusable Closed Supply Containers by Custom Blender

This BMP is intended to be consistent with all regulations governing the use of reusable containers.

A specific Custom Blender manages each fleet of R/R Closed Supply Containers and is responsible for all aspects of inspection and refilled.

R/R Closed Supply Containers are inspected to assure the integrity of each vessel and closure system, including tamper-evident seals, prior to refilling and reuse. They are pressure tested per UN/DOT Class II regulations prior to being put in service.

R/R Closed Supply Containers are "product-dedicated". They can only be refilled with the same basic custom blended herbicide formulations that they originally contained, including the same active ingredients and similar diluents, without triple rinsing. Otherwise the Custom Blender must triple rinse and thorough cleaning tanks, valves, and other components before refilling and re-use with different products.

Regulations preclude Custom Blenders from preparing Custom blends on a speculative basis and holding them in inventory in anticipation of an order. R/R Closed Supply Containers are only refilled with custom blends when an Applicator's order is placed with the Distributor and relayed to the Custom Blender. They are filled with formulations specified by the Applicator for a specific purpose.

Any prior labeling is removed and the refilled container receives new labeling specific to the contents of the R/R Closed Supply Container.

At the end of service life (5 years or 30 turns) the container is retired and decommissioned.

Decommissioning R/R Closed Supply Containers at End of Service Life.

This BMP is intended to promote the recycling of R/R Closed Supply Containers that have reached the end of their useful service life.

The closed connection valve is removed. When practical, it is refurbished and, if possible, returned to service on a new R/R container.

The returnable reusable vessel being retired is not to be re-purposed in any way. It should be rendered unusable and it, as well as the other plastic parts such as the sump, should be recycled.

The R/R Closed Supply Container's unique ID number should be retired. It should not be reissued to a new container. A record of the ultimate disposal of the container and number should be maintained.

The Custom Blender is responsible for decommissioning and disposal of their R/R Closed Supply Containers. Decommission tasks are completed at the Custom Blender's facilities, not in the field.

Use of Traditional One-Way Disposable, Open Containers.

Financial analysis has demonstrated that this BMP can be adopted without the industry incurring any additional cost. However, some package good products supplied in single use disposable one-way containers will continue to be used in the UVM industry. Examples of where it is appropriate to use traditional one-way disposable, open containers include:

- When the requirements of a small project result in the need to mix small quantities involving less that 60 gallons (4 -15 gallon containers) of Dilute Concentrate.
- When an Applicator expects to use less than 270 gallons (two pallets of 9 - 15 gallon containers) of dilute concentrate per year

- Short interval immediate demand, where there would be no time to order and receive a custom blend.
- When there is a need to add additional Active Ingredients to control a specific species.
- When using a dry flowable that is otherwise unstable in a custom blend.

When single use disposable one-way containers are used they should be stored, used, and disposed of properly in a manner consistent with label requirements. Empty one-way containers require triple rinsing per regulations that require:

- Container to be filled to 25% volume for each of three rinses to achieve 99% decontamination. This means that the total volume of rinsate will be the equivalent of 75% of the volume of each one-way container.
- Rinsing be done "promptly", reducing the practice of gather up and storing empties for rinsing later off-site in large batches.

The preferred method of disposing of rinsate generated from triple rinsing one-way disposable containers is to rinse them on the job site, pour the rinsate into the spray tank as part of the required diluent, and apply it properly on the job site.

One-way disposable containers should be rendered unusable by crushing, puncturing, or other means. The preferred method of final disposal of the one-way container is by recycling.

It may be possible to use the "jet rinse" process to prepare empty one-way containers for disposal. In this process the container is punctured and a high-pressure spray is directed to the inside of the container. It is an approved method of processing empty disposable containers in some regulatory jurisdictions.

One-way disposable containers used to supply herbicides as "package goods" are specifically precluded from reuse for any purpose and are not to be re-filled and used as a "Service Container".

Commercial Considerations

This BMP is intended for use as a specific reference in Utility specifications for the procurement of vegetation management services under contracting with applicators. It may also be used in the establishment of standard work practices for a Utility's in-house resources.

This BMP is intended for use by Applicators in purchase agreements for herbicides from Distributors, and flow-through orders from a Distributor to a Custom Blender.

The preferred method for acquiring herbicide concentrates, Custom Blends, and Ready to Use formulations is for them to be purchased directly by the Applicator from the Distributor. It is less common for herbicide concentrates, Custom Blends, and Ready to Use formulations to be purchased directly by a Utility and subsequently provided to the Applicator.

Quality Compliance Audits

Audit are recommended to assure consistency with the intended outcomes and this BMP. The recommended approach is to "trust but verify".

Custom Blenders should have Quality Control processes in place and be able to provide documentation demonstrating that the Dilute Concentrates and Ready to Apply formulations being provided are of the required level of quality, contain all specific contents, and that no unauthorized substitutions were made.

Custom Blenders should have written agreements and protocols from the herbicide Producers that address specific quality control procedures that must be followed.

The Custom Blender should retain sample specimens of each batch of Dilute Concentrate produced for a specific Applicator and job. These samples should be retained through the end of the second growing season following the season of application. These samples should be available for analysis by the Producer, Distributor, Applicator or Owner upon request.

Distributors should have Quality Control processes in place and be able to provide documentation demonstrating that the Dilute Concentrates and Ready to Apply formulations being ordered by the Applicator were accurately relayed to the Custom Blender, and that no unauthorized substitutions were made.

Applicators should have Quality Control processes in place and be able to provide documentation demonstrating that the Dilute Concentrates and Ready to Apply formulations specified by the Utility are what has been purchased and applied to the ROW, and that no unauthorized substitutions were made.

The Utility should have Quality Assurance processes in place that include the right to audit Custom Blenders' and Applicators' practices from order, through application and return of empty returnable/reusable container. The Utility and Applicator may audit the Custom Blender's facilities, or rely on audit reports from others.

Producers may audit Custom Blender facilities and assess the Dilute Concentrate and Ready to Apply formulations being produced.

Appendix C: Standard Formulations of Custom Blends Used in Financial Analysis

Table 3 Representative Custom Blend formulations used in each of four application methods typically used in the UVM industry.

Active Ingredients, adjuvants, and diluents	Low Volume Basal ready to apply mix, (no dilution)	Low Volume Foliar 15gal:300gal (1:20 dilution)	Hydraulic Foliar 15gal:900gal (1:60 dilution)	Aerial Application 15gal:150gal (1:10 dilution)
Garlon 4 Ultra	20.00%			
Garlon 3A			45.00%	70.00%
Tordon K	5.00%		15.00%	10.00%
Milestone VM		10.00%	3.30%	
Accord VM		70.00%		
Arsenal		5.00%		
Surfactant		10.00%	15.00%	20.00%
Total A.I.	25.00%	95.00%	78.30%	100.00%
Water as diluent		5.00%	21.70%	0.00%
Basal oil as diluent	75.00%			

Appendix D: Universal Assumptions Used in Financial Analysis

Table 4 Values for, and explanation of, variables common to all aspects of the financial analysis

Variable	Range	Source / Notes
Cost of Capital	9%	This value is based on feedback from Utility and Customer Blenders, and represents a middle value within the reported range.
RR Closed Supply Container chronological life	5 years	Based on Custom Blender's expectations for containers currently in use.
λ_1 RR Closed Supply Container service life	30 turns	Based on Custom Blender's expectations for containers currently in use
RR Closed Supply Container size	15 gallons	Based on containers currently in use
Disposable container size	2.5 gallons	Based on one-way package goods in common use
Labor cost – Custom Blender	$50/hr	Fully loaded cost of technician labor
Labor cost - spray crew	$25/hr	Homogenized fully loaded cost (billable rates) for field force labor, all classification
Crew hours / day	9 hours	Both 8 and 10-hour workdays are common for spray crews. Aerial crews work irregular hours. 9 hours was selected as a reasonable common value.

Appendix E: Application Specific Assumptions Used in Financial Analysis

Table 5 Application specific *Data*[4] used across all initiatives.

	DC: LV Foliar	DC: HV Foliar	DC: Aerial	R2U: Basal
Spray or Mix Tank Size	250 gal	300 gal	1000 gal	50 gal
Active ingredient in custom blend supplied in RR Closed Supply Container	96%	78.3%	100%	100%
Total applied mix from custom blend supplied in RR Closed Supply Container	300 gal	900 gal	150 gal	15 gal
Purchase price[5] of custom blend in RR Closed Supply Container	±$27/gal	±$52/gal	±$87/gal	±$54/gal
Length of a typical spray season (application days/yr)	72 days	72 days	65 days	100 days
Cost of resolving claims and complaints per season	$1,000/crew	$1000 /crew	$2000/crew	$500 /crew
General Foreman cost of managing claims and complaints per season	$500/GF	$500/GF	$500/GF	$500/GF
Mix over error incident rate: How often is an application ready mix too "hot"? (frequency of occurrence)	3.0%	3.0%	3.0%	0.0%
Mix error: If a mix is too "hot", how much over the intended rate?	4.0%	2.0%	2.0%	0.0%
Mix under error incident rate: How often is an application ready mix too "light"? (frequency of occurrence)	1.0%	1.0%	1.0%	0.0%

[4] The references and calculations for the data in this table are provided in the appendix
[5] Based on market rated in Q1 2010. Values reported are rounded to nearest $1.to preserve commercial confidentiality. Actual rates were used financial analysis.

Appendix F: Returnable Reusable Container Assumptions Used in Financial Analysis

The following table lists calculated variables, their ranges, and the sources and assumptions (in italics) made for modeling purposes for the RR initiative. Some of the calculations are representative of the HV Foliar case.

Table 6 Values for, and explanation of, variables used in the financial analysis of use of Returnable Reusable containers.

Variable	Range or Typical Value	Source / Notes
Reusable/returnable container unit cost	$35	This is the cost of the 15-gallon plastic container used in the current version of the RR Closed Supply Container, based on input from Custom Blenders.
RR Closed Supply Container chronological life	5 years	Based on Custom Blender's expectations for containers currently in use.
RR Closed Supply Container service life	30 turns	Based on Custom Blender's expectations for containers currently in use
Prep time prior to reuse and refill of RR Closed Supply Container	5 min	Includes receiving, inspection, cleaning and prep for refill, Based on Custom Blender experience of >1 pallet (9 containers) per hour.
Round Trip Shipping cost for Custom Blends RR Closed Supply Container	$2.00/gal	Based on a survey of shipping rates provided by custom blenders. Custom, Rates varied from < $1.50/gal for short distances to >$3.00 for delivery to West Coast. Estimated that 2/3 of cost is outbound when containers are full and 1/3 cost for return of empties.
End of life processing time per RR Closed Supply Container	10 min	Decommission the RR Closed Supply Container including extract valve, triple rinsing, retiring ID number.
Disposal cost for RR Closed Supply Container	$0/container	There are pesticide industry container disposal programs available. They are well suited to Custom Blenders operating at a fixed location..
Damage/loss rate for RR Closed Supply Containers	1.0%/yr	Rate of damage and/or loss resulting in the need to replace RR **Closed Supply Containers,** based on experience of Custom Blenders,
Applicator crew time required to transfer custom blend from RR Closed Supply container to spray tank	7 min/man hr.	Time to transfer custom blend to mix or spray tank with minimal measuring and mixing required. Based on Applicator experience. Low estimate of 5 min to high of 11 min per man-hour. Assumes a transfer is a two-person operation.
Value of Green PR or Goodwill benefit	$0	Study was unsuccessful in establishing quantitative estimate of the qualitative "soft " benefit s of using returnable containers.

Appendix G: One-Way Disposable Container Assumptions Used in Financial Analysis

Table 7 Values for, and explanation of, variables used in the financial analysis of use of one-way disposable containers.

Variable	Range or Typical Value	Source / Notes
Cost of a 2.5 gallon one-way disposable container	$3.33	Based on data provided by Producer. Low estimate of $2.90, to high of $3.75. Includes container, cap, labels, packaging,
One-way shipping discount factor	0.67	This factor is used adjust the round trip shipping cost of RR Closed Supply container. Assumes that outbound shipping cost are similar due to similar weights and volumes, and no return shipping of empties.
Applicator crew time required to transfer package goods in one-way disposable containers to spray tank	20 min/ man hr	Time to open containers, measure and transfer combination of active ingredients and adjuvants to mix or spray tank. Based on Applicator experience. Low estimate of 15 min to high of 30 min per man-hour. Assumes a transfer is a two-person operation.
Applicator time required for rinsing & processing a one-way disposable containers	5 min.	This is the time required to properly triple rinse (25% vol. each time) and render each one- way disposable containers unusable. Based on Applicator experience either doing this in a job site or at a central location.
Transport of an empty one-way containers for disposal	$0.75	Once cleared and crushed they will need to be saved, then taken to disposal facility, preferably for recycling. This is the cost of collecting, saving, and transporting the rinsed and crushed container to a disposal facility.
One-way container disposal fee	$0.10	This is potential done at no cost if centralized, but given the disperse nature of work locations it is more likely to be done at facilities that require a fee.

Appendix H: Closed Connection Assumptions Used in Financial Analysis

Table 8 Values for, and explanation of, variables used in the financial analysis of use of closed connections at transfer points.

Variable	Range or Typical Value	Source / Notes
Cost of RR Supply Container closure system	$50	This includes the cost of the valve, sum, tamper evident seal, ID tags and labor to assemble. Everything but the plastic container itself, , based on input from Custom Blenders. .
RR Close Supply Container cost recovery support program from Producers	0%	This is a placeholder that was created to account for any assistance Producers provided to Custom Blenders in initially establishing a fleet of RR Closed Supply Containers. No reimbursement program was identified.
Applicator cost to set up a rig for use of RR Closed Supply Containers	$500	Estimated cost of valves, fittings, hoses and container handling equipment. Based on Applicator experience. Low estimate of $400 to high of $500 per rig.
Applicator cost for transfer pumps	$500	Estimated cost of pumps used to transfer custom blends from RR Closed Supply Container to spray or mix tank. Manual and electric options available. Low estimate of <$200 to $700 per pump.
Applicator set up cost recovery support program from Producers	80%	This is the percent of cost that is potentially recoverable through an equipment reimbursement program offered by one Producer. The support is offered in the form of a rebate program and is based on applied volumes. Study suggests that medium and large scale applicators have the potential to recover 100% of their cost in the first season.
Pump maintenance	$100/yr	The cost to rebuilding a transfer pump each spray season. One pump per spray rig.
Valve failure rate	0.0%	This is a placeholder anticipating that valves on spray figs would fail at a measurable rate. Valve failures were not reported as a significant problem.
Realizable benefit capture rate from using closed transfer interlocks	20%	This is a factor used reduce the expected benefits of use of a closed system. This is a form of "reality check" commonly used in financial analysis. It recognizes that rarely are all potential benefit realized, In this case we are expecting to capture only 20% of theoretical value being created, and is appropriately conservative.
Adverse Applicator exposure (health)	$-	Cost implication of adverse exposure on health. Adopting close system reduces applicator exposure, but health risks are already low. The affect is negligible.
Regulatory attention (inspections & investigations)	$-	Cost exposure to increased regulatory attention such as inspections following adverse events. Current exposure is already low, The affect is negligible.

Appendix I: Tracking System Assumptions Used in Financial Analysis

Table 9 Values for, and explanation of, variables used in the financial analysis of the impact of a container tracking system on inventory.

Variable	Range or Typical Value	Source / Notes
Pre-tracking excess inventory	20 days	This is an extra 20 days supply of inventory based on the typical use rate during normal operation during the spray season.
Excess contingency inventory	50% of total excess	Inventory held as a contingency for unplanned demand
Improvement in contingency inventory using tracking	50% reduction	Reduction in the excess inventory on hand because of perceived need to cover unknown contingencies. Assumed rate of improvement due to implementation of tracking system.
Excess concentrate inventory	30% of total excess	Inventory in the form of partial pallet orders, open partially full containers, and mismatches in ratios of products purchased
Improvement in excess concentrate inventory using tracking	30% reduction	Reduction in the excess inventory on hand because of excess concentrated on hand. Assumed rate of improvement to implementation of tracking system.
Over-prediction inventory	20% of total excess	Inventory held in excess of need due to inaccurate estimating.
Improvement in over-prediction inventory using tracking	5% reduction	Reduction in the excess inventory on hand because of inaccurate estimation of needs. Assumed rate of improvement due to implementation of tracking system.
Improvement in risk of inventory shortage using tracking	25%	Reduction in the risk of not having the right herbicides and adjuvants on hand when needed available through the use of a tracking system
Cost of expedited shipping if inventory on hand is inadequate	2X standard shipping cost	The premium cost of shipping for a last minute expedited delivery.
Days of inventory ordered on an expedited basis	1 day	Estimated quantity of inventory that would have to be ordered on a list minute expedited basis to avoid running out.
Inventory Shrinkage	2%	Amount of inventory loss due to all causes.
Shrinkage due to misallocation	70%	Amount of inventory loss due to poor accounting, misallocation to jobs, and misplacement.
Improvement in misallocation rate using tracking	50%	Reduction in accounting errors etc causing misallocation. Assumed rate of improvement due to implementation of tracking system.
Shrinkage due to	30%	Amount of inventory loss due to theft.

misappropriation		
Improvement misappropriation rate using tracking	30%	Reduction in loss due to theft. Assumed rate of improvement due to implementation of tracking.
Cost to enroll RR Closed Supply Container in tracking system	$1/container	This is based on set-up fees for an Ag, industry internet based tracking service.
Cost of a scan cost per container per location	$0.05/scan	This is based on the transaction fees for an Ag. Industry internet based tracking service
Number of locations per container	4	Number of time the container might be scanned.