Innovative Herbicide Sprayers for Roadsides, Slopes and Ditches
The Minnesota Department of Transportation (Mn/DOT) has been active in developing the best technology for roadside vegetation control. One method, herbicide spraying, helps eliminate unwanted vegetation. Treatment of unwanted weeds often requires the use of different herbicides. Sprayers must have the capacity to spray more than one chemical at a time, negotiate rough terrains, and apply herbicides safely and in a way that preserves the environment. This report presents the results from testing and evaluating four automated sprayers: The B&B Ditch Sprayer 300 Prototype, a Wanner Innovative Sprayer, the Micro-Track Spray System, and the SCS 750.

All four tested sprayers are more economically feasible than the traditional sprayer. The B&B Ditch Sprayer has the lowest net annual savings of the four tested sprayers. The Wanner Sprayer is more economical for use in large districts or in areas with extensive road miles. The Micro-Track Sprayer has the highest rate of return, and also reduces annual costs. The SCS Sprayer has the highest net annual savings and also can monitor, tabulate, and print all vital statistics. The report details product features, testing, and results.
Innovative Herbicide Sprayers for Roadsides, Slopes and Ditches

Final Report

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The author and the Minnesota Department of Transportation do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to this report.
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1. Carrol Evans, Mn/DOT District 6B, Owatonna, Maintenance Superintendent
2. Wes Smith, Mn/DOT District 7A, Maintenance Supervisor
3. Jack Fiereck, Mn/DOT District 7A, Maintenance Supervisor
4. Joan Smith, Mn/DOT, Central Office Maintenance
5. Graphics Unit, Mn/DOT, Central Office Communications
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The Minnesota Department of Transportation (Mn/DOT) has been active in developing the best technology for roadside vegetation control. One method of vegetation control is the use of herbicides. Herbicide sprays help to eliminate unwanted vegetation. The control of weeds along Minnesota's highways is an important part of good highway maintenance and grooming. For many years Mn/DOT has managed roadside slopes and ditches using an inverting unit that offered effective herbicide placement and minimized drifting of the herbicide onto adjacent properties. This method provided good control of herbicide drift, but products used with this system did not always get the job done and in many cases were ineffective.

As operators identify and treat unwanted weeds, it is necessary to use different herbicides to obtain maximum control of unwanted vegetation. To accomplish this, the need for conventional sprayer has been realized in recent years. The conventional sprayer must have the capacity to spray more than one chemical at a time. The sprayer must be able to negotiate rough terrain and travel through wet and soft ground. Another criterion for the sprayer is the capability to spray herbicides while still maintaining a safe and comfortable environment for the operator. Analogous to the safety of the equipment operator is the preservation of the environment. The ability for the sprayer to apply herbicides at an accurate, uniform and specified dosages is very important.

Pursuant to the need of a conventional sprayer, the Maintenance Research Office has been involved with the testing and evaluation of four (4) automated sprayers. Maintenance workers from the Mankato and Owatonna areas recommended the following:

I. The B&B Ditch Sprayer 300 Prototype was developed by B&B Custom Fabrication of Garden City, Minnesota. This equipment contains a 300-gallon over-shaped plastic tank. The sprayer is equipped with two spray booms each consisting of drop nozzles. The spray boom provided a 60-foot spray pattern. The spray boom has an innovative spring-loaded feature.
II. The Mankato Maintenance Area tested and evaluated the second sprayer, a Wanner Innovative Sprayer. The sprayer system includes an eight hundred and fifty gallon (850 gallon) stainless steel tank. The spray material is dispensed from the tank and delivered to the spray nozzles via a pumping system. The sprayer has spray booms consisting of drop nozzles and end mounted boom buster roadside nozzles. Additionally, there is a single straight stream nozzle mounted on the end of the boom. The system is also equipped with drop nozzles, which are used for spraying road shoulders. All spray nozzles are remotely controlled from the truck cab. The Wanner Innovative Sprayer was mounted on a Class 33, 1993 model truck.

III. The third sprayer evaluated was the Micro-Track Spray System, a multiple injection spray system with console monitors. This system has the unique characteristic of being able to be connected to any size supply tank. The system is capable of spraying up to five different herbicides simultaneously. The supply tank, chemical tanks, pumps, monitors and nozzles are all mounted on one unit (tractor). No trailers are needed for this spray system.

IV. The fourth sprayer is the SCS 750, which was developed by Raven Industries Inc. of Sioux Falls, South Dakota. The SCS 750 can independently control the liquid, and granular dispensing systems and the overall hydraulic system at the same time. The console can regulate five chemicals or four chemicals and a carrier at one time. If spot spraying is needed, each chemical can be controlled by a manual switch. Hand spraying attachments also are available for spot spraying. The spray rate is controlled by a wheel driven speed sensor. Visual and audible alarms alert the operator to any deviation from the programmed rate of application. Measurements can be calculated using the metric or U.S. measurement systems. Calibrations and weather information are stored in the ten-year memory capacity. A compact printer is plugged into the 750 console to obtain a readout of the daily activities. The SCS 750 Chemical Injection System can be equipped with up to ten (10) spray booms. Each spray boom has down spray nozzles and end boom buster nozzles. The booms are controlled via a boom control box. The SCS 750 Spray System uses a 300-gallon elliptical tank that is placed on a trailer. This injection system was developed by Raven Industries Inc. of Sioux Falls, South Dakota.
INTRODUCTION

The Minnesota Department of Transportation (Mn/DOT) has been active in developing the best technology for roadside vegetation control. One method of vegetation control is the use of herbicides. Herbicide sprays help to eliminate unwanted vegetation. The control of weeds along Minnesota’s highways is an important part of good highway maintenance and grooming.

“For many years Mn/DOT has managed roadside slopes and ditches using an inverting unit that offered effective herbicide placement and minimized drifting of the herbicides onto adjacent properties. This method provided good control of herbicide drift, but products used with this system did not always get the job done and in many cases were ineffective” says Carrol Evans, Maintenance Superintendent at the Owatonna office. “Diesel fuel was the choice carrier for the herbicide. This caused burning of grasses and vegetation and because of environmental concerns, Mn/DOT has stopped using this practice. In some cases crop oil was used as a carrier, but also proved to be ineffective.”

In recent years, many new herbicides that can be applied using a conventional sprayer and water as the carrier have been introduced. This, along with drift control agents has helped to minimize the drift problem.

As operators identify and treat unwanted weeds, it is necessary to use different herbicides to obtain maximum control of unwanted vegetation. To do this requires several different applications to gain control over unwanted weeds. These unwanted weeds are located on a wide range of topographic relief. The terrain that has to be treated is sometimes rugged. For this reason the equipment that is used must be able to negotiate rough terrain. It should be versatile enough to travel through wet and soft ground. Another operational consideration is the toxicity of herbicides. Due to the toxic nature of most herbicides, extreme care must be taken to ensure the safety of the equipment operator. The ability to spray herbicides while still maintaining a safe and comfortable environment for the operator is very important.
Analogous to the safety of the equipment operator is the preservation of the environment. To accomplish this preservation, herbicides must be applied in accurate, uniform and specified dosages. The ability for any spray mechanism to meet this requirement is a real benefit.

Any new spray mechanism should be cost effective. That is, it should be economically feasible to implement the use of the equipment.
BACKGROUND

During the late 1980's concerns arose within Mn/DOT regarding the shrinking work force and budgets. Another concern was for the public's expectations for better services. For those reasons, Mn/DOT started the Maintenance Operations Research Program. This program was developed for the purpose of formulating and initiating new maintenance technologies and methods to optimize Mn/DOT's resources.

The program was started in 1990 with one part-time Maintenance Operations Research Engineer (M.O.R.E.). In May 1992 the first full-time M.O.R.E. was hired.

The Maintenance Operations Research Program covers anything relating to Mn/DOT's maintenance operations activities. Mn/DOT's maintenance operations activities include equipment, materials, processes and methods. The program promote applied or "on the road" research, but at times will support directly related laboratory research. Mn/DOT's maintenance research unit and the University of Minnesota are often partners in researching, testing and developing new ideas in transportation. Not only does Mn/DOT's maintenance research unit work with local education and private business institutions, the unit also works with national and international government, education and private business institutions. Research engineers from Mn/DOT have been working with transportation engineers and institutions from Sweden, Norway, Canada, and Finland. The main focus of study between those countries and Mn/DOT has been winter road maintenance.

The maintenance research program also encourages active maintenance workers involvement from all maintenance areas. The program has an annual budget of $750,000. Other funds may include Federal Highway Administration (FHWA) grants/reimbursements as well as funds from other research bodies. Equipment and materials vendors who are involved in research partnerships may contribute toward a certain research program.

One focus of study of the maintenance research program is the elimination of unwanted roadside vegetation. This involvement has brought about the testing and evaluation of four automated
sprayers. Those sprayers were recommended by maintenance workers from various maintenance areas. The following will discuss the characteristics of each sprayer along with appropriate diagrams, photographs and other illustrations.
SPRAYERS

The Mankato maintenance area has been active in developing new sprayers and has field tested and evaluated three commercial sprayers; the B&B Ditch Sprayer 300 Prototype, the Wanner Innovative Sprayer, and the Micro-Track Spray System. In addition to these, the Owatonna maintenance area field tested a SCS 750 Chemical Injection System Sprayer.

I. B&B Ditch Sprayer 300 Prototype

The B&B Ditch Sprayer 300 Prototype was developed by B&B Custom Fabrication of Garden City, Minnesota. This equipment contains a 300 gallon, oval-shaped plastic tank. The oval shape of the tank keeps its center of gravity closer to the ground as opposed to a circular tank. This makes the Ditch Sprayer 300 more stable and mobile on adverse terrain. The Ditch Sprayer 300 also is equipped with two spray booms consisting of drop nozzles and end-mounted Boom Buster roadside nozzles. The spray boom provides a 60 foot wide spray pattern. This lengthy spray pattern makes it more possible to treat areas that were not accessible with sprayer with shorter spray patterns. The spray boom has an innovative spring-loaded feature.

A spring-loaded boom makes it possible for the Ditch Sprayer 300 to travel more easily through areas that are occupied with sign posts, railings, and other obstacles. The Ditch Sprayer 300 Prototype seen in Figure 3.1, can be attached to a tractor. A tractor equipped with an environmentally controlled cab can give comfort and safety to the operator from the chemicals being sprayed. The Ditch Sprayer 300 has one noticeable disadvantage; it is able to spray only one chemical at a time. The sprayer model tested costs about $6,443.00.

II. Wanner Innovative Sprayer

The second sprayer field tested and evaluated by the Mankato Maintenance area was a Wanner Innovative Sprayer seen in Figure 3.2.
This sprayer system includes an eight hundred and fifty gallon stainless steel tank. This tank is separated into two compartments (200 gal. - 650 gal. split). Each compartment has a sixteen-inch full opening manhole. The tank includes dual suction lines for the main compartment and spare tubes in both compartments for agitation of the spray materials. The spray material is dispensed from the tank and delivered to the spray nozzles via a pumping system.

The pumping system includes strainers, electric solenoid valves and sprayer control consoles along with all necessary valves and fittings. The system can deliver approximately sixty gallons of liquid per minute at 60 psi through the spray nozzles via a spray boom.

The spray boom consists of drop nozzles placed approximately two feet apart on the main twelve foot section of the boom, and end mounted Boom Buster roadside nozzles. Additionally, there is a single straight stream nozzle mounted on the end of the boom. The straight steam nozzle is remotely controlled from the truck cab to vary the spray angle. Each section of the boom (drop nozzles, Boom Buster and straight stream) is controlled by electric controls mounted in the truck cab. This system has the capability to vary the spray pattern from ten feet to seventy-five feet while maintaining the same desired rate per acre. The system also is equipped with drop nozzles, which are attached to a metal frame. This frame depicted in Figure 3.3 is located approximately two feet directly below the truck’s tailgate. Those drop nozzles are used for spraying road shoulders and is remotely controlled from the truck cab.

The Wanner Sprayer allows the user to tank mix two types of herbicides independently and dispense from either tank on the go at a uniform desired rate. This uniform rate of application is accomplished by the use of a KC-2500LS cruise control. The KC-2500LS, which is shown in Figure 3.4, enables highly uniform application rates by providing precise ground speed control from 4-25 mph (± 0.5 mph).
Figure 3.1 - B&B Ditch Sprayer 300 Prototype

Figure 3.2 - Wanner Innovative Sprayer
Figure 3.3 - Drop Nozzle Attached to Frame

Figure 3.4 - KC-2500LS Cruise Control
This type of sprayer was mounted on a class 33, 1993 model truck. The boom is mounted to the wing mast. The existing truck hydraulic system is used to operate the hydraulic driven pump.

The Wanner Innovative Sprayer works well for large scale spraying. Wes Smith, Mankato Sub-area Supervisor, has indicated that the system works well and is effective in controlling unwanted vegetation. He predicts a 30 percent reduction in spraying labor costs.

Though the Wanner Sprayer is an impressive and innovative piece of equipment, it is costly. The system costs approximately $11,200. It also requires the full dedication of a Class 33 truck. A benefit cost analysis was conducted and presented in Appendix A to determine the economic feasibility of all four sprayers.

III. Micro-Track Spray System

The third sprayer evaluated was the Micro-Track Spray System, which was developed by Micro-Track of Minnesota and proposed by Jack Fiereck, Area Supervisor at the Le Sueur Truck Station, Mankato maintenance area.

The Micro-Track Spray System in Figure 3.5 is a multiple injection spray system with a console monitor (see Figure 3.6).

This system has the unique characteristic of being able to be connected to any size supply tank. The system is capable of spraying up to five different herbicides simultaneously. Boom Buster nozzles are used with this spray system. Each nozzle emits a thirty-five foot spray pattern. The supply and chemical tanks, pumps, monitors and nozzles are all mounted on one unit (tractor). A trailer is not needed for this spray system.

The Micro-Track Spray System costs approximately $5,684. It has a life expectancy of about twenty years. The expected annual spraying time saved, according to Mr. Fiereck is two hundred to three hundred hours. He said savings will come about from the use of less operators, reduction in the
number of trips made due to a multiple herbicide spray, more efficient chemical usage and a reduction on the amount of time dedicated to spraying. The only problem indicated from the Micro-Tech Spray System field test is that liquid remains in the spray lines after spraying is completed.

IV. SCS 750 Chemical Injection System

Carrol Evans, Superintendent of Mn/DOT’s Owatonna maintenance area was the project sponsor for the SCS 750 Chemical Injection System. This injection system was developed by Raven Industries Inc. of Sioux Falls, South Dakota. This system seen in the following Figure 3.7 is comprised primarily of: A) operator console and cables; B) flowmeter; C) control valves; D) mixer; E) injection modules; F) speed sensor; G) chemical tank(s); H) boom control box.

The SCS 750 can independently control the liquid, and granular dispensing systems and the overall hydraulic systems at the same time. The console can regulate five chemicals or four chemicals and a carrier at one time. If spot spraying is needed, each chemical can be controlled by a manual switch. Hand spraying attachments are also available for spot spraying. The spray rate is controlled by a wheel driven speed sensor. Visual and audible alarms alert the operator to any deviation from the programmed rate of application. Measurements can be calculated using the Metric or U.S. Measurements Systems. Calibrations and weather information are stored in the ten-year memory capacity.

This system makes it easy to check distances, volume left in the tanks, total volume applied, application (volume/min.), total areas covered and time. Simply push a button and readings for each chemical and the carrier appears all at one time on the console screen as indicated in Figure 3.8.
Figure 3.5 - Micro-Track Spray System

Figure 3.6 - Console Monitor
Figure 3.7 - SCS 750 Chemical Injection System

Figure 3.8 - Console Screen
A compact printer is plugged into the 750 console to obtain a readout of the daily activities, i.e., product used, amount used, distance covered, amounts remaining, speed, operator, wind, temperature, date and time. This satisfies the legal requirements for record keeping, and also works well for test sections of new chemicals. An example of a typical printout is shown in Figure 3.9.

An injection module is required for each chemical being injected. The module includes a positive displacement metering pump driven by a 12-volt motor. Also included in this package is a motor control, flow switch, vacuum switch, three-way valve, and a stainless steel housing. Custom-designed poly tanks for the injections system are offered in 8, 16, and 24 gallon sizes.

The SCS 750 chemical injection system can be equipped with up to ten spray booms. Each spray boom has down spray nozzles. These nozzles provide a sixty-foot spray pattern. The booms are controlled via a boom control box. The operating angles of the boom can be adjusted to make the boom parallel with any grounds being sprayed. The boom control is also used to rise or lower the boom to avoid objects such as sign posts, and guard rails when traveling. The SCS 750 Spray System uses a 300-gallon elliptical tank that is placed on a trailer. The trailer is equipped with floatation tractor tires making it suitable for travel in wet areas. This spray system costs approximately $12,950 as tested.
**Figure 3.9 - Printer**

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VEHICLE TOTAL AREA: [Value] FIELD AREA: [Value]

Initial: [Name]

Notes: [Notes]

X denotes data change by operator between Meters and End of Field.

--- Figure 3.10 - Sample Printout ---
CONCLUSION

All four tested sprayers are more economically feasible than the traditional sprayer (see Appendix). The B&B Ditch Sprayer has the lowest net annual savings ($23,255) of the four tested sprayers. However, it offers a rate of return of 360 percent, greater than the rate of return received from the Wanner Sprayer (76 percent).

The Wanner Sprayer is more economical for use in large districts or in area with extensive road miles. This is due to the Wanner Sprayer’s capability for applying herbicides at high speeds and accurate amounts. The large site of the supply tank is also a factor in the Wanner Sprayer’s ability to service large areas.

The Micro-Track Sprayer has the highest rate of return (1142 percent). It is also able to reduce cost by about $64,942 annually.

The SCS 750 Sprayer has the highest net annual savings ($65,812). This sprayer also has the added advantage of being able to monitor, tabulate and print all vital statistics (area, dosages, weather conditions, application rate, etc.). This form of record keeping is important for environmental, social and legal reasons.
APPENDIX
An economic analysis was performed as a comparison between the tested sprayers and the traditional sprayers. The Mankato district was used as an example for performing this economic analysis. According to the Mankato maintenance workers, approximately three hundred (300) miles of roadside is treated with herbicides in the Mankato district. This constitutes an area of about four thousand three hundred and sixty (4,360) acres. This economic analysis took into consideration the cost savings on labor, materials, equipment and the maintenance of the equipment. An annual interest rate of eight percent (8%) was used for this analysis.
### Traditional Sprayers

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**Cost:**

- **Labor**: $27,250/year
- **Materials**: $162,454/year
- **Maintenance**: $300/year
- **Equipment**: $5,500

**Total Annual Cost:**

- Equipment = $5,500 (A/5,500, 8%, 20) = $564.00
- Labor = $27,000.00
- Materials = $162,400.00
- Maintenance = $300.00
  - Total = $190,264.00/year
### B & B Ditch Sprayer 300 Prototype

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<td>Equipment</td>
<td>$6,443</td>
</tr>
</tbody>
</table>

**Total Annual Cost:**

| Equipment = $6,443 (A/6,443, 8%, 20) = $656.00 |
| Labor = $21,800.00 |
| Materials = $144,403.00 |
| Maintenance = $150.00 |
| Total = $167,009.00/year |
Wanner Innovative Sprayer

Equipment $11,200
Labor $25.00/hour
Material $25.44/acre
Maintenance $300.00/year
No. of Acre 4,360
Life Expectancy 20 years
Working Rate 12 acre/hour
Class 33 Truck $55,000
Truck Cost Rate $24.50/hour
Life Expectancy of Truck 10 years

Cost:

<table>
<thead>
<tr>
<th>Component</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor</td>
<td>$9,100/year</td>
</tr>
<tr>
<td>Materials</td>
<td>$111,000/year</td>
</tr>
<tr>
<td>Maintenance</td>
<td>$300/year</td>
</tr>
<tr>
<td>Truck</td>
<td>$55,000</td>
</tr>
<tr>
<td>Equipment</td>
<td>$11,200</td>
</tr>
<tr>
<td>Cost Rate</td>
<td>$9,800/year</td>
</tr>
</tbody>
</table>

Total Annual Cost:

- Equipment = $11,200 (A/11,200, 8%, 20) = $1,141.00
- Labor = $9,100.00
- Materials = $111,000.00
- Truck = [$60,000 (p/f. 8%, 10) + $55,000] (A/P, 8%, 20) = $8,436.00
- Truck Cost Rate = $9,800.00
- Maintenance = $300.00

Total $139,777.00/year

The truck cost rate is the amount of money lost by not using the truck during the winter season. A Class 33 truck can be used during the winter for snow and ice control.
### SCS 750 Chemical Injection System

<table>
<thead>
<tr>
<th>Equipment</th>
<th>$12,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor</td>
<td>$25.00/hour</td>
</tr>
<tr>
<td>Material</td>
<td>$25.44/acre</td>
</tr>
<tr>
<td>Maintenance</td>
<td>$200.00/year</td>
</tr>
<tr>
<td>No. of Acre</td>
<td>4,360</td>
</tr>
<tr>
<td>Life Expectancy</td>
<td>20 years</td>
</tr>
<tr>
<td>Working Rate</td>
<td>9 acre/hour</td>
</tr>
</tbody>
</table>

#### Cost:

- **Labor** $12,111/year
- **Materials** $110,918/year
- **Maintenance** $200/year
- **Equipment** $12,000

#### Total Annual Cost:

\[
\text{Equipment} = \frac{A/12,000}{8\%, 20} = \$1,223.00 \\
\text{Labor} = \$12,111.00 \\
\text{Materials} = \$110,918.00 \\
\text{Maintenance} = \$200.00 \\
\text{Total} = \$124,452.00/year
\]
Micro-Track Spray System

<table>
<thead>
<tr>
<th>Equipment</th>
<th>$5,684</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor</td>
<td>$25.00/hour</td>
</tr>
<tr>
<td>Material</td>
<td>$25.44/acre</td>
</tr>
<tr>
<td>Maintenance</td>
<td>$200.00/year</td>
</tr>
<tr>
<td>No. of Acre</td>
<td>4,360</td>
</tr>
<tr>
<td>Life Expectancy</td>
<td>20 years</td>
</tr>
<tr>
<td>Working Rate</td>
<td>8 acre/hour</td>
</tr>
</tbody>
</table>

**Cost:**

- Labor: $13,625/year
- Materials: $110,918/year
- Maintenance: $200/year
- Equipment: $5,684

**Total Annual Cost:**

\[
\text{Equipment} = \frac{\$5,684}{(A/5,684, 8\%, 20)} = \$579.00 \\
\text{Labor} = \$13,625.00 \\
\text{Materials} = \$110,918.00 \\
\text{Maintenance} = \$200.00 \\
\text{Total} = \$125,322.00/\text{year}
\]