ATTACHMENT 1

REPORT ON WEED CONTROL USING HOT WATER / STEAM AND HERBICDES IN THE CITY OF JOONDALUP

PREPARED FOR THE CITY OF JOONDALUP
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Background:

Weeds are a chronic problem that cost various industries millions of dollars every year. Often the most economical means of controlling weeds in these industries is via the application of herbicides.

Local Councils also experience significant cost when controlling weeds however the considerations Councils have to give when selecting a weed control method often involves a larger range of issues compared to weed control in other industries.

This report therefore will compare thermal weed control methods and the herbicide use for various urban purposes with the Joondalup City Council.

Consultants Brief:

Compare the cost of herbicide based weed control and thermal based weed control.

Examine the advantages and disadvantages of both methods.

Identify the most suitable circumstances for use of these technologies.

Methodology:

Study 1 - Thermal weed control

Study 2 - Thermal weed control - hot water and steam combination

Study 3 - An examination of weed control using herbicides

Study 4 - Weed control using the herbicides Amitrole and Glyphosate

Study 5 - Risk management with herbicides

Study 1 - Thermal weed control

There are primarily four types of thermal weed control. These include flame or fire, hot water, steam, and steam and hot water combination.

Flame methods are not considered in this study as they provide an unacceptable fire risk in Australian conditions and are considered unsuitable for urban situations. Each of the other methods has been investigated below.

In comparing the three remaining methods (hot water, steam, and steam and hot water combination) some important criteria have received more emphasis. The first was the temperature achieved at the nozzle tip. This is important as the time taken to kill a weed and overall kill rate of these methods depends on the temperature being delivered at the nozzle tip. The second consideration was the amount of water used, as water use needs to be efficient in our water limiting environment. Furthermore high water use results in more down time refilling.

Thermal weed control - Hot water

The hot water method uses unacceptable amounts of water (greater than 600 liters per hour). It delivers temperatures in the low 90 degrees Celsius range and holds these temperatures for an acceptable period of time or at least longer than steam methods. While temperature loss is not excessive past the nozzle tip the initial delivery temperature is low and requires slower operational speeds to ensure weed kill is effective. Temperature impact 1 cm below ground is considered very effective and is important when looking to kill plant cells in the base of the plant which is necessary for the control of perennial weeds.

Thermal weed control - Steam

The steam method is much more water efficient and delivers temperatures that are initially higher than that of the hot water method however the steam method experiences rapid cooling which reduces it effectiveness in controlling weeds. The impact of cooling is reduced to some degree, but not completely, by the use of a hood at the end of the application nozzle. The steam however has poor ground penetration which results in slower operational speeds and poor control of perennial species.

Thermal weed control - Hot water and Steam combination

The hot water plus steam combination does in effect combine the attributes of the previous two methods. It has acceptable water use (250 to 350 liters per hour), with water heated under pressure to 130 to 140 degrees Celsius and delivered at the nozzle at around 97 degrees Celsius. This temperature ensures acceptable operational speeds can be achieved as well as effective weed control. Heat penetration into the soil surface is also adequate for weed control purposes.

Conclusion:

In summary it was concluded that the combination of steam and hot water is most effective at controlling weeds and has acceptable water use rates.

Study 2 - Thermal weed control - hot water and steam combination.

Pros: Hot water and steam is very effective at killing annuals, some perennials and some permeable seed near the soil surface. There is virtually a zero risk of non-target plant damage (except when applied on lawn or oval situations) and it is generally more benign to the environment than alternative herbicide options, although it does use more water.

Because its operation is more labour intensive and output is often restricted to one nozzle, the areas (scale) targeted for this method of weed control should be focused on those where weeds are confined to stripes or small patches. For example this method would be more suitable for smaller scale operations targeted at weeds in pathways and roadside cracks, garden beds and around the base of established trees. Areas considered less suitable would include larger scale operations in sumps or extensive roadside and pathways weed control programs. Thermal weed control (hot water and steam combination) would also be more suitable for use in areas where residences are known to have health risks, in areas that have significant environmental value, or in areas with a high concentration of human activity such as City Centers.

Cons: The hot water and steam combination, like the other thermal weed control methods, is effectively a contact, non-systemic means of controlling weeds. Hence, if part of the weed is not treated there is a risk that the whole plant will survive. Furthermore, non-systemic means of weed control are less effective against some perennials. This is

because many perennials store carbohydrate reserves in their crown and root system. When new growth is needed the stored carbohydrate is mobilized by the plant to develop new growth. These parts of the plant (crown and upper root system) are often protected by woody tissue or are imbedded under the soil surface and, therefore, are protected from the effects of the treatment.

Research - 1: The following research was conducted on white and red clover by Acacia Smith, Leslie Phillips-Catton and Jennifer Symms in the US. Results are summarized and conclude that overall hot water/steam initially decreases the presence of weeds. However, this decrease only lasts about 4-6 weeks until the species start recovering. More specifically hot water/steam decreased the presence of White Clover *(Trifolium repens*) but did not decrease the presence of Red Clover (*Trifolium pretense*). It was proposed in this research that more frequent treatment with hot water/steam, would improve results.

Research - 2: This research was undertaken in the US by a City Council. In summary they found that hot water/steam controlled annual weeds by burning plant cells; however the method was ineffective against many perennials. They found the method was unsuitable for parks, lawns and ovals and that the method was slow and labour intensive. To be effective the hot water/steam method required repeated treatment applications through the growing season.

Research - 3: The research outlined below was conducted at Colorado State University Cooperative Extension Agent (Agriculture) in Adams County. Hot water/steam applications to horticultural crop rows provided excellent weed control on small annual weeds and good to fair activity on deep rooted perennial weeds. To ensure season long management of weeds multiple applications were necessary. The most cost effective water rate found was 250 liters per hour.

Research - 4: Research over four years conducted by Virbickaite *et al* at the Lithuanian University of Agriculture found thermal weed control on annuals weeds was 22% more effective than mechanical (cultivation) weed control, however mechanical weed control was 32% more effective against perennial weeds.

Interviews: Several interviews were conducted with operational staff and owners of hot water/steam weed control systems in Perth and Sydney. In summary they agreed that this method was most effective on annual weeds and operations were fastest when weeds

were small and density was low. They indicated that some perennial weeds such as couch (*Cynodon dactylon*) were not controlled very effectively by this method. Initially couch would brown off however some weeks latter it would re-grow. Operational staff indicated that maintaining very high temperatures at the nozzle was extremely important for good weed kill and reasonable speed of operation. They also indicated that operator experience was essential as some weeds required longer treatment time than others to ensure effective control.

Costs: Cost in Australia range from $80 to $350 per km of pathway and roadside curb combination. The large variation in price is made up of a range in labour cost from $80 to $100 per hour for two people and a work rate range of 1 to 0.35 km per hour. The work rate is the most variable component and depends on the density of weeds and the type of weeds present. The most common price range was between $165 and $220 per km for paths and roadside curbing.

Conclusion: Hot water/steam is most effective on young annual weeds and least effective on older perennial weeds. In some cases control of perennial weeds will be ineffective however this depends on the weed species present and its age. Thermal weed control (hot water and steam combination) is best utilized in situations where conservation or health considerations are high and weed density is low. In addition, best results are obtained when follow up weed control is undertaken 4 to 6 weeks after the initial treatment. To control weeds over a period of a year it is likely that between 3 and 5 applications will be necessary, depending on rainfall and the extent of the weed seed bank.

Study 3 - An examination of weed control using herbicides.

Comparable herbicides to thermal weed control methods are those known as knockdown herbicides. These are non selective and will kill all plants they are applied to. Within this group there are three classes of herbicides and these include contact non-persistent herbicides such as Paraquat and Diquat available in the product Sprayseed; translocated non-persistent herbicides such as Glyphosate available as Roundup and translocated persistent herbicides such as Amitrole, available in various product names.

Sprayseed (contact herbicide with no residual effects):
Sprayseed is not considered as a viable alternative in urban areas due to its S7 poisons schedule rating and ineffectiveness on many perennials.

Glyphosate (systemic herbicide with no residual effects):
Glyphosate is one of the few products registered for weed control in water catchments. It requires very low volumes of water and is effective against annual and perennial weeds. It will not however kill weeds germinating after its application. Its non-residual nature means any glyphosate movement off-site will not impact on non-target plants.

Glyphosate is not a dangerous good according to the dangerous goods code and its poisons schedule classification is S5.

Amitrole (systemic herbicide with residual effects):
Amitrole is also registered for use in water catchments. It requires similar water volumes to Glyphosate, is effective against annual and perennial weeds, and has some residual weed control properties. These residual properties can reduce the need for follow up weed control and in these circumstances are more cost effective. Conversely any off-site movement of amitrole may impact on non-target plants. As an example amitrole sprayed over weeds in pathway cracks will result in some of the herbicide landing on the pathway which could be washed by rainfall or sprinklers into lawn edges or garden beds where Amitrole could impact on non-target plants.

Amitrole like glyphosate is not a dangerous good and has a S5 poisons schedule classification.

Conclusion:
Glyphosate and amitrole are the preferred knockdown herbicides. Glyphosate is acceptable for use in areas where runoff may occur onto other areas containing vegetation, while amitrole, or mixtures of these herbicides is acceptable for use in areas that do not have runoff onto nearby areas containing vegetation. To control weeds over a year using these products 2 to 3 applications would be required.

Study 4 - Weed control using the herbicides Amitrole and Glyphosate.

Pros: Amitrole and glyphosate are effective at killing both annual and perennial weeds with some residual weed control evident when amitrole is applied. The systemic nature of these herbicides ensures effective control of perennials and if part of the weed is sprayed, the herbicide is translocated throughout the plant to cause death.

Herbicide application is not labour intensive and suitable to a wide range of situations including ovals, parks, lawns, pathways and roadways (except amitrole on pathways due to possible run-off and off site affects). Glyphosate can also be used by trained personal under controlled conditions in areas that have significant environmental value.

Cons: There is a risk of non-target plant damage via spray drift (and over spray) for Glyphosate or spray drift (and over spray) and run-off for amitrole. The occurrence of this is considered a low risk however it is dependant on spray pressures, wind speed, operator care and skill level. While the systemic nature of these herbicides is a plus for killing target weeds it is also a negative when spray drift or overspray occurs onto non-target plants.

These products should be avoided where possible in areas where residences have known health risks.

Costs: Costs in Australia range from $90 to $130 per km of pathway and roadside curb combination. The variation in price is small and is attributed to a highly developed and competitive industry. A breakdown of pricing indicates $25 to $40 is charged for road side curbs and from $65 to $90 per km for foot paths.

Conclusion: Amitrole and glyphosate are a cost effective means of weed control and provide reliable kill rates on target weeds. The speed of operation provides significant advantages when large scale operations are to be undertaken. Both herbicides however should be restricted where residential health sensitivities are known.

Study 5 - Risk management with herbicides:

There are several steps that can be taken to reduce potential problems with the application of herbicides. These include;

1) Selecting herbicide products with a broad range of label use specifications. For example glyphosate can be purchased under many different product names and not all products allow for general garden use, use in aquatic areas, use on unwanted trees or use in bush-land situations. This example applies to other herbicides and their product range.

2) Ensuring licensed and experience staff are used. While licensing is a legal requirement, ensuring staff have at least 12 month experience is more likely to ensure miss-use or careless use will not occur.

3) Ensuring post-spray operations are reported on at the end of each day. Data such as area and location sprayed, the type of spraying being conducted (eg footpaths), the herbicide used, the rate applied, the spray pressure applied, the wind speed and direction on site and the operator's name and vehicle registration, will ensure additional care is taken and any problems can be easily traced and action taken to overcome the problem in future operations.

4) Incorporating these and other appropriate specification in any tender and subsequent contract developed by the JCC. Possible examples include…..

a. The contractor will follow all label and permit specifications.

b. Where the herbicide is available in a number of different products the contactor will use the product with the broadest possible label specification.

c. All operators must be licensed and have a minimum of 12 months experience.

d. Hooded sprayers should be used were appropriate.

e. The contractor will measure wind speed on site and cease all spraying if wind speeds exceed 20 km per hour or at label specifications which ever is lower.

f. All equipment will be tested and calibrated prior to use and calibrations forwarded to the JCC.

g. MSDS (Material Safety Data Sheets) will be kept on site by the contactor for each spraying operation.

h. Any costs associated with non-target plant damage will be born by the contractor.

i. Any herbicides used will be approved by an independent expert.

j. After spraying operations the following information will be sent to the JCC at the end of each day. Data sheets should outline the area and location sprayed, the type of spraying being conducted, the pesticide used, the rate applied, the spray pressure applied, the wind speed and direction on site and the operator's name and vehicle registration.

Findings:

1) A summary of considerations is provided in Table 1.

2) As a generalization, herbicides are more cost effective and have better kill rates than thermal weed control methods. Their cost advantages and speed of application indicate that they are suitable for large scale operations. Cost comparisons include:

- Herbicide cost for pathway and roadside curb combination are $90 to $130 per operation compared with thermal which has a most common price range of $165 to $220.
- Weed control via herbicide application requires 2 to 3 applications per year for pathway and roadside curb combination while thermal treatment requires 3 to 6 applications per year.
- Assuming a low price of $165 per operation for thermal weed control and 3 operations per year, the cost is $495 while over the same period herbicide application at $90 per operation with 2 operations per year is $180. As a general rule therefore thermal weed control per year will be between 2 and 4 times more expensive than the application of herbicides.

3) Thermal weed control methods are best utilized where environmental or health issues are significant and where off site damage to non-target plants is a high risk.

4) The costs and speed at which thermal weed control can be undertaken may limit its scale of operation.

5) Weed control efficiency is improved if the frequency of thermal weed control is no longer then six weeks apart and, where there is an occurrence of perennial weeds which are hard to kill, hand weeding or herbicide spot spraying may be necessary on second cycle treatments.

Table 1 Shows a comparison of thermal weed control and the herbicides amitrole and glyphoate using different assessment criteria and different circumstances. The scores below are on a scale of zero to ten with higher scores indicating more positive attributes while lower scores indicate more negative attributes.

	Thermal weed control	Amitrole	Glyphosate
Cost effectiveness	4-6	9	8
Efficacy on annuals	8-9	9	9
Efficacy on perennials	5-6	8	8
Speed of operation	4	9	9
Need for follow up treatments	4	8-9	6-7
Off site impact	9	5-6	7-8
Environmental impact	9	6	8
Efficient water use	5	8	8
Overall rating	48-52 (60 - 65%)	62-64 (77-80%)	63-65 (78-81%)
Suitability to……			
Large scale operations	4	9	9
Ovals/Parks	4	6	8
Garden beds	9	n/a	7-8
Paths	6-7*	n/a	9
Roadsides crub	6-7*	7	9
Health risk situations	9	n/a	5#
Environmentally sensitive situations	9	n/a	7
Sumps	2	9	8

* Scale of operation may be limited due to operational speed which impacts on the area that can be covered inside a reasonable time period. This is important as weeds need to be killed before seed set occurs and thermal operations will need to be completed at least twice over the same area no more then 6 weeks apart for effective weed control.

Mostly public perception rather than definable medical sensitivities although exceptions exist.

Recommendations:

1) The council should consider thermal weed control (hot water/steam) on a trail bases around residential areas where health risk situations are known, environmentally sensitive sites occur or where human foot traffic is very high.

Consideration in these circumstances needs to be given to the issue that thermal weed control contractors will require a minimum area/distance/time to make the exercise viable. It is estimated this will be 1 week's work, or 35 km of pathway and curb or an approximately cost of $4,000 to $6,000 for a single application. Independent records should be taken to determine existing weed density prior to treatment and subsequent densities at 2, 4 and 6 weeks after application. Future decisions on continuation or expansion of thermal weed control can include considerations of this data.

Note also that compared to the traditional weed control industries, the thermal weed control industry is young. Typically these circumstances can lead to large variations in pricing and quality of work. I would recommend caution where very cheap quotes are received and ensure steps are put in place to protect the Council's return on any funds outlaid. This includes specific contract specifications. The single largest complaint in the investigations of thermal weed control is weed control failure. The city should ensure any contract for thermal weed control specifies that two applications be completed between 4 and 6 weeks apart (no sooner or no latter) and that 90% weed control be achieved on inspection 5 weeks after the second thermal treatment.

Like herbicide applications thermal weed control can have problems when…..

(a) the application temperature is too low,

(b) the nozzle head is too far from the target weed,

(c) the treatment time is too short,

(d) the water rate is too low,

(e) the target weeds are too large.

2) The council should consider that for large scale weed control the use of herbicides be resumed as they do not represent an undue risk to health or environment where label specifications are followed. Weed control using herbicides remains the most cost and time effective means of controlling weeds. Furthermore, delays in weed control will result in weeds becoming more tolerant (most weeds become more tolerant with age) and more likely to produce seed. Herbicides can be a problem when…..

(a) the incorrect herbicide is chosen/used,

(b) the incorrect rate is applied,

(c) the incorrect spray pressure is used,

(d) the wind speed is too high,

(e) the operator is careless in their application

To ensure these problems are avoided, it is suggest the council consider….

(a) Engaging an expert to determine herbicide choice and rate specification.

(b) Contracts with spray operators be examined carefully by a relevant expert and protective clauses added to emphasize quality control.

(c) As part of the contract spraying operations, data sheets should be faxed/submitted to the JCC at the end of each day's operation. Data sheets should outline area and location sprayed, the type of spraying being conducted, the herbicide used, the rate applied, the spray pressure applied, the wind speed and direction on site and the operator's name and vehicle registration.

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