

**Marin Municipal Water District
Vegetation Management Plan Update**

Interim Background Report No. 2

Chemical Weed Control Techniques

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A. Introduction

Public agencies, private groups who own or manage lands, private contractors, and private individuals have worked for decades to develop effective and cost-efficient methods to rid public and private lands of invasive weeds. The Marin Municipal Water District (MMWD) has been part of this effort for many years. In 1994, MMWD adopted its original Vegetation Management Plan (VMP). While that plan was focused on managing vegetation to reduce the risk of wildfire affecting the District's Mt. Tamalpais watershed and adjacent private properties, it also addressed the impacts of the spread of invasive weeds on the ecological health of the watershed. MMWD is in the process of updating that original VMP.

A part of this update is to identify feasible and safe methods of managing weeds on the District's watersheds. The watersheds contain many species of weeds that MMWD needs to address to preserve biodiversity. The most severe threat is from the expansion of broom, and the bulk of MMWD's weed management actions have dealt with controlling this weed. Therefore, much of this background report focuses on broom control.

The basic goals of the plan update were prepared and presented to the public at a workshop on January 23, 2008. The basic goals, as amended by input received at that workshop, are:

- Maintain the existing significant biological resources of the watersheds.
- Restore degraded habitats on the watersheds.
- Reduce the hazard of uncontrolled wildfires along the residential perimeter of the Mt. Tamalpais watershed and limit the extent of damage within and adjacent to that watershed should a wildfire occur.
- Revise future management decisions as needed to respond to changing conditions, and to develop a foundation for developing a management strategy that addresses long-term ecological changes.

A key method for realizing the first three goals is to control and, if feasible, eliminate invasive non-native plant species (hereinafter, called "weeds"). In May 2008, the District's consultants prepared an interim draft report of weed-control techniques that did not use herbicides. These techniques were presented at a second public workshop on May 14, 2008. In addition to a summary of the project and the report by MMWD staff

and its consultant, the workshop included a discussion of weeds and weed control by Dr. Carla Bossard of St. Mary's College, an expert on weeds (particularly broom) and weed control. The public had the opportunity to ask questions of several vegetation management experts at that meeting, including Dr. Bossard, Jeff Creque (a grazing expert with Land Stewardship Consultation), Mark Heath (a weed control expert with Shelterbelt Builders), John Herr (a biological control expert with the USDA Research Center in Berkeley), and Tim Hyland (a weed control expert with significant expertise in prescribed burning with the California Department of Parks).

The feasible non-chemical techniques that were described and discussed at that meeting are included on Tables 3 to 5 and Table 7. Dr. Bossard presented an overview of weeds and the problems they produce. She noted that invasive weed species tend to have broader environmental tolerances (e.g., for soil moisture conditions, temperature, nutrients, etc.) and fewer environmental restrictions than many of the native species. These invasive weeds are also often characterized by their high reproductive success and effective dispersal methods. Because they have no to few diseases or insects that prey on them, they do not need to expend energy fighting off these attacks and can focus energy on reproduction. All these factors favor the spread of these invasive weed species over native plants, especially in areas where disturbance has occurred (e.g., burned, mowed, or heavily grazed areas).

The feasible non-chemical techniques that could be used on a large-scale basis include forms of prescribed burning and mechanical cutting or mowing. Techniques that are suitable for small-scale removals include hand removal, propane torching of seedlings, and scalping seedlings. Techniques that are not widely in use, still considered experimental, or considered impractical at most scales include scalping with heavy equipment, competitive planting, cutting plants below the surface, cutting and peeling bark, hydro-mechanical obliteration, mulching, solarization, Waipuna foam, and livestock grazing. During the panel discussion and the question-and-answer session, Jeff Creque confirmed that goat grazing could reduce broom populations but it required extensive grazing over multiple years and that the goats needed to be overseen at all times by a knowledgeable herder who could direct the animals away from natives towards the target species and to manage the herd. As he said, a major problem with using goats is a "people" problem (i.e., that there are few trained and dedicated herders available).

John Herr was asked whether there were any biological controls being tested or considered for release by the USDA. He said there was nothing imminent for broom. There are already-introduced insects for yellow star thistle, but they will not eliminate populations of those thistles, and they are already on the watershed. More detailed notes about the questions and answers presented at this workshop can be seen at the Districts' website.

<http://www.marinwater.org/controller?action=menuclick&id=420>

Second Background Report

This second Background Report describes and summarizes the various methods for weed control that integrate the use of herbicides with the various burning, mowing/cutting, pulling, tarping, mulching, and grazing techniques that were developed for and presented at the May 14, 2008 workshop. This report is the second in a series of

technical reports that will be used by MMWD staff and its consultants to develop the Alternatives Analysis for the MMWD Vegetation Management Plan Update. This report contains the following:

- A description of the techniques that have been used by MMWD and other land management agencies to control or remove invasive non-native species;
- A description of the techniques that incorporate herbicides that have been used by MMWD and other land management agencies to control or remove invasive non-native species;
- A discussion of which of these techniques is feasible or preferred on a landscape level of treatment and how the determination of feasibility was reached; and
- A discussion of resources available to carry out these techniques and data on the productivity of using different sorts of labor resources.

The District's consultants will be working over the next two months to finalize this Background Report. The revised report will be available on the District's website, and those who desire notification when updates and/or the final Background Report is available can join the District's listserve by emailing weeds@marinwater.org.

Subsequent background reports will provide information on methods to manage for biodiversity (Background Report No. 3), Fire Management (Background Report No. 4), and Management Alternatives (Background Report No. 5). Upon completion of these background studies a Draft Vegetation Management Plan (VMP) will be prepared for public and MMWD Board review.

This report makes no final recommendations about what techniques MMWD should use for managing weeds. A range of alternate recommendations will be developed this summer and presented for public review in October 2008 prior to a workshop on the alternatives in November 2008. The purpose of this report is to examine the efficacy, logistics and potential environmental and health risks associated with weed control options that include limited herbicide use within the context of the Districts' Integrated Pest Management Program.

The public is invited to provide any additional questions or data they believe should be answered or included in the final Background Report.

B. Basics of Weed Control

1. Data Sources

The list of techniques described in this report was developed using the following sources:

- On February 6, 2008, MMWD hosted a workshop for professional land managers and firms who conduct weed control on a landscape-level basis. The objective of this workshop was to allow people who had been working on broom control to share their experience and data on the efficacy of various control methods widely used,

and to discuss new experimental controls. Forty-two people, representing 27 land management agencies and professional vegetation management companies attended the workshop. The list of attendees is included in Appendix A. The input from these experts was a primary source for identifying feasible techniques as well as the pros and cons of those techniques.

- In Mill Valley on April 11, 2008, MMWD hosted The Mount Tamalpais Watershed Symposium: Preservation, Extinction, and Change on a Local Scale. This symposium, attended by 250 people, featured 15 presentations and discussion with nationally known experts in vegetation, wildlife, global climate change, and fire hazard. The presentations made by these experts were used in developing this report.
- At a May 14, 2008 workshop, MMWD presented the list of non-chemical techniques to the public that were included in the interim draft Background Report No. 1. Input from that workshop plus the data in the interim Background report were used in preparing this Background Report.
- A review of techniques that MMWD has used in the past and the associated MMWD qualitative observations and monitoring data.
- The experience of the project consulting team, especially Bob Brenton of Brenton Vegetation Management Services, Ann Howald and Eric Wrubel of Garcia & Associates, Mark Heath of Shelterbelt Builders, Susan Kegley of Pesticide Research Institute, and Dr. Marion Moses of the Pesticide Education Center.

Ann Howald is the Senior Botanist for Garcia and Associates, based in San Anselmo. She has conducted comprehensive inventories of invasive weeds in many locations in California, and has developed weed control recommendations based on principles of integrated pest management for a variety of invasive plants, including: French broom, Scotch broom, yellow star-thistle, Fuller's teasel, Harding grass, pampas grass, Himalayan blackberry, Klamathweed, tree-of-heaven, eucalyptus, and many others. She has prepared weed management plans covering multiple species for implementation at the landscape level for The Nature Conservancy, Pacific Gas and Electric Company, California Department of Parks and Recreation and others. She has participated in on-the-ground weed control efforts for French broom, Scotch broom, pampas grass, Himalayan blackberry, Klamathweed and other species. She is a founder, past president, past board member (10 years) and initiator of the List of California's Wildland Weeds of Greatest Ecological Significance for the California Invasive Plant Council.

Bob Brenton is a licensed Pest Control Advisor (PCA) with 25 years experience in weed control and integrated vegetation management. He has extensive experience in wildland weed control. He has a BS in Agronomy from the University of Illinois and a Masters degree in Weed Science from Clemson University. He has implemented weed management plans covering multiple species at the landscape level for The Nature Conservancy, Pacific Gas and Electric Company, California Department of Parks and Recreation, Sacramento Municipal Utility District, and others. He has implemented many plans that Ann Howald developed.

Mark Heath is the Principal of Shelterbelt Builders, An Open Land Management & Restoration Company. He is a recognized expert in wildland weed control, Bay Area plant ecology, and habitat restoration. He has developed a watershed-based weed management plan for San Bruno Mountain Watch and the California Coastal Conservancy in 2005, prepared an Invasive Plant Mapping and Control Strategy for the Midpeninsula Regional Open Space District, and he is currently working on a 32-acre gorse (*Ulex europaea*) control project for San Mateo County, a Canary Island St. John's wort (*Hypericum canariense*) Eradication Plan for the Peninsula Open Space Trust, and a Fuel Break Vegetation Management Plan for the Marin County Open Space District.

Eric Wrubel is a consulting botanist with Garcia and Associates, and is engaged in master's thesis research at San Francisco State University on the vegetation ecology of Bay Area coastal scrub. He has over ten years experience working with the flora of California. He has conducted botanical surveys and mapping projects of native and non-native plants throughout the state. During his four years as a supervisor at Shelterbelt Builders, he implemented and monitored restoration and revegetation projects in the Bay Area; becoming intimately familiar with the management and identification of Northern California's invasive wildland weeds. He has extensive experience with manual and mechanical techniques for the control of broom and other weeds, and has worked on several large-scale French broom removal projects in Marin for the Golden Gate National Recreation Area.

Dr. Susan Kegley is the Principal and CEO of the Pesticide Research Institute. She is an organic chemist with expertise in pesticide toxicology, pollutant fate and transport; environmental monitoring and analytical chemistry; and experience with pesticide regulation, pesticide data sources and the pesticide toxicology and epidemiology literature. After 14 years of teaching, research and curriculum development in academia, Dr. Kegley worked as a Senior Scientist for nine years at Pesticide Action Network North America, a non-governmental, non-profit organization that works to promote sustainable alternatives to toxic pesticides. Pesticide Research Institute (PRI) is an environmental consulting firm with expertise in the human health and ecosystem effects of pesticides, industrial organics, inorganics and heavy metals; toxics use reduction and Integrated Pest Management; pollutant fate and transport; and environmental sampling and analysis. Established in 2006 by Dr. Kegley, PRI brings expertise in pesticide toxicology, environmental monitoring and risk assessment, as well as experience with pesticide and chemical regulatory infrastructure, ecosystem and pollutant transport modeling, pesticide data sources, and the pesticide toxicology literature.

Dr. Kegley has been assisted on this project by Dr. Erin Conlisk, a recent graduate of the University of California at Berkeley and by Dr. Marion Moses, an epidemiologist and the director of the Pesticide Education Center, a non-profit group in San Francisco. The Center was founded in 1988 to educate workers and the public about the hazards of pesticides to human health and the environment. Dr. Moses is a physician board certified in Public Health and Preventive Medicine. She received her BSN from Georgetown University in 1957, and her M.D. from Temple University in 1976. She did her internship in Internal Medicine at the University of Colorado, and her residency in Occupational and Environmental Medicine at Mount Sinai in New York City. She has served on several U.S. EPA committees, including the Pesticide

Program Dialogue Committee, the Tolerance Reassessment Advisory Committee (TRAC) and the Endocrine Disruptors Screening/Testing Advisory Committee. She was a member of the USEPA/University of California Davis's National Advisory Committee on Pesticide Farm Safety, and served on the Veterans Administration, National Advisory Committee on the Health Related Effects of Herbicides. She has published articles on pesticides in peer reviewed journals and in textbooks.

- A review of the most current literature on control of the target weeds (included in the bibliography of this report). See the following links for lists of the most up-to-date publications on weeds and weed control:
 - California Invasive Plant Council (Cal-IPC) publications and research at <http://www.cal-ipc.org/index.php>
 - The Global Invasive Species Team at <http://tncweeds.ucdavis.edu/esadocs.html>
 - California Department of Food and Agriculture's "Noxious Times" at http://www.cdfa.ca.gov/PHPPS/ipc/noxioustimes/noxtimes_archives.html
 - Weed Prevention and Management Guidelines for Public Lands, U.S. Department of the Interior, Bureau of Land Management at <http://www.blm.gov/ca/pa/weeds/weedprevent.html>
 - The Nature Conservancy (Global Invasive Species Team) at <http://www.cal-ipc.org/resources/index.php>
 - U.S. Department of Agriculture (Invasive and Noxious Weeds) at <http://www.cal-ipc.org/resources/index.php>
 - U.C. Cooperative Extension Weed Research and Information Center at <http://wric.ucdavis.edu/information/information.html>
 - The U.S. Forest Service, Fire Effects Information System at <http://www.fs.fed.us/database/feis/plants/weed/weedpage.html>
 - Californians for Alternatives to Toxics at <http://www.alternatives2toxics.org/>

While the literature on weed control was thoroughly reviewed, this report relies heavily on the experience of MMWD and the other public landowning agencies in the general Bay Area. Reports in the literature are often not current, do not apply to the local climate and conditions, or are not directed towards weed control and removal on a large scale.

2. Definitions of Terms Used in this Report

Native species are those species growing within their natural range and natural zone of dispersal potential. They are species or subspecies that are within the range that they could occupy without direct or indirect introduction and/or care by humans (Randall and Hoshovsky 2000).

Non-native species are those species growing beyond their natural range or natural zone of potential dispersal, including all domesticated and feral species and all hybrids involving at least one non-native parent species (Randall and Hoshovsky 2000). Other terms that are often used as synonyms for non-native include alien, exotic, and introduced species.

Invasive species are species whose introduction causes or is likely to cause economic or environmental harm or harm to human health (Gates 2008). Invasive species reduce biodiversity by displacing native organisms, bringing about changes in species composition, community structure, or ecosystem function (Randall and Hoshovsky 2000). Many invasive species form monocultures (dense stands of one plant) that push out native species and reduce food and shelter needed by native wildlife, including endangered species (Cal-IPC 2006b). Not all non-native plants are invasive. Only a small minority of the thousands of species introduced to California have escaped cultivation, and a minority of those that have escaped spread into wildlands.

Weeds are species, populations, and individual plants that are unwanted because they interfere with management goals and objectives (Randall and Hoshovsky 2000). In the context of this report, weeds are synonymous with invasive plant species.

Control is management action to reduce the negative impacts of an invasive species, often by eliminating a significant portion of an invasive population in a given area. The most effective types of control are prevention and early detection (Hoshovsky and Randall 2000).

Containment is management action to limit the spread of an invasive species from a given area, while making little or no effort to reduce the existing population. This option is often used with persistent infestations that have already degraded the local environment severely, and have the potential to spread into high value habitat.

Eradication is the complete elimination of an invasive species' population from a given area. Eradication is seldom a realistic or desirable goal because at a regional level it tends to become more difficult and costly as the population of the invasive species is reduced to low levels. Eradication is sometimes a management goal for localized, nascent populations of particularly noxious weeds (Hoshovsky and Randall 2000).

Annual plants complete their life cycle (germination through death) in one year or growing season. They are essentially non-woody plants (Hickman 1993).

Perennial plants live more than two years or growing seasons. The term is usually applied to plants that are essentially non-woody above-ground (Hickman 1993).

Biennial plants complete their life cycle (germination through death) in two years or growing season (generally flowering only in the second) and are non-woody (Hickman 1993).

Shrubs are woody plants of relatively short maximum height, as compared to trees, and are usually much-branched from the base (Hickman 1993).

Pesticides are any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest. Pests can be insects, mice and other animals, unwanted plants (weeds), fungi, or microorganisms like bacteria and viruses. Though often misunderstood to refer only to *insecticides*, the term pesticide also applies to herbicides, fungicides, and various other substances used to control pests. Under United States law, a pesticide is also any substance or mixture of substances intended

for use as a plant regulator, defoliant, or desiccant (U.S. EPA Office of Pesticide Programs 1997).

Herbicides are a category of pesticide that is used to kill plants, usually weeds.

Conventional Herbicides are herbicides that are formulated from synthesized (i.e., man-made) chemicals and are not approved for use in organic agriculture.

Organic Herbicides are approved for use in organic agriculture with active ingredients comprised of naturally occurring compounds.

Surfactants are chemical compounds added to a pesticide that acts as an emulsifier, enhances absorption and effectiveness of the pesticide, and/or changes the surface tension of a solution as a control for spray drift. Herbicides often have reduced effectiveness without the addition of a surfactant.

Integrated Pest Management. The US Environmental Protection Agency (EPA) defines IPM as:

Integrated Pest Management (IPM) is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices. IPM programs use current, comprehensive information on the life cycles of pests and their interaction with the environment. This information, in combination with available pest control methods, is used to manage pest damage by the most economical means, and with the least possible hazard to people, property, and the environment.

The IPM approach can be applied to both agricultural and non-agricultural settings, such as the home, garden, and workplace. IPM takes advantage of all appropriate pest management options including, but not limited to, the judicious use of pesticides. In contrast, organic food production applies many of the same concepts as IPM but limits the use of pesticides to those that are produced from natural sources, as opposed to synthetic chemicals.

Appendix B includes MMWD's IPM Program and its IPM Program Handbook. These documents describe how, when, and under what circumstances MMWD has applied herbicides and other pesticides. As the introduction to the Handbook states:

Integrated pest management (IPM) is the blending of effective, economical, and environmentally sound pest control methods into a single but flexible approach to manage pest populations within acceptable limits. Those who practice IPM begin by analyzing the nature and the source of the pest problem. They then rely on a range of preventive and treatment strategies that can be a combination of cultural, physical, mechanical, or biological treatments. Only the least-toxic chemical pesticides should be used, and always as a last resort.

IPM sharply reduces pesticide use. This helps alleviate a threat to humans, wildlife and beneficial organisms. Its use improves water quality, avoids soil contamination, and keeps hazardous chemicals out of the food chain.

3. Target Weeds

Table 1 lists weeds (invasive non-native plants) that are currently or have the potential to adversely affect the biodiversity of the watersheds or compromise the District's wildfire risk reduction program. This list was developed from information in the California Invasive Plant Council and California Department of Food and Agriculture noxious weed ratings, the experience of MMWD staff, and the expertise of the consulting team. The table by no means lists all the non-native plant species present on the watersheds. It focuses on those weed species that are defined as "invasive" – species that spread within the environment and cause environmental or economic harm and are agents of ecosystem change. The table prioritizes the invasive weeds according to their potential damage to the watersheds. The three species of broom are the highest priority. MMWD estimates that final mapping of the broom populations will show that these species of broom currently occupy approximately 1,000 acres of the Mt. Tamalpais watershed with additional populations at the Nicasio and Soulagoule watersheds.

The other non-prioritized weeds included in the table occupy far smaller acreages. However, left uncontrolled, these species can rapidly expand their colonization and displacement of native species. Many of these species are actively managed by MMWD staff with varying degrees of success.

Table 1
Non-native Invasive Plant Species of Greatest Concern to MMWD

Net Acreage	Common Name	Cal-IPC Status ¹	CDFR Ranking ²	Life Form	MMWD Priority	Gross Acreage ⁴	Net Acreage ⁵
<i>Genista monspessulana</i>	French broom	High	C	Shrub	1	798.5 ⁶	334.0
<i>Cytisus scoparius</i>	Scotch broom	High	C	Shrub	2		
<i>Spartium junceum</i>	Spanish broom	High	Not ranked	Shrub	3		
<i>Centaurea solstitialis</i>	yellow starthistle	High	C	Annual herb	4	85	19.0
<i>Carthamus lanatus</i>	distaff thistle	Moderate	B	Annual herb	5	0	0
<i>Centaurea calcitrapa</i>	purple starthistle	Moderate	B	Annual herb	6	100	1.0
<i>Aegilops triuncialis</i>	barbed goatgrass	High	B	Annual grass	7	65	6.5
<i>Taeniatherum caput-medusae</i>	Medusahead	High	C	Annual grass	8	Not yet mapped	Not yet mapped
<i>Ehrharta erecta</i>	panic veldtgrass	Moderate	Not ranked	Perennial grass	9	2	0.02
<i>Dipsacus species</i>	teasel	Moderate	Not ranked	Biennial herbs	10	1	0.2
<i>Festuca arundinacea</i>	tall fescue	Moderate	Not ranked	Perennial bunchgrass	11	20	18.0
<i>Phalaris aquatica</i>	Harding grass	High	Not ranked	Perennial bunchgrass	12	Not yet mapped	Not yet mapped
Other Species:							
Acacia species: <i>A. dealbata</i> <i>A. melanoxylon</i> others not rated	wattle	Moderate Limited	Not ranked	Tree		1.0	0.01
* <i>Ageratina adenophora</i>	eupatorium	Moderate	Not ranked	Perennial herb		0	0
<i>Cortaderia jubata</i>	pampas grass	High	Not ranked	Perennial bunchgrass	13	40	8.8
<i>Crataegus monogyna</i>	European hawthorn	Limited	Not ranked	Tree	13	1	0.05
<i>Crocsmia crocosmaeflora</i>	montbretia	Limited	Not ranked	Perennial herb	13	Not yet mapped	Not yet mapped
<i>Delairea odorata</i>	cape ivy	High	Not ranked	Vine	13	2	0.1

Table 1
Non-native Invasive Plant Species of Greatest Concern to MMWD

Scientific Name	Common Name	Cal-IPC Status ¹	CDFA Ranking ²	Life Form	MMWD Priority ³	Gross Acreage ⁴	Net Acreage ⁵
<i>Dittrichia graveolens</i>	stinkweed	Moderate	Not ranked	Annual herb	13	Not yet mapped	Not yet mapped
<i>Echium</i> species: <i>E. candicans</i> others not rated	pride of Madeira	Limited	Not ranked	Shrub	13	2	0.05
<i>Eucalyptus globulus</i>	Tasmanian bluegum	Moderate	Not ranked	Tree	13	0.1	0.01
<i>Foeniculum vulgare</i>	fennel	High	Not ranked	Perennial herb	13	Not yet mapped	Not yet mapped
* <i>Helichrysum petiolare</i>	licorice plant	Limited	Not ranked	Subshrub	13	0	0
<i>Mentha pulegium</i>	pennyroyal	Moderate	Not ranked	Perennial herb	13	Not yet mapped	Not yet mapped
<i>Myosotis latifolia</i>	broadleaf forget-me-not	Limited	Not ranked	Perennial herb	13	Not yet mapped	Not yet mapped
<i>Pinus</i> species	non-native pines	Not rated	Not ranked	Trees	13	Not yet mapped	Not yet mapped
<i>Vinca major</i>	big periwinkle	Moderate	Not ranked	Perennial herb	13	<5	<5

Notes:

- 1 - California Invasive Plant Council ratings: High – species that have severe ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal and establishment. Most are widely distributed ecologically. Moderate – species that have substantial and apparent – but generally not severe – ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal, though establishment is generally dependent upon ecological disturbance. Ecological amplitude and distribution may range from limited to widespread. Limited – species that are invasive but their ecological impacts are minor on a statewide level, or there was not enough information to justify a higher score. Their reproductive biology and other attributes result in low to moderate rates of invasiveness. Ecological amplitude and distribution are generally limited, although these species may be locally persistent and problematic.
- 2 –California Department of Food and Agriculture noxious weed ratings: A noxious weed is a plant that has been defined as a pest by law or regulation. “A” rated weeds are plants of known economic importance subject to state (or agricultural commissioner when acting as a state agent) enforced action involving: eradication, quarantine, containment, rejection or other holding action; “B” rated weeds are plants of known economic importance subject to: eradication, containment, control or other holding action at the discretion of the individual county agricultural commissioner or a plant of known economic importance subject to state endorsed holding action and eradication only when found in a nursery; “C” rated weeds are plants subject to no state enforced action outside of nurseries except to retard spread, at the discretion of the commissioner, or plants subject to no state enforced action except to provide for pest cleanliness in nurseries.
- 3 - All species that are not prioritized are of equal concern but less concern than the 12 prioritized species.
- 4 - The acreage of a given vegetation management unit assessed by a mapper and determined to have some degree of weed infestation.
- 5 - A subset of the Gross Acreage, the net acreage is only that area which directly has that weed (without interstitial spaces). The Net Acreage is a measurement of the Gross Acreage x % Cover of that weed at that location.
- 6 – Mapping of broom is incomplete and ongoing. The broom species are not always differentiated by mappers as they often co-occur.
- * Present on adjacent lands but not detected as of 2007 on MMWD lands.

Source: MMWD

4. The Problem

Unless the target weeds are controlled, they expand exponentially at the expense of native vegetation. In the Mt Tamalpais, Nicasio and Soulajule watersheds, weeds are diminishing watershed biodiversity, interrupting natural ecosystem processes, and compromising restoration efforts. This is counter to the goals of the District..

The three species of broom currently pose the most significant risk for watershed biodiversity. High priority invasive plants other than brooms have been grouped into generalized guilds based on similar life history traits and responses to control techniques. This approach distills information and avoids redundancy in species control descriptions. However, it should be noted that while some species can be grouped by certain shared traits, they might not share other traits. Ultimately, successful management of invasive species depends on the response of each species to environmental variables and control techniques.

The future vegetation management plan will make recommendations about which methods should be used. The plan will combine methods as sometimes one method is used for the initial treatment with other methods used as follow-up treatments. The goal of the plan is not solely to control or eliminate the invasive weeds. The plan will also address how to enhance the ecosystem processes to prevent reinvasion or invasion by another invasive weed. To accomplish these aims requires an integrated management program that is dependent on the location of the weed population, access, topography, climatic conditions, other vegetation and wildlife in the area, the resources that are available for control actions, chemical use restrictions, and other factors. This background report describes the techniques and Tables 3 to 5 and Table 7 describe the draft approach to integrating the recommended techniques.

One of the ultimate goals is to protect significant natural resources still present on watershed lands. To do this, MMWD cannot allow continued weed reproduction and spread to occur. Few land managers consider landscape-scale eradication of large weed populations with persistent seed banks to be possible. Therefore, most are working towards preventing new infestations and achieving sustained control over many years by containing existing populations.

Broom Physiology and Morphology

The three broom species are invasive shrubs that grow in grasslands, scrub, and woodland habitats. Once introduced, they can quickly colonize disturbed areas, trail sides, roadways and streambanks, and sometimes spread into wildlands. French broom is the most widespread and damaging of the weedy brooms, in some places forming dense, almost impenetrable thickets and invading native vegetation (McClintock 1985). French broom is an upright, many-branched, evergreen, yellow-flowered shrub that can grow to 10 feet or more in height. It is native to Mediterranean countries and the Azores, and is thought to have been introduced to the San Francisco Bay Area in the mid-1800s as an ornamental. Young plants grow rapidly and, in Marin County, can produce flowers and seeds within one and a half years, when approximately two feet tall. French broom is a prolific seed producer. A medium-sized shrub can produce over 8,000 seeds per year. The pods open explosively, flinging seeds up to 12 feet from the parent shrub. Seeds released from the pods are distributed longer distances by ants, birds, and other

animals, and in river water and rain wash in mud, and on road maintenance equipment. French broom plants are deep-rooted and resprout rapidly after freezing, cutting or mechanical damage to the stem, and sometimes after fire. Fire and mechanical soil disturbance both stimulate seed germination, and seedling densities of more than 100 per square foot have been observed after fire. Seeds germinate from the soil seedbank. In places where mature broom plants have been established for years, the soil seedbank can contain 465 to 6,733 seeds per square meter (approximately 9 square feet) (Hoskings 1994, Parker and Kershner 1989). In California, French broom has no pests or diseases capable of significantly reducing its reproductive rate or ability to spread.

Scotch broom is also a serious threat to watershed biodiversity, though there are considerably fewer Scotch broom plants on the watershed than French broom. In general, Scotch broom is found in drier, sunnier locations. Individual shrubs have been known to live up to 17 years. Scotch broom also grows 6 to 10 feet tall. Young plants are easily distinguished from French broom by the flowers and by the ridges on their dark green stems (Hoshovsky, 1986). Scotch broom leaves are smaller and fewer than French broom, giving the plant a wiry look.

Spanish broom is distinguished from the other types of broom by its smooth, round stems, single leaves, and large flowers. Leaves are shed during summer drought, giving a very stick-like appearance. Its taproot can reach depths of 6 feet, making Spanish broom the hardest of the three brooms to uproot.

Weed Presence on the Watersheds

MMWD has been actively mapping the location of weed populations on the Mt. Tamalpais Watershed (mapping of the other two watersheds has not yet been initiated). To date, the mapping has concentrated on broom and star thistle species in areas with known populations or areas of known disturbance; a total of 6,080 acres have been surveyed intensively via cross-country transects and mapped. Staff have identified an additional 650 acres that are near existing populations or areas of disturbance for mapping in the near future. The remaining 12,330 acres are not expected to have major populations of weeds and will be surveyed from roads and trails. Of the areas mapped to date, MMWD has identified broom on 798 acres. This includes about 118 acres characterized as having "high" densities of broom (66% to 90% of the area populated with broom plants); 214 acres of "medium" densities (36% to 65% coverage with broom); 241 acres of "low" densities (11% to 35% coverage); 16 acres of "scarce" densities (1% to 10% coverage); and 154 acres with "pioneer" densities (less than 1% - areas that are being invaded by pioneer plants).

While the current mapping effort is focused on the broom species, MMWD staff also records the locations of additional weed species encountered during the surveys. MMWD has identified approximately 100 acres with purple starthistle, characterized as having scarce densities and approximately 85 acres of yellow starthistle, characterized as having either scarce or low densities. Small populations of additional species have also been noted.

C. Potential Methods of Controlling Weeds

The target weeds can be controlled or killed using a variety of techniques. Background Report No. 1 described the various techniques that do not involve the use of herbicides. These include variations on cutting, digging, pulling, burning, tarping, mulching, and grazing the weeds.

An additional common tool used for killing weeds is the use of herbicides. Land managers frequently integrate herbicide applications with other methods, especially when working at a landscape level because they are effective, efficient, and often less expensive than other techniques. However, herbicides pose unique risks to human and environmental health. This report examines the possibility of incorporating 9 specific chemicals (3 conventional herbicides, 3 organic herbicides, 2 surfactants, and one dye) into the MMWD Integrated Weed Management Program. Specifically, this report examines the efficacy of these products, the logistics involved in employing them, the ways in which they could be used to augment non-chemical weed control methods, and the possible human and environmental health risks associated with their use. A determination as to whether or not any of these 9 chemicals *should* be added to MMWD weed control tool box will not be part of this report, but rather will be made later in the overall vegetation management planning process.

1. Past Use of Herbicides by MMWD

Prior to 1995, MMWD's herbicide use was largely restricted to painting eucalyptus stumps with Pathfinder II to prevent re-sprouting. From 1995 to August 2005, herbicides have been used as part of an integrated pest management approach under the guidelines of the 1995 Mt. Tamalpais Area Vegetation Management Plan to control the spread of acacia, French broom, Scotch broom, Spanish broom, pampas grass, yellow starthistle, and fennel on the watershed.

Three herbicides were applied over the six-year period: Pathfinder II™ (Triclopyr), Roundup™ (glyphosate with the surfactant POEA), and Transline™ (clopyralid). Pathfinder II was applied at full strength, Roundup was diluted to a 2% solution, and Transline was diluted ¼ fluid ounce per gallon of water (per manufacturer's suggested application rate). Herbicides were applied by painting directly on stumps or spot application using 4-gallon backpacks or a 25-gallon ATV-mounted wand applicator. Treated areas included: Mill Valley Air Force Base, Debris Box Hill, Rock Spring, Sky Oaks Meadow, and along fuelbreaks, emergency vehicle routes, and roadways (Panoramic Highway, Old Railroad Grade, Gravity Car Road, Phoenix Road, Ridgecrest Boulevard, and Sky Oaks Road) in accordance with the MMWD Herbicide Use Guidelines (see Appendix B).

Prior to 1999, herbicide use was limited to minimal (less than 0.1 gallon) applications of Pathfinder to eucalyptus stumps in order to prevent resprouts. In 1999 and 2000, Pathfinder was applied to French broom stumps in fuelbreaks, and Transline was applied to isolated patches of yellow starthistle in meadows and on roadside berms. Watershed staff shifted from Pathfinder and Transline to Roundup Pro for broom control and yellow starthistle control in 2001 and 2002, respectively, because of Roundup's shorter environmental persistence.

In 2003, the District formalized its Integrated Pest Management policy and guidelines (Appendix B). Among the precautionary measures required under the policy is a quarter-mile-wide herbicide exclusion zone around reservoirs and a 100-foot-wide exclusion zone along all water-bearing streams. The processes of public notification and least-toxic herbicide selection were formalized, and an oversight committee was established. Least-toxic herbicides were selected from the City of San Francisco’s “Approved Pesticide List” (City and County of San Francisco 2003) because District staff considered the toxicology and environmental review process that created that list to be exemplary with regard to professionalism, objectivity, and scientific rigor.

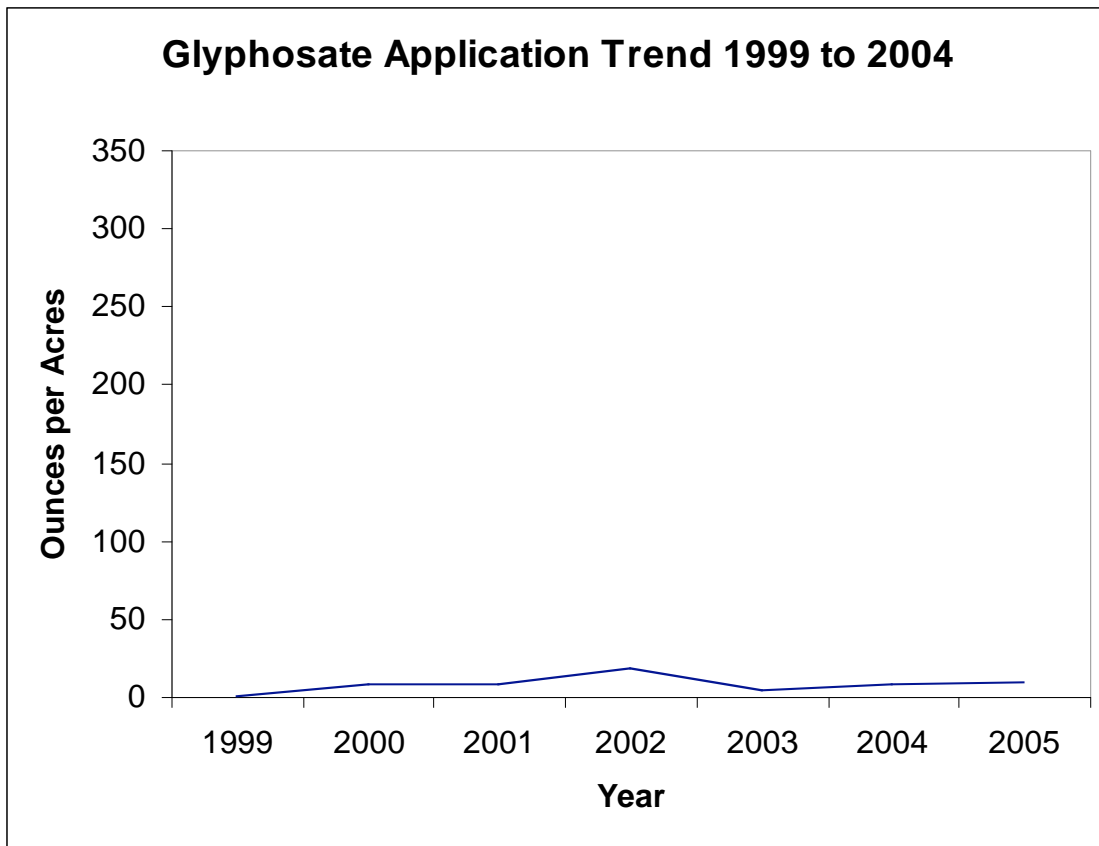
At the same time Watershed management staff increased herbicide applications within fuelbreaks because past attempts to control French broom along the urban wildland interface by mowing, burning, grazing, and hand removal had proven inadequate. Although the quantity of herbicide used increased from 5.9 to 81.0 pounds in a 7-year period, (Table 2), the number of acres under treatment increased from 8.2 to nearly 188. The application “rate,” or pounds per acre, of herbicide remained well below the manufacturers’ recommended rate; for example Monsanto recommends a rate of 350 ounces of Roundup Pro per acre (Figure 1), and MMWD’s average annual application rate never exceeded 20 ounces per acre.

In August of 2005, responding to public concern, the Marin Municipal Water District Board of Directors suspended the use of all herbicides on Watershed lands, pending a review of all other alternative treatment options, which is one of the tasks being undertaken as part of this update of the District's Vegetation Management Plan.

**Table 2
Marin Municipal Water District Herbicide Use 1999 – 2005
Pounds of Active Ingredient Per Acre**

Year	Pathfinder II (triclopyr)			Roundup or Platte Kleen-up Pro (glyphosate with POEA)			Transline (clopypalid)			All Herbicides Combined	
	Total lbs Active Ingredient	Total Acres Treated	Pounds Per Acre	Total lbs Active Ingredient	Total Acres Treated	Pounds Per Acre	Total lbs Active Ingredient	Total Acres Treated	Pounds Per Acre	Total lbs Active Ingredient	Total Acres Treated
1999	5.90	8.2	0.72							5.90	8.2
2000	3.80	3.2	1.19	0.50	2.0	0.25	0.75	96.4	0.008	5.05	101.6
2001				0.63	2.6	0.24	0.28	77.6	0.004	0.91	80.2
2002				5.10	9.2	0.55				5.10	9.2
2003				12.10	91.0	0.13				12.10	91.0
2004				30.50	132.4	0.23				30.50	132.4
2005				81.00	188.0	0.43				81.00	188.0

Figure 1



Summary of Use By Other Agencies and Use in Marin County

In 2006, 58,341 pounds of pesticides were applied in Marin County, including 27,627 pounds for landscape maintenance (California Department of Pesticide Regulation, http://www.cdpr.ca.gov/docs/pur/pur06rep/06_pur.htm). The reported pounds correspond only to applications made by agricultural or landscape applicators that are required to register their use with the County Agricultural Commissioner. It does not include applications of commercial herbicides and other pesticides purchased at local stores and applied by homeowners. Of the reported total, 2,452 pounds of glyphosate were applied in 43 separate applications on 199 acres, including 1,559 pounds for landscape maintenance and 714 pounds for right-of-way maintenance.

The attendees of the broom workshop hosted by MMWD in February 2008, including all representatives of public agencies responsible for managing wildland properties use herbicides as part of their IPM to control invasive weeds. This includes the National Park Services (Point Reyes National Seashore), Golden Gate National Recreation Area, U.S. Bureau of Land Management, US Fish and Wildlife Service (San Pablo Bay National Wildlife Refuge), California Department of Forestry, California State Parks, Marin County Open Space District, Midpeninsula Open Space District, East Bay Regional Parks, San Francisco Public Utilities Commission, and Santa Lucia

Conservancy. These public agencies manage over 95% of the public open space in Marin County. In addition, many of the towns and cities in the County include herbicide use within their weed control and IMP programs. On a more regional scale, virtually all State and Federal agencies as well as private non-profit groups such as The Nature Conservancy incorporate herbicides in their integrated weed control programs. For example, The Nature Conservancy's guidelines state:

The Nature Conservancy uses herbicides only when and where they contribute to the perpetuation of species, communities, and ecosystems targeted for preservation or when they provide the most efficient and/or environmentally compatible method for control of plants that 1) could be hazardous to staff and visitors or 2) are legally designated as "noxious" species requiring control.

- 1) *Herbicides shall be used only in situations where benefits of controlling targeted "pests" outweigh overall risks of using herbicides and other methods are prohibitively expensive, not effective, or more likely to cause unintended damage than the herbicide.*
- 2) *A herbicide may be used only in a manner consistent with its labeling.*

A herbicide may be used only in compliance with all federal, state and local regulations, including those related to licensing and/or certification of applicators, use of protective and safety gear, and posting requirements.¹

The above description of the existing use by other agencies is by no means intended as an "excuse" or endorsement for herbicide use. Rather, it is intended to put MMWD's past use of such herbicides in context and to show that other agencies responsible for land management have opted to include herbicide use even though there will always remain some risks and some unknowns and uncertainties about whether these herbicides pose a significant health or ecosystem hazard. This project includes a full risk assessment so that MMWD will understand these risks and unknowns when they decide whether or not to include herbicides in the District IPM program.

2. Selected Herbicide Candidates

The consulting team working with MMWD staff identified a list of 6 herbicides and 3 surfactants/dyes (additives that increase an herbicide's efficacy) for possible incorporation in MMWD's integrated weed management program. The selection was made after reviewing the herbicides that are being effectively used by other public land agencies in the area and reviewing the literature. An initial list of herbicides recommended by Brenton VMS was reviewed by Pesticide Research Institute and other consulting team members to eliminate those that are ineffective or have obvious unacceptable safety risks or environmental effects. Based on the initial scope of work for this project, the team selected 3 synthetic herbicides, 3 formulated organic herbicides ("organic" means the herbicides are formulated from products that naturally occur in the

¹ *Disney Wilderness Preserve Standard Operating Procedure for Herbicide Use, Cindy Campbell and revised by Mandy Tu, 2002 – consistent with TNC's Standard Operating Procedure for Herbicide Use*

world and are not synthetic; it does not mean they are made from organically grown products), 2 surfactants, and 1 dye. While additional herbicides and surfactants/dyes could have been assessed, herbicides on this list can effectively address the 27 target weeds and have fewer risks and impacts, relative to other potential candidates.

The selected candidates include:

Synthetic Herbicides

Aquamaster (53.8% Glyphosate, isopropylamine salt)

Transline (40.9% Clopyralid, monoethanolamine salt)

Garlon4 Ultra (60.5% Triclopyr, butoxy ethyl ester)

Formulated Organic Herbicides

Scythe (57% pelargonic acid)

Matran (50% clove oil, 50% emulsifiers)

Acetic Acid (15 % vinegar)

Surfactants

Competitor (ethyl oleate, sorbitan alkylpolyethoxlate ester, dialkyl polyoxyethylene glycol)

Silgard (polysiloxane)

Marker Dye

Blazon (proprietary information)

3. The Use of Herbicides for the Control and Eradication of Weeds

Brenton Vegetation Management Services prepared the following overview of the products considered in this report and the various means of employing them. Bob Brenton is a Certified Pest Control Advisor (PCA) who prepares Integrated Pest Management (IPM) programs for public and private clients. A PCA is the individual who is legally required to prepare any program that involves the use of herbicides. The recommendations for herbicide use are based on the experience of that firm. These are **preliminary** recommendations for possible use based on what herbicide efficiently treats the target weeds while minimizing health, safety, and environmental effects. As described in Section D below, a risk assessment of these chemicals has been completed by the Pesticide Research Institute. The Alternatives Analysis Report will include an alternative(s) that incorporates the use of herbicides, although it may not be identified as the preferred alternative. The final recommended use may differ from the preliminary recommendations made here due to information generated by the risk assessment, additional impact analysis prepared for the Biodiversity and Fire Hazard Reduction Report, and input from other agencies, the public, and other sources.

An herbicide is a category of pesticide that is used to kill plants, usually weeds (see the previous discussion of the definition of weeds). Much of what is known about weeds and weed control is a result of research and development in the agricultural arena, including production agriculture, landscape contracting, turf management, nurseries, forestry, range management, and non-crop management. Much of the current herbicide use, as well as IPM policy, is the result of agronomic research and development. For this reason, thresholds are typically defined in economic terms, including crop injury or competition and subsequent yield reduction. It should be noted that conditions in

wildland settings such the MMWD watersheds often differ considerably from agricultural settings.

Commercially produced herbicides were first used for the control of agricultural weeds in the early 20th century. The initial materials and methods used were crude, but they provided alternatives to more labor intensive and sometimes less selective manual and mechanical methods. In the early 1940s, the first synthetic herbicide (2, 4-D) was developed and introduced into row crop agriculture. Additional new compounds were discovered mostly by trial and error. Simple biological screening determined efficacy, and, if deemed viable, these products were brought to the market. In the 1970s and 1980s, companies were able to design, synthesize, develop and market herbicides with specific modes of action for specific purposes. It became possible to synthesize and develop herbicides to address specific weed control needs. Coinciding with advances in herbicide technology was the further development and adaptation of integrated pest management strategies. IPM is the incorporation of all available pest management tools to provide the optimum result. Also, thresholds were established to determine when and what tools would be most appropriate to reduce or eliminate a particular pest problem. Thresholds included pest populations; pest types (e.g., what species of insects or weeds), and projected economic loss. Advances in herbicide technology allowed for more specific thresholds and reductions in rates and the amount of herbicide applied because of the development of more species-specific herbicides.

4. Herbicide Classifications and Characteristics

Herbicides are complex chemicals that differ greatly in how they function in a plant, how they behave in the environment and the risk they pose to ecosystems. IPM practitioners must understand the range of chemicals when considering them for use. Herbicides can be grouped or classified several ways. Classifications include application method, application timing, mode of action, activity spectrum, and formulation. The following are the more common criteria for the classification of herbicides.

Pre-emergent herbicides are applied to the soil to prevent the germination and growth of seedling plants usually as applied through soil uptake. Typically these herbicides have no foliar activity, though some are effective on existing vegetation. These herbicides can be classified as "soil active."

Post-emergent herbicides are applied to existing vegetation. Uptake to the plant is through the foliage, including through the stem. With a few exceptions, post-emergent herbicides have little or no viable soil activity. These herbicides can be classified as "foliar active."

Systemic compounds translocate through the plant to affect one of several activity sites by moving readily through the plant's vascular system. Soil-active and foliar-active herbicides can both be systemic. The ability of the herbicide to translocate determines in part how and when the herbicide is applied. An herbicide that is systemic can be applied to a portion of a plant and be lethal to the entire plant. Complete and thorough coverage is not always necessary. The advantage of these compounds is a more efficient application since the entire plant need not be treated. The risk involved with the use of a systemic herbicides is that drift from these herbicides can cause significant injury to non-target plants.

Contact herbicides are almost all foliar-applied, post-emergent herbicides (the exception is the diphenyl ether class of herbicides, which have both soil and foliar activity but are considered contact herbicides). Contact herbicides are cell wall disruptors. They do not translocate through the plant. These are considered non-systemic herbicides. They have limited to no mobility in the plant vascular system. They cause significant rapid cell wall or vascular disruption that prohibits translocation. Only those portions of the plant receiving an herbicide application will be controlled. An advantage of this is that these herbicides can be used to chemically prune vegetation, and they do not have as much risk to off-target vegetation as systemic herbicides. They are fast-acting herbicides that act only on the foliage that they contact, and they do not move into the root or vegetative reproductive portions of plants. Therefore, they are not very effective on woody or herbaceous perennial plants. Many of the organic (non-synthesized) herbicides are in this category.

Selective herbicides are compounds that have activity on a limited number of species or only on a specific family. An example of family selectivity would be herbicides that work only on grass as opposed to broadleaf weeds. There are a several herbicides that have activity only on broadleaf plants (dicots), likewise there are several that have activity only on grasses (monocots). These herbicides can be pre-emergent, post-emergent, systemic, and/or contact herbicides.

Non-selective herbicides control all vegetation. Both broadleaf and grass species are susceptible to some herbicides.

Mechanism of Action

The mechanism of action is another method of grouping herbicides (Weed Science of America 2007). The mechanism of action is the biochemical process by which the herbicide actually affects the plant. It is the site or biochemical process in the susceptible plant where the herbicide is active or disruptive. The 9th edition of the Weed Sciences Society of America's Herbicide Handbook lists 17 classes of herbicide based on Mechanism of Action. Below is a brief discussion of the major classifications.

ACCase inhibitors are compounds that kill grasses. Acetyl coenzyme A carboxylase (ACCCase) is part of the first step of lipid synthesis. Thus, ACCCase inhibitors affect cell membrane production in the meristems of the grass plant. The ACCCases of grasses are sensitive to these herbicides, whereas the ACCCases of dicot plants are not.

ALS inhibitors, the acetolactate synthase (ALS) enzyme (also known as acetohydroxyacid synthase, or AHAS) is the first step in the synthesis of the branched-chain amino acids (valine, leucine, and isoleucine). These herbicides slowly starve affected plants of these amino acids which eventually leads to inhibition of DNA synthesis. They affect grasses and dicots alike. The ALS inhibitor family includes sulfonylureas (SUs), imidazolinones (IMIs), triazolopyrimidines (TPs), pyrimidinyl oxybenzoates (POBs), and sulfonylamino carbonyl triazolinones (SCTs). ALS is a biological pathway that exists only in plants and not in animals thus making the ALS-inhibitors among the safest herbicides.

EPSPS inhibitors, the enolpyruvylshikimate 3-phosphate synthase enzyme EPSPS is used in the synthesis of the amino acids tryptophan, phenylalanine and tyrosine. These herbicides prevent this step from occurring. In short they starve the plant by not producing ATP energy, and they poison themselves with respiratory waste that cannot be discarded. They affect grasses and dicots alike. Glyphosate is a systemic EPSPS inhibitor.

Synthetic auxins inaugurated the era of organic herbicides. They were discovered in the 1940s after a long study of the plant growth regulator auxin. Synthetic auxins mimic this plant hormone. They have several points of action on the cell membrane, and are effective in the control of dicot plants. The plant literally grows itself to death. Eventually the plant cannot sustain the rate of cell wall elongation. Cell integrity is lost. The actual site of action is not known.

Photosystem II inhibitors reduce electron flow from water to nicotinamide adenine dinucleotide phosphate dehydrogenase NADPH₂ (an enzyme catalyst in the photosynthetic process) at the photochemical step in photosynthesis. They bind to the Q_b site on the D1 protein, and prevent quinone from binding to this site. Therefore, this group of compounds causes electrons to accumulate on chlorophyll molecules. As a consequence, oxidation reactions in excess of those normally tolerated by the cell occur, and the plant dies. The triazine herbicides (including atrazine) and urea derivatives (diuron) are photosystem II inhibitors. Basically, the plant is unable to convert the sun's energy to a useable energy source

Cell Membrane disruptor compounds result in rapid disruption of cell membranes and a very rapid mortality. The bipyridyliums and the di-phenyl ethers penetrate into the cytoplasm and cause the formation of peroxides and free electrons (light is required), which almost immediately destroy the cell membranes. Herbicidal oils dissolve membranes directly. Rapid destruction of cell membranes prevents translocation to other regions of the plant. Severe injury is evident hours after application, first as water-soaked areas which later turn yellow or brown. Maximum kill is attained in a week or less. Partial coverage of a plant with spray results in spotting and/or partial shoot kill. New growth on surviving plants will be normal in appearance. Foliar activity alone can provide only shoot kill.

Cell Division inhibition herbicides affect root or shoot inhibition. Root inhibitors inhibit the steps in plant cell division responsible for chromosome separation and cell wall formation. They bind to soil colloids and are unlikely to leach to ground or surface waters. These root inhibitors do not translocate. Shoot inhibitors are soil applied for control of seedling grasses and some broadleaf plants as well as suppression of some perennials growing from tubers and rhizomes. Injury appears as malformed (twisted), dark green shoots and leaves on injured young plants.

5. Herbicide Use for the Control of Noxious Weeds on the MMWD Watershed

Invasive weed control is most effective when incorporated into an integrated vegetation management plan with the focus on habitat restoration and/or preservation. Only a small number of the hundreds of commercially available herbicides are appropriate for incorporation into an IPM plan that is designed to control target weeds while still

encouraging revegetation and native restoration. Several considerations must be made regarding herbicide choice. First is the practicality of using the herbicide. Does it make sense based on the weed population, proximity to sensitive areas or plants, density of the stand, and physiological characteristics of the plant as well as other environmental factors? If it does make sense, then the characteristics of the herbicide must be considered, including spectrum of activity, mode of action, environmental compatibilities, and toxicological properties.

Spectrum of Activity.

“Spectrum of activity” is a consideration of efficacy of an herbicide across all plant species. Any tool for consideration must be effective on the intended target, and herbicide consideration is no different. However, it is important to understand the entire spectrum of activity of that herbicide. A herbicide may be considered to be selective to (dicots) and not grasses (monocots). Often, herbicides used on broadleaf weeds are also selective to a specific family or families. An example would be a herbicide that is active on members of the legume or composite family but not mustards. Further, there are herbicides that are selective within a family. A consideration must be if the spectrum of activity can extend to all members of that family. If the intended target is broom, a legume, and a desirable plant in the area is a rare or sensitive lupine, also a legume, there is potential for unintended consequences. Efficacy on non-intended targets must be considered and mitigated. To avoid unintended results, steps must be taken to avoid off-target impacts. If mitigation cannot provide adequate protection, then that herbicide should not be considered. Mitigation can include timing and targeted application

Mechanism of Action

The mode or "mechanism of action" (MOA) is defined as the manner in which the herbicide is absorbed by the plant and is active in the plant at the tissue or cellular level (Weed Science of America 2007)). A more specific consideration is how the herbicide enters the plant and whether or not it has soil activity. Also important is whether the herbicide is a systemic or a contact type. Herbicides with soil activity can be beneficial in preventing the germination of undesirable seedlings or target plants. Soil activity can also adversely affect the growth of desirable plants. The ability of an herbicide to translocate can determine efficacy on woody or perennial species. The specific site of action an herbicide has at the cellular level is not a significant consideration unless there is concern about resistance. For example, Telar (ALS amino acid synthesis inhibition) has a single site MOA. There are several weed biotypes that are now resistant to this herbicide as a result of this specific action site. If the species of interest in the program has resistant biotypes or produces considerable seed, or requires multiple applications, then these single-site herbicides should not be used, or at least used in combination with other herbicides that have activity on the target species. Some examples of the herbicide mode of actions were listed previously.

Environmental Compatibilities

Herbicide persistence, degradation, and behavior can vary greatly from compound to compound. Behavior is a result of the chemical properties of the material and can be significantly impacted by soil type, moisture and other environmental factors, including pH, temperature, rainfall, etc. A particular herbicide may be very active on a particular species, but should be considered only with precautions or even discounted if the potential for negative environmental impact exists. It is important to understand all aspects of the environmental compatibilities of the various herbicides. The physical characteristics of an herbicide can be used to predict behavior and results in the environment. However, these predictions may not result in an actual environmental impact in the field. There are often other substances and processes occurring in the natural setting that modify the physical characteristics of the chemical.

This is an important consideration when developing an integrated program and determining what tools to use. For example, an herbicide might be weakly bound to soil, that is, very water soluble. This would suggest that the herbicide has the potential for leaching into the groundwater or running off and causing water contamination. However, in the field, this does not always occur. An example would be the herbicide Oust (active ingredient sulfometuron methyl). Physical characteristics (water solubility and weak soil adsorption) suggest that Oust has the potential to leach and move off target. However, the potential to leach or move off target are affected by soil chemistry, soil type and organic matter. Field studies determined that Oust was relatively immobile, and the potential for Oust to leach or move off site is unlikely.

Toxological Properties

The toxological properties of an herbicide need to be considered when evaluating potential tools for an IPM program. Effective herbicides with typically acceptable environmental compatibilities, such as a short half life, soil immobility, or non-toxicity to invertebrates, should not be considered if there is potential for harm to other wildlife or to the applicator as a result of direct exposure or secondary effects. It is important to understand the toxicology of an herbicide and make sure the actual risk is identified and included in the consideration of using that herbicide. The specific toxicity of an herbicide needs to be put into the context of its planned use. The acute toxicity of an herbicide is expressed as the LD50. LD50 is the dose, usually exposed through feeding, that is lethal to 50% of a test population.

The risk that is posed by an herbicide is a factor of hazard along with potential exposure. Hazard is expressed in the actual toxicity of the herbicide, along with prescribed use rate (field concentration). Potential exposure is the likelihood of coming in contact with the herbicide. Frequency of application and use of Personal Protective Equipment (PPE) will determine exposure.

6. Specific Herbicides and Other Chemicals Being Considered for Incorporation in MMWD's IPM Program

Three synthetic herbicides, 3 formulated organic herbicides, 1 dye, and 2 surfactants are being considered for the potential inclusion into the IPM portion of the Vegetation

Management Plan. These compounds were selected based on their efficacy, environmental and public health hazards, and the other criteria discussed above. The following is a brief description of the herbicides and other chemicals being considered.

Synthetic Herbicides

Aquamaster

Aquamaster (the active ingredient [ai] is glyphosate) is formulated as a four pound ai/gallon isopropyl amine salt without any surfactant. Aquamaster is a broad-spectrum, non-selective, systemic, post-emergent herbicide used to control annual and perennial plants, including grasses, sedges, broad-leaved weeds, and woody plants. It has no pre-emergent activity. Glyphosate formulated as Aquamaster can be applied to water for aquatic vegetation management. Aquamaster is used for the control of exotic plant species in sensitive ecosystems. The active ingredient glyphosate is one of the most commonly used and most studied herbicides. Extensive documentation is available regarding its behavior in the environment.

Mode of Action

Aquamaster is absorbed slowly into the leaves of the target plant. It requires six or more hours of rain-free weather to insure maximum uptake and efficacy. There is no root uptake. Once inside the plant, glyphosate travels readily through the phloem to key activity sites, inhibiting the formation of essential amino acids and plant-specific biochemical processes. Glyphosate is persistent in susceptible plants, and this, in part, is why the herbicide is so effective. Symptoms-- usually chlorosis and the appearance of a reddish purple tint in certain species-- are visible within five days, followed by necrosis within two weeks.

If included in MMWD's IPM tool box, Aquamaster would be prescribed for a wide variety of weeds and applied as a 1%-to-3% solution for low-volume, spot treatment delivery not to exceed two quarts of formulated product per acre. Broadcast applications would be made at a two quart per acre rate.

Garlon 4 Ultra

Garlon 4 Ultra (the active ingredient is triclopyr ester) is a broadleaf selective, post-emergent, terrestrial herbicide used for control of most annual and perennial broadleaf weeds and brush in crop and non-crop sites. It has no herbicidal activity on grass species. Garlon 4 Ultra is a 4 pound ai/gallon mix of triclopyr formulated as butoxyethyl ester.

Mode of Action

Garlon 4 Ultra is an auxin-mimicking herbicide, specifically, Indole-3-acetic acid (IAA), a plant hormone that regulates cell division and expansion. It is transported through the phloem and xylem of the plant and accumulates in the meristematic tissue of the shoots of susceptible plants, accelerating growth and resulting in ruptured cell walls. Triclopyr is rapidly metabolized in the plant with 85% of a dose being metabolized within three days. After application, susceptible plants cease growth soon over a period of one to

three weeks; plants turn from green to reddish yellow to brown. Epinasty (i.e., twisting, wilting, and deformation) at the growing point is evident. Newer growth becomes mushy and necrotic.

If included in the final IPM, Garlon 4 Ultra would be prescribed for the control of brush and broadleaf weeds. A 0.5% solution of Garlon 4 Ultra would be spot applied. Prescribed use rates would not exceed 40 ounces of formulated product per acre.

Transline

Transline (the active ingredient is clopyralid) is a selective, post-emergent herbicide. Various formulations are labeled for use in managing crops, forestry, range, and utility rights of way. Transline is 3 pound ai/gallon of monoethanolamine formulation of clopyralid.

Mode of Action

Transline is also an auxin-mimicking herbicide. It stimulates rapid cell elongation which results in a ruptured cell wall and the destruction of the cell wall. Transline is rapidly absorbed with 97% of a dose being absorbed within 24 hours. Transline translocates readily within the plant, with 50% of the dose being translocated out of the leaf within 24 hours. Clopyralid is slowly metabolized in susceptible plants. Herbicidal activity is evident within 24 to 48 hours. Symptoms include epinasty, chlorosis, and a wilted appearance.

If included in the final IPM, Transline would be used primarily for the control of yellow star thistle. It would be prescribed at a rate of four ounces per acre of formulated product.

Formulated Organic Herbicides

Scythe

Scythe (the active ingredient is pelargonic acid) is formulated as a 4.2 pound ai/gallon of pelargonic acid with a fatty acid component. Scythe is a broad-spectrum, non-selective contact, post-emergent herbicide used to burn down annual and perennial plants including grasses, sedges, broad-leaved weeds, woody plants, moss, lichens, and algae. The herbicide is labeled for use on non-cropland as well as on a great variety of crops. Pelargonic acid is also used in commercial fruit production to thin blossoms. Scythe is only active on green vegetation and may require repeat applications on new or emerging vegetation. Scythe also has activity on insects and is reported to have fungicidal properties as well (Weed Science of America 2007; Material Safety Data Sheet [MSDS] for Scythe; and EPA fact sheet (217500) Pelargonic acid).

Mode of Action

Scythe causes rapid cell death. Activity is obvious within minutes of application. Rapid change in cell pH appears to result in the cellular destruction as a result of loss of membrane integrity. Symptoms appear quickly. Treated vegetation appears darkened and water soaked. The herbicide does not translocate. Only that vegetation that is

treated is affected, some treated weeds are capable of regenerating from roots or other untreated parts. The metabolism of how it acts is not well understood. There are no known cases of resistance.

If included in the final IPM, Scythe would be applied at a concentration of 3% to 5% for non-selective high volume foliar applications. It would be used for the control of herbaceous grass and broadleaf weeds.

Matran

Matran (the active ingredient is clove oil) is a non-selective, post-emergent, contact herbicide used for the removal of annual and perennial vegetation. The degree of control is directly related to coverage. Efficacy is less on dormant, biennial or perennial forbs and woody vegetation. Matran is 50% clove oil and 50% "other" (listed as winter green oil, butyl lactate and lecithin). Matran is considered a minimal risk pesticide by the EPA and is exempt from federal regulation. It is not subject to the same level of testing as are synthetic pesticides (Material Safety Data Sheet [MSDS] for Matran; and EPA fact sheet).

Mode of Action

Cell disruption via loss of membrane integrity appears to be the primary mechanism of action in plants. Symptoms are similar to pelargonic acid. Like Scythe, Matran is active on green vegetation only, and most effective against annual species and seedlings of perennials and woody vegetation.

If included in the final IPM, Matran would be prescribed at 3% to 8% for the control of herbaceous vegetation. It would be applied as a high volume foliar treatment.

Acetic acid

Acetic acid is available in many formulations and has many pesticide uses. Common formulations available for weed control include a 25% concentrate and a 6.25% "Ready to Use" (RTU). Acetic acid is non-selective and used for the control of herbaceous grass and broadleaf weeds. Products containing acetic acid are labeled for use in residential, landscape, non-crop, rights of way and industrial lands (Material Safety Data Sheet [MSDS] for acetic acid; and EPA fact sheet).

Mode of Action

Acetic acid, like clove oil and pelargonic acid, acts to rapidly disrupt cell membrane integrity. Only vegetation being treated is effected. Annuals are more susceptible than perennials or woody species.

If included in the final IPM, acetic acid would be used for the control of annual herbaceous weeds and broom seedlings. It would be prescribed at a concentration of 15%. It would be applied as a high volume foliar application.

Surfactants

Surface active agents, or surfactants, are additives used to enhance the activity of foliar applied herbicides. Many commercial herbicides already contain internal surfactants in the formulation. While the label might not require adding a surfactant, the addition of one will improve herbicidal activity. Herbicides formulated without surfactants have little to no activity without the addition of a surfactant. There are several classes of surfactant. If herbicides are included in the final IPM, the plan would utilize two surfactants: a modified seed oil (MSO) for both foliar and basal applications and an organo-silicate surfactant for foliar applications.

Competitor

Competitor is in a class of surfactants known as modified seed oils (MSOs). Specifically, Competitor is 98% Ethyl Oleate formulated with emulsifiers to allow for mixing with water. MSOs are effective surfactants because they enhance the uptake of herbicide with minimal potential for leaf surface injury (phytotoxicity), and they reduce the potential for evaporation allowing more herbicide to translocate into the plant in hot dry conditions (Material Safety Data Sheet [MSDS] for Competitor).

Mode of Action

Competitor reduces the surface tension of water on the surface of the leaf, breaks down the waxy surface of the leaf, and aids in moisture retention on the leaf surface. These combined characteristics work to enhance the uptake of the herbicide. These surfactants are well-suited for systemic herbicides that are applied via low volume application. The lack of phytotoxicity by the surfactant itself allows for more uptake of the herbicide without leaf injury and potential impediment of uptake. The smaller more concentrated droplets remain on the leaf surface for a longer period of time allowing more herbicide uptake without evaporation.

Competitor would be used as a surfactant in low volume foliar applications and as a diluent for basal and cut stump applications. As a surfactant, Competitor would be used at concentrations of 1% to 3%. As a diluent, Competitor would comprise 75% to 80% of a mixture with Garlon4 Ultra for basal and cut stump treatments

Sylgard

Sylgard is a silicone-based surfactant known as an organo-silicate surfactant. These types of surfactants are sometimes referred to as a "super wetter" because of their superior ability to reduce surface tension. Sylgard is used at rates much lower than conventional non-ionic surfactants or MSOs. Sylgard is a 100% silicone-based surfactant (Material Safety Data Sheet [MSDS] for Sylgard).

Mode of Action

Sylgard reduces the surface tension of water allowing the herbicide mixture to spread evenly and thoroughly across the leaf surface. This is similar to all surfactants, but Sylgard is considerably more efficient. Sylgard would be prescribed as a surfactant for

use in foliar applications. It would be prescribed at a concentration of 0.06 to 0.12% by volume or 8 to 12 ounces per 100 gallons of water.

Marker Dyes and Colorants

Dyes are used to show where an herbicide application has been made to avoid retreatment and ensure that all target plants are treated. They are beneficial as they help prevent skips, overlap and incidental exposure during reentry. They also help determine potential off-target injury. One marker dye is proposed for possible use.

Blazon

Blazon is a marker dye that will be used with all foliar applications and with some cut stump applications. Blazon is a water-soluble dye used as a pattern indicator. The primary function is to prevent overlap or skip. It also alerts public to the presence of a pesticide application (SERA/USFS risk assessment; Material Safety Data Sheet [MSDS] for Competitor).

7. Potential Uses of Herbicides

Herbicides will be further considered and assessed for potential inclusion into the IPM plan's portfolio of control measures. The herbicides listed above were selected based on their efficacy, practicality, toxicity and environmental compatibility. Herbicide efficacy and mitigation of off-target impacts are as dependent on application timing and technique as they are on spectrum and environmental characteristics of the herbicides. Proposed application methods include foliar (both high and low volume); basal (low volume and thin line); and cut stump. Application methods would be prescribed in consideration of each species, location and season, and they would be consistent with the District IPM plan. Application methods being considered are described in Tables 2 to 4 and Table 7, which describe the methods (that include herbicides) and species. Specific considerations would include species, timing, densities, management objectives and season. A description of application methods is presented below. The specific details of how, what, where, when, and what quantity would be applied would be part of the site-specific PCA recommendations that would be developed once all the environmental review is completed and if the final plan includes herbicide use.

Application Descriptions

Foliar Applications

Low Volume Foliar

Low volume foliar applications are target-specific, judicious applications of herbicide. Low volume is defined as application of not more than 25 gallons per acre (GPA) of mixed, finished solution; ideally, the volume used is less than 10 GPA. A majority of the foliar herbicide applications prescribed will be low volume foliar. The following describes the application equipment and techniques most appropriate for low volume foliar applications. Low volume foliar applications are preferred applications because they tend to be plant-specific, efficient, and effective with minimal potential for off-target injury.

Also, systemic herbicides such as glyphosate work well when applied as a low volume foliar application. If included in the final IPM, low volume foliar applications would be used for treating seedlings that cannot be treated by propane torch flaming and by scout teams who are scouting for outlying broom plants or other outlying target weeds.

Equipment

Application-specific equipment is essential to insure a low volume (for both broadcast foliar and spot applications) application is delivered. Essential equipment would include nozzles, wands, drift guards, and the type of sprayer (backpack, quad mount, wick or other).

Nozzles. There are several nozzles to select from. However, this can be narrowed to a few that will serve the purpose of low volume foliar. Design (make and angle) and volume are key characteristics in nozzle selection. There are two basic designs: flat fan or adjustable cone. Flat fans should be narrow angle, 40° or 60° with a 0.1 or 0.2 GPM delivery rate, at 30 psi at the nozzle, with drift guard technology. An example would be the Tee Jet 6501 DG or 4001 DG. Adjustable cones, such as the X-1, deliver precise application at a volume of 0.1 gallon per minute at 30 PSI.

Drift guards. Drift Guards such as the Solo 49-00-430 can be added to the end of either nozzle to further reduce drift. The guard acts as a shield that directs the angle and direction of the spray nozzle regardless of pressure or height from the ground. When used in combination with reduced or focused angle nozzles like the 4001, drift and off target movement can be significantly reduced, and the application better targeted.

Wands. An "extend wand" allows for more precise placement of herbicide with less movement and more ease of access to difficult to reach locations. The "B&G extend a band wand" is available in lengths of up to 24 inches. These wands also have a positive shut off valve in the tip, which guarantees immediate cessation of spray and does not drip. In line pressure regulators can be easily adapted to these wands.

Chemical container. Backpack applicators are low volume (less than 5 gallons) and can be taken to many locations with ease. Solo is a very common manufacturer of backpack pump sprayers. SP, Jacto, and Birchmeier also manufacture backpack sprayers. Piston pump mechanisms and internal pressure regulators are preferred as they provide agitation, allow more material to be pumped out of the backpack and help regulate pressure

Herbicide

The herbicide's mode of action and characteristic are also important to the success of this application. Herbicides that are systemic, plant persistent, and do not cause initial disruption of cell integrity are ideally suited for low volume applications, clopyralid, glyphosate and imazapyr are three such herbicides. Only clopyralid and glyphosate will be considered for use in this IPM program. Competitor would be the surfactant used. Dye would be added to the mix as well.

Technique

A low volume application applies a small amount of herbicide to the leaf surface; a more concentrated solution is applied judiciously to the upper portions of the plant. With an arch or upside U motion, the applicator moves the wand across the target plant while spraying the plant. Much like when using spray paint, the motion should be steady, quick and with control. Once the plant has been treated, the trigger is released to stop the application. The goal is to target distribution of the herbicide solution to the upper 50% of the target plant with 20% to 50% leaf cover.

High Volume Foliar

High volume foliar applications are area-specific, more general applications, ideal for large, high density populations of the weed. It is often used with monocultures where sensitive or desirable species are not present. High volume is defined as 25 gallons per acre (GPA) of mixed, finished solution or more. This method would be prescribed on a limited basis. The following describes the application equipment and techniques most appropriate for high volume foliar

Equipment

Application is similar to that for use with low volume applications. Essential equipment would include nozzles, wands, drift guards, and the type of sprayer; backpack, quad mount, or other. Application equipment with a motorized pump is the most efficient method of application.

Nozzles. Flood Jets are the most appropriate. These are able to deliver higher volumes with low pressure less than 30 psi. Examples would include TK-7.5 or TK 10. Flat fan nozzles can be used but are less efficient. Fan angle should be 80° and deliver 30 to 50 GPA at 40 PSI. Examples would include the 8005 or 8006 nozzle.

Drift guards. Drift Guards can be used, but reduce the efficiency of the application. If the population is large enough and off target movement is not an issue, then these may not be necessary. The drift guard would be similar to that used for low volume foliar.

Wands. Use the same wands described for low volume foliar applications.

Chemical containers. The same backpacks described for low volume foliar can be used. Motorized sprayers can improve efficacy and efficiency. Quad mounted tanks with a Sure Flo electric pump can also be used. The pump should deliver between 1 and 2 GPM at 60 PSI at the pump.

Herbicide

The herbicide's mode of action and physical characteristic are not as important to the success of this application. Systemic, locally systemic and contact herbicides are equally effective. Herbicide distribution is sufficient across the plant to insure efficacy. All herbicides proposed for consideration in the program can be applied this way. Sylgard would be the surfactant, and dye would be added.

Technique

High volume applications are larger volumes of herbicide applied to the leaf surface. Application concentrations are more dilute and applied more liberally to the leaf surface. The entire plant is treated with attention to insure thorough coverage. The goal is to target distribution of the herbicide solution to 90% of the target plant with 80% to 100% leaf cover. Often times with dense populations of small forbs such as star thistle, the field area is as much the target of the application as individual plants (because they are too numerous and interspersed with other plants to target individually).

Basal Applications

Low Volume Basal

Low volume basal applications are target-specific, judicious applications of herbicide. Low volume basal applications target the lower 10 to 12 inches of the trunk or stem of a target plant. The application is made to wet the plant, but not to run off. Total application volume of mixed, finished solution should be 10 gallons or less per acre. Ideally the volume is less than 2 GPA. This application will have a limited but strategic use for control of woody species such as broom. This technique would not be prescribed for the control of herbaceous weeds. This application is an effective way of dealing with adult plants. It is very target specific and off-target drift is minimized. Also potential for worker or public exposure is significantly reduced by the nature of the application. This application offers excellent seasonal flexibility.

Equipment

Application-specific equipment is essential to insure that a low volume, focused application is delivered. Essential equipment would include nozzles, wands, and the appropriate type of sprayer (backpack, quad mount, wick or other).

Nozzles. Nozzle selection is limited. Adjustable cones are the best choice. An example would be the 5500 X-1. This will deliver accurate application at a volume of 0.1 gallon or less per minute at nozzle pressures of 10 to 20 psi. It would allow for thin line as well as traditional basal applications. The ideal adjustment or setting is a coarse cone with a 10° to 15° angle from the nozzle. Adjustments can be made to accommodate the target species.

Wands. An extend wand allows for more precise placement of herbicide with less movement and more ease of access to difficult to reach locations. These wands were described previously.

Chemical Container. The backpacks previously described would be used.

Herbicide

The herbicide's mode of action, formulation, and characteristics are important considerations for this application. Systemic, ester- or oil-based formulations of herbicide are the only options. If included in the final IPM, Garlon 4 Ultra would be used for this

application. Competitor would be the surfactant, and Blazon with an emulsifier would be the dye.

Technique

Low Volume Basal. A 25% dilution of Garlon 4 in Competitor (the surfactant) is applied to the lower 8 to 12 inches of the stem or trunk of target species. Volumes applied average 1 to 2 ounces of solution per 3-inch stem. Applying the herbicide to the complete circumference is necessary. Stem diameter must be less than 6 inches with juvenile or thin bark. This technique is not effective with larger stems or more coarse bark, because the herbicide cannot penetrate the bark. This treatment is rain-fast (i.e., will not dissolve and run off) immediately and is much less subject to drift. This technique is ideally suited for stem densities below 400 per acre with an average stem diameter of 3 inches.

Thin Line Basal. This method is very similar to low volume basal except for the delivery technique and target area. The equipment is similar as well. This is ideally suited for dense stands, above 400 stems per acre and an average stem diameter of 1 inch or less. This is a very labor efficient way to treat sapling broom plants while minimizing applicator exposure. The adjustable nozzle is set to deliver a straight stream. Herbicide is applied as a straight stream across the stem in a "z" pattern starting with the upper portion of the stem and moving down. Only one side need be treated, although application to both sides will improve control. This will result in more of the herbicide being applied off-target. However, in a dense broom stand there is often little species diversity. This evaluation would be made on a site-specific basis.

Cut Surface Applications

Cut Stump

Cut stump applications are very precise and targeted applications. These applications involve cutting the plant stem and applying herbicide immediately following the cutting to the cambial layer. Volumes on average are no more than 2 ounces per stem for 4-inch stems or trunks. For broom, 0.1 to 0.2 ounces per stem (<1 inch) would be applied. Volume applied varies with the diameter of the cut stump.

Equipment

Application-specific equipment is essential to insure a low volume precise application. Various application devices have been used: sponges, paint brushes, and wicks. However, backpack sprayers or pressurized hand cans are best. Either must be able to be set to a low pressure <10 psi at the nozzle. The most important equipment is the nozzle and the wand.

While wicking works well, it is very labor intensive to cut, remove the biomass, and actually touch every cut stem, and it is difficult to apply the herbicide in the short one-half hour window after cutting.

Nozzles. Choices are limited. Many of the backpack equipment manufacturers offer an adjustable nozzle with the purchase of a backpack or hand can. However, these are

usually low quality and short-lived. An adjustable cone such as the 5500 X-1 delivers precise application at a volume of 0.1 gallon per minute, and it is a high quality nozzle that will deliver a precise amount.

Wands. The B&G extend a band wand is the best choice

Spray container. Backpack applicators are less than 2.5 gallons and can be taken to many locations with ease. The manufacturers of the backpacks also offer hand cans. These are smaller 1 to 2 gallon capacity application devices. The entire tank is pressurized with a top-mounted pump handle in the lid. These are versatile application devices, and they are unlikely to spill.

Herbicide

Both systemic and locally systemic herbicides work well for traditional applications. Undiluted herbicide works well; it is not advisable to dilute the herbicide in water as this will result in reduced efficacy. Garlon 4 Ultra and Aquamaster can both be used. If the herbicide is to be diluted in oil, then only Garlon 4 Ultra can be used. For the modified application, Competitor would be added as a surfactant. For applications with undiluted herbicide, no surfactant would be used. Dye is used with all applications.

Technique

There are two categories of cut stump treatment - conventional and modified. Conventional application is best for larger stems or trunks (greater than 3 inches in diameter). It begins with cutting the trunk as close to the ground as possible. Immediately following the cut, apply undiluted herbicide directly to the cambium. Avoid applications to the bark or the heartwood. Insure the entire cambium circumference is treated.

Modified cut stump treatment is necessary when the stems are smaller or cannot be cut flush to the ground. This application is similar to the Low Volume Basal application. Stems are treated following cutting. Application can be made up to ½ hour following the cut. The entire stem including bark is treated to wet with 25% dilution of Garlon4 Ultra in Competitor oil. The concentration is lower than with conventional applications, but the application target area is increased. Larger stems and mature coarse bark will reduce efficacy.

8. Maximum Potential Herbicide Use Rates

If herbicides are included in the final IPM, the following describes the maximum rate that herbicides could be used. It is expected that in many to most cases the amount used would be significantly less. These application rates are for an acre that is completely vegetated with the target weed (i.e., if broom only covers one-third of an target area, the application rate would be one-third the rate listed below per gross acre).

Glyphosate

The maximum rate of application for all treatments and species would not exceed 2 quarts or 2 pounds of active ingredient per acre.

Broom low volume foliar	1-2 quarts per acre
Broom seedling low volume foliar	2 quarts per acre
Thistles; spot foliar	1 quart per acre
Annual grasses	1 quart per acre
Perennial grasses	could approach 2 quarts per acre
Cut stump	1 quart per acre

Garlon 4 Ultra

Broom high volume foliar	1 quart per broadcast acre
Broom low volume basal and thin line	1 to 2 quarts per acres
Thistles; spot foliar	1 pint per acre
Cut stump	1 to 2 quarts per acre

Transline

Thistles; all foliar applications	4 ounces per acre
Broom seedlings	4 to 6 ounces per acre

Scythe

Broom seedling high volume foliar	2 gallons per acre
Thistles; spot foliar	1 gallon per acre
Annual grasses	1 gallon per acre

Matran

Broom seedling; high volume foliar	2 gallons per acre
Thistles; spot foliar	1 gallon per acre
Annual grasses	1 gallon per acre

Acetic Acid

Broom seedling; high volume foliar	5 gallons per acre
Thistles; spot foliar	3 gallons per acre
Annual grasses	3 gallons per acre

Competitor

Sylgard

Blazon

not more than 4 quarts per acre
not more than 8 ounces per acre
2 ounces per acre

D. Human Health Hazards and Environmental Consequences of Using Herbicides

Pesticide Research Institute is conducting a full assessment of the initially proposed herbicides, surfactants, and dye. The data included in their analysis will be used to guide the choice of alternatives for the plan. As of this writing, the introductory chapters (the Overview and Background Chapters) are available for review on the District's website. The chapters assessing the risks of the several chemicals being considered for inclusion in the IPM program will be posted throughout the summer of 2008 on the District's website as they are completed.

E. Broom Control Technique Comparisons

1. Broom Control Techniques Comparison Tables

Table 3 summarizes the previous information about herbicides plus the various non-chemical techniques that were identified and discussed in Background Report No. 1. It includes columns that describe:

- The constraints on using the technique;
- The scale of the population that the technique is typically used on;
- Other approaches that the technique is often used with;
- Potential health impacts of using the techniques; and
- Potential negative environmental effects.

It should be noted that the "Potential health impacts" and "Potential negative environmental effects" columns are gross simplifications of the information contained within the Pesticide Research Institute report.

Table 4 summarizes the efficacy of the techniques for the five life stages of broom. The table describes:

- The scale that the technique is typically used on; and
- Notes on the applicability of the technique;

Table 5 shows how these techniques could be integrated to treat broom at a landscape level.

2. Comparison of the Efficacy of Techniques Used by MMWD

MMWD has monitored a number of treated broom stands over the past 10 years and has correlated stem densities with the control techniques used at each site. Table 6 below presents those data as compared to a control group where no treatment occurred.

**Table 3
Summary of Broom Control Techniques**

	Treatment	Adult	Seedling	Seed Bank	Constraints	Scale	Integrated Approaches	Health Impacts	Environmental Effects
PRESCRIBED FIRE	Broadcast Burning uncut plants (grasslands)	>80%	>80%	10-50%	timing - fuel load/moisture - permitting - multiagency coordination	5 acre+	ineffective alone - needs seedling follow-up	smoke in urban environments	secondary invasions, wildfire, destruction of native plant plants and seeds, aesthetics, impacts to nests and small wildlife
	Broadcast Burning cut material (grasslands and woodlands)	>80%	>80%	>50%	timing - permitting - multiagency coordination, fuel load	5 acre+	cutting pre-treatment optimum, ineffective alone - needs follow-up	smoke in urban environments	secondary invasions, wildfire, damage to desirable canopy, destruction of native plant plants and seeds, aesthetics, impacts to nests and small wildlife
	Propane Torch Flaming	<10%	>80%	<10%	timing, terrain, adult stands need to be removed first	<2 acre	adult stands must be removed first	minor burns to workers	wildfire ignition if vegetation is too dry
MECHANICAL	Cutting/Mowing - brushcutter (powered)	50-80%	50-80%	<10%	broom stems <2" dia., single stemmed	1/2 acre +	chainsaws usually required for large individuals, optimum on flat terrain	ergonomic strains, cuts, petroleum product spills	petroleum product spills, noise, seasonal nesting bird disturbance, small wildlife mortality, seasonal fire risk,
	Cutting/Mowing - Heavy Equipment	50-80%	50-80%	<10%	flat, open, accessible terrain only	1/2 acre +	ineffective alone - needs seedling follow-up	petroleum product spills	non-target vegetation cutting, petroleum product spills, seasonal fire risk, seasonal nesting bird disturbance, loss of wildlife habitat, direct killing of wildlife, aesthetics
	Hot Foam (Waipuna)	10-50%	>50%	<10%	road access, large volumes of water required	<1 acre	adult stands and large seedlings removal requires follow-up	unknown	non-target vegetation impacts
	HydroMechanical Obliteration	unknown	unknown	unknown	road access, large volumes of water required	<5 acre	adult stands and large seedlings removal requires follow-up	cuts/bruises	soil disturbance
	Scraping/Pulling - Heavy Equipment	>50%	50-80%	>50%	flat, open, accessible terrain only	1/2 acre +	ineffective alone - needs seedling follow-up	petroleum product spills	non-target vegetation cutting, petroleum product spills, seasonal fire risk, seasonal nesting bird disturbance, loss of wildlife habitat, direct killing of wildlife, aesthetics
HAND (NON-POWER)	Cutting - Saw (non-powered)	10-50%	<10%	<10%	timing	<1 acre	ineffective alone - needs seedling and reprofing adult follow-up	cuts	negligible
	Mowing - Scythe (non-powered)	<10%	50-80%	<10%	highly trained/fit operator, not suitable for mature adult plants	<1 acre	ineffective alone - needs seedling follow-up	ergonomic strains	non-target vegetation
	Cutting Roots below Grade	>50%	>50%	10-50%	wet season only, non-rocky sites	<1 acre	ineffective alone - needs seedling follow-up	cuts	soil disturbance - erosion and prepare seedbed for weeds
	Cut/Peel Bark	50-80%	Not applicable	<10%	plants can not have damaged stems, multistemmed trunks	<1 acre	ineffective alone - needs seedling follow-up	cuts	negligible
	Hand Pulling (no tools)	<10%	>80%	<10%	wet season only, not suitable for large adult plants	<1 acre	large plants require tools for removal, excellent for follow-up control	ergonomic strains	soil disturbance - erosion and prepare seedbed for weeds
	Weed Wrench	>80%	Not applicable	<10%	winter only	<1 acre	pre-cutting large stands improves efficiency	ergonomic strains	soil disturbance - erosion and prepare seedbed for weeds
	Scraping (hand tools)	<10%	50-80%	<10%	winter/spring optimum	<1 acre	adult stands must be removed first	ergonomic strains	soil disturbance - erosion and prepare seedbed for weeds
CULTURAL	Competitive Planting	<10%	10-50%	10-50%	timing, species selection, adult stands need to be removed first	<1 acre	optimum with mulch, adult plant removal	none	negligible
	Grazing	10-50%	10-50%	<10%	timing, requires infrastructure	<1 acre	requires adult resprout and seedling follow-up	potential fecal contamination	soil disturbance, non-target vegetation damage
	Mulching - Organics	10-50%	10-50%	>50%	road access required, requires relatively flat site, adult stands need to be removed first	<1 acre	requires adult plant removal	none	negligible
	Mulching - Synthetics (solarization)	10-50%	10-50%	>50%	road access required, requires relatively flat site, adult stands need to be removed first	<1 acre	requires adult plant removal	none	negligible
CHEMICAL	Low Volume Foliar	yes	yes	yes	timing and plant density, species	5 acres <400 plants per acre	effective follow-up to all the above	potential toxicity	off-target species impacts, water quality
	Conventional Foliar	yes	yes	yes	timing and plant density, species	5 acres > 400 plants per acre	effective as initial control approach; will require manual and cultural follow-up	potential toxicity	off-target species impacts, water quality
	Low Volume Basal	some	no	some	species and plant density	1-3 acres <400 stems per acre	effective as initial control approach; will require manual and mechanical follow-up; seeding and possible seedling treatment as well	potential toxicity	off-target species impacts, water quality
	Thin Line Basal	some	no	some	species and plant density	1-3 acres >400 stems per acre, stems smaller than 1"	effective as an initial control approach; will require manual and or mechanical follow-up	potential toxicity	off-target species impacts, water quality
	Conventional Cut Stump	some	no	some	species, density and biomass removal requirements	Stems greater than 3 inches, acres will vary	requires initial removal of adult plants, limited use, incidental treatment	potential toxicity	off-target species impacts, water quality
	Modified Cut Stump	some	no	some	species, density and biomass removal requirements	Stems less than 3 inches, acres will vary	requires initial removal of adult plants; will require seedling follow-up	potential toxicity	off-target species impacts, water quality

Table 4
Efficacy of Broom Control Techniques for Various Plant Life Stages

Optimal Control Strategies by Lifestage			
Life Stage	Method	Scale	Notes
Adult Control - Biomass Removal	Broadcast Burning (grasslands)	5 acre+	
	Broadcast Burning cut material (grass;lands and woodlands)	5 acre+	
	Cutting/Mowing - brushcutter (powered)	1/2 acre +	chainsaws used for steep terrain
	Cutting/Mowing - Heavy Equipment	1/2 acre +	
	Cutting - Saw (non-powered)	<1 acre	
	Cutting Roots below Grade	<1 acre	variable effectiveness, requires disposable tools
	Cut/Peel Bark	<1 acre	very slow
	Hand Pulling (no tools)	<1 acre	large plants require tools for removal
	Weed Wrench	<1 acre	pre-cutting large stands improves efficiency
	Herbicide; Cut stump	<5 acres	follow up to adult removal
Juvenile Plants	Broadcast Burning (grasslands)	5 acre+	
	Cutting/Mowing - brushcutter (powered)	1/2 acre +	chainsaws used for steep terrain
	Cutting/Mowing - Heavy Equipment	1/2 acre +	
	Hand Pulling (no tools)	<1 acre	large plants require tools for removal
	Weed Wrench	<1 acre	pre-cutting large stands improves efficiency
	Mowing - Scythe (non-powered)	<1 acre	requires specialty training, uncommon tool
	Scraping (hand tools)	<1 acre	Pulaski axe, McCleod/Rogue hoes, good for Scotch broom
	Herbicide; foliar, basal	1-5 acres	species and density will determine method
Seedlings/Seed Bank	Broadcast Burning (grasslands)	5 acre+	
	Propane Torch Flaming	<2 acre	
	Hot Foam	<1 acre	uncommon, expensive tool, road access needed
	HydroMechanical Obliteration	<1 acre	uncommon, expensive tool, road access needed
	Scraping/Pulling - Heavy Equipment	1/2 acre +	
	Competitive Planting	<1 acre	optimum with mulch
	Mulching - Organics	<1 acre	requires adult plant removal
	Mulching - Synthetics (solarization)	<1 acre	requires adult plant removal
Herbicide; Foliar	1-5 acres	effective on seedlings and seed viability	
Lower Suppression	Cutting/Mowing - brushcutter (powered)	1/2 acre +	repeated, consistent cutting can reduce flowering
	Cutting/Mowing - Heavy Equipment	1/2 acre +	repeated, consistent cutting can reduce flowering
	Cutting - Saw (non-powered)	<1 acre	
	Grazing	<1 acre	requires temporary/permanent infrastructure

**Table 5
Integrated Methods for Landscape Level Broom Control**

	Method	Initial Removal/Biomass Reduction	Resprout Treatment	Seedling Treatment	Scale	Area Treated	Comments
Prescribed Fire	Broadcast Burn (uncut plants, grasslands only)	YR1: Hand/Weed Wrench™ pull broom, leave adult biomass on ground, follow-up several months later with cool spring burn when broom debris has dried.	YR2: Repeat burn to kill seedlings and mature plants that survived.	YR3+: Alternate season burns; hand pulling in later phases of treatment.	Large	5 acre +	Ideal for grassland/coastal prairie where frequent burns can be carried by grass fuel loads. Any burn requires significant overhead of agency coordination/permitting/health&safety. Potential to increase broom density. Secondary weed invasions likely follow burn disturbance.
	Broadcast Burn cut plants (grassland-woodland)	YR1: Cut broom with brushcutters (small stands)/heavy equipment, leave adult biomass on ground, follow-up later with broadcast burn when broom debris has dried.	YR2: Repeat burn in grasslands. In woodlands, YR2 rarely has enough fuel for a follow up burn. YR3 is questionable in woodlands unless repeat mowing occurs. Mowing may be required in YR3 to prevent seed set.	YR3+: Alternate season burns; hand pulling in later phases of treatment; In woodlands, alternate burning, resting, mowing, mowing, mowing, burning to allow for sufficient fuel load development.	Large	5 acre +	High frequency burning in woodlands will cause high mortality to woody trees and tends to open woodland canopy. Potential to increase broom density. Secondary weed invasions likely follow burn disturbance.
NOTES ON BURNING TREATMENTS: All burning works well for single species management when repeat burning frequency can be guaranteed until project completion. If burn treatment frequency is ever interrupted or delayed, broom populations will rapidly recolonize and double in density, reversing all previous control attempts. All burning creates disturbance which is often exploited by other opportunistic invasive weeds thus requiring a further series of restoration treatments. Most agencies report burning is a wildcard in urban environments and often becomes politically or administratively infeasible for 2nd year and other repeat control attempts.							
Hand and Mechanical	Cut - Winter Pile Burn or Wind Row Burn - Flame	YR1: Cut broom with brushcutters (small stands)/heavy equipment. Pile or stack in wind rows and tarp. Follow-up with winter burning.	YR2 or shortly after Winter Burn: propane flame seedlings.	YR3+: Alternate flaming, pulling then convert to pulling in later phases.	Medium	1-5 acres	Expensive. Winter burns get around permit and crew issues. Often followed by seedling flush which can be removed same season.
	Cut - Winter Pile Burn or Wind Row Burn - Mow	YR1: Cut broom to less than 3 inches in height with brushcutters (small stands)/heavy equipment. Pile or stack in wind rows and tarp. Follow-up with winter burning.	Mow annually	Mow annually.	Large	5 acre +	Cost effective method of suppressing seed set. More cost efficient than propane flaming and pulling
	Cut - Pile - Pull - Propane Flame	YR1: Cut broom to 2 ft in height with brushcutters/chainsaws (small stands)/heavy equipment, pile adult biomass to facilitate follow-up treatments. Immediately following cutting regime, broom is pulled by hand/Weed Wrench™.	YR2: Flaming with propane torch - hand pulling; habitat distinction necessary. Many of our sites have too much vegetation to allow for follow-up flaming after a brushcutter or handpulling pass.	YR3+: Flaming with propane torch - hand pulling.	Small/Medium	1-5 acre	Cutting is only used to improve efficiency of pulling by adjusting vegetation to an optimum stump height. This series of techniques is optimum for precision removal of small - medium stands of broom.
	Pull - Pile - Propane Flame	YR1: Hand/Weed Wrench™ pull broom, pile adult biomass to facilitate follow-up treatments.	YR2: Flaming with propane torch - hand pulling.	YR3+: Flaming with propane torch - hand pulling.	Small/Medium	1-5 acre	Expensive. Technique on larger scales may produce potential for erosion but erosion control impedes flaming follow-up - optimum for smaller, flat areas. Flaming tools for large production uncommon and still need development.
	Pull - Pile - Mow	YR1: Hand/Weed Wrench™ pull broom, pile adult biomass to facilitate follow-up treatments.	YR2: Mow 2X-4X during growing season.	YR3+: Mow 2X-4X during growing season.	Small/Medium	1-5 acre	Technique appropriate when volunteer labor can be used to pull initial stands but agency staff has limited means for follow-up - method for suppression only. Only results in long term suppression.
	Pull - Pile - Pull	YR1: Hand/Weed Wrench™ pull broom, pile adult biomass to facilitate follow-up treatments.	YR2: Pull broom.	YR3+: Pull broom about every other year, after the first 3 years --no seeding aged plants to deal with.	Small	<1 acre	Ideal for small patches with easy access. Typical method for small restoration projects implemented by volunteers.
	Pull - Pile - Mulch - Pull	YR1: Hand/Weed Wrench™ pull broom, pile adult biomass to facilitate follow-up treatments. Immediately after pulling apply thick mulch (>12") with rice straw, wood chips or other organic material.	YR2: Pull broom.	YR3+: Pull broom.	Small/Medium	1-5 acre	Untested. Rice straw mulch may or may not significantly reduce resprouts. Excessive mulch can prevent native establishment..
NOTES ON CUT/PULL TREATMENTS: Piling and processing cut/pulled vegetation is critical for initial stages. On-site piling/processing is almost always the preferred option. Piles are stacked neatly and buck mulched chipped, or burned in place to reduce biomass. In general, methods reliant on pulling large stands of broom for multiple years require use of abundant, inexpensive labor (volunteer or temporary paid). Flaming is a relatively new method with few commercially available tools for large scale implementation. Custom fabrication and product development would be necessary for large scale use of this tool.							
Herbicide	Cut - Burn - Apply Herbicide - Pull	YR1: Cut broom with brushcutters (small stands)/heavy equipment, leave adult biomass on ground, follow-up later with hot fall burn when broom debris has dried.	YR2: Apply herbicide to resprouts and seedlings.	YR3+: Flame seedlings. If miss flaming window due to the large scale of treatment, then apply herbicide.	Large	5 acre +	For appropriate agencies where fire is an option, optimizes biomass removal with fire and follow-up with spot herbicide treatment. Flushes seedbed.
	Cut - Pile - Apply Herbicide - Pull	YR1: Cut broom with brushcutters/chainsaws (small stands)/heavy equipment, pile adult biomass to facilitate follow-up treatments. Allow several months for regrowth and apply foliar herbicide to reprofing plants.	YR2: Flame seedlings. Apply herbicide to resprouts and seedlings if they cannot be flamed during the wet season window..	YR3+: Flame seedlings. If miss flaming window due to the large scale of treatment, then apply herbicide.	Small - Large	0-5 acre +	Technique is the most selective and efficient integrated method for hand control of medium to large sized broom stands. Optimum technique when special status species are present.
	Cut - Pile - Apply Herbicide- Flame/Spray	YR1: Cut broom as above, immediately pile adult biomass out of the way and immediately treat cut stumps with herbicide. Pile burn after plants have dried.	YR2: Flame seedlings with propane torch. Apply herbicide to seedlings that cannot be flamed during the wet season window.	YR3+: Flame seedlings or apply herbicide if miss the flaming window..	Small - Large	0-5+ acres	Technique is most selective method, but difficult to implement as the window for herbicide application is very short.
	Basal Treat - Cut - Burn - Flame or Apply Herbicide	YR1: Use a wand or pressure apply herbicide to stems. Cut plants after they die. Pile burn or broadcast burn.	YR2: Flame seedlings with propane torch. Apply herbicide to seedlings that cannot be flamed during the wet season window.	YR3+: Flame seedlings or apply herbicide if miss the flaming window.	Small - Large	0-5+ acres	Technique is equivalent to preceding approach. Flushes seedbed.
	Cut - Mulch - Apply Herbicide	YR1: cut and mulch large broom stands in place, leaving thick broom mulch layer in place (12-24").	YR2: Apply herbicide to resprouts (thick mulch results in only stump sprouts).	YR3+: Pull or apply herbicide if pulling	Large	5 acre +	Optimum for cost effective initial removal/biomass reduction when fire is not an option. Heavy mulch reduces seed sprouts for up to 2 years following initial removal and secondary weed invasions uncommon. Only tested on gorse.
NOTES ON INTEGRATED HERBICIDE APPROACHES: The general theme with all these techniques is to cut and process the initial biomass with fire or mechanical methods and then follow-up with herbicide for intermediate control and finish with hand method stewardship. The initial reduction in biomass reduces the amount of herbicide necessary for complete control. Tools like flaming and mulching could further reduce the herbicide necessary for the same net effect.							

**Table 6
Broom Density By Treatment History**

Treatment	Sites	Years of Treatment Regime	Mean stems per acre	Dominant Life Stage
No Treatment (Control Group)	Canyon Trail Eliot Trail	>8	93,100	Adult
Handpulling	Lake Lagunitas Shoreline	12	16,800	Sapling
Annual mowing	Pine Point	>12	40,000	Resprout
Annual mowing with follow-up herbicide application	Indian Fire Road, Old Railroad Grade, Gravity Car	1 to 3 years	15,500	Seedling
Periodic prescribed burn with annual mowing	Phoenix Lake Fawn Ridge	>8	57,600	Resprout
Periodic prescribed burn with annual mowing and follow-up herbicide application	Fawn Ridge, Sky Oaks Meadow	1 to 3 years	24,600	Seedling

3. Criteria Used for Rating of Techniques

In a subsequent report, MMWD will present alternative implementation strategies to manage watershed vegetation to meet plan goals and objectives. Criteria used to evaluate the potential suitability of any given weed control technique or combination of techniques will include efficacy with regards to meeting plan goals, efficiency and feasibility on a landscape scale, cost and potential negative impacts to public health and environmental impacts. Components of public health and environmental impacts to be considered include (in alphabetical order):

- Accidental ignition potential
- Aesthetics
- Air quality
- Amphibians
- Carbon emissions
- Environmental persistence
- Erosion and runoff
- Nesting birds
- Noise
- Non-target terrestrial and aquatic vegetation
- Pollinators
- Public health and safety
- Salmonids
- Soil productivity and microorganisms
- Water quality
- Worker health and safety

The previous discussions and tables provide some data for these selection criteria.

Estimating the costs of using a given technique or combination of techniques is not a straightforward process. The costs are entirely dependent on at least the following factors:

- The characteristic of the weed species and specific stand – whether they are seedling, saplings, adults, resprouts, or some mix of all ages;
- The topography – how steep the slope is;
- Access – how easy it is to reach the stand;
- What labor source is available, i.e. will the work be done by MMWD staff, a private contractor, adult offenders/probationary workers, or volunteers;
- The expertise of the workers and equipment operators;
- The presence of sensitive resources in the area or hazards (cliffs, poison oak, etc.);
- The season and weather conditions;
- The prior management history of the site; and
- The overall goals and objectives for the treatment area.

At a program level of analysis, a range of costs can be provided that encompasses the various factors. Herbicide application costs are easier to estimate than non-chemical techniques. For broom treatments, the chemicals cost about \$25 per acre. For thistles, the chemicals cost about \$20 per acre, and for all other target weeds the chemicals costs \$10 to \$12 per acre. Labor costs for all applications range from \$75 to \$100 per acre.

Peer Review

To follow up on the information received at the February 2009 broom workshop, MMWD is conducting additional surveys among the attendees of the workshop and other broom control experts about the effectiveness, efficiency and cost of the various techniques that were identified at the workshop and are summarized above. The results of this survey are not known at the time this report was prepared.

If warranted, the results of these surveys will be used to revise the information and conclusions in this background report when the consulting team develops the plan alternatives.

Finally, the completed report will be presented for peer review at a broom-focused workshop at the annual California Invasive Plant Council (Cal-IPC) symposium to be held in early October in Chico, California.

E. Potential Control Techniques for Other Weeds

Table 7 summarizes the techniques for the high priority weeds (other than broom).

1. Annual Thistles Control Techniques

Thistles are spiny, herbaceous members of the Aster family (*Asteraceae*). Most thistles have evolved with grazing regimes, and have developed defenses such as spines, and the ability to resprout and produce seed quickly and prolifically after being cut or grazed. Thistle seeds have a bristly or plume-like structure, called a pappus, that facilitates long-range dispersal by wind or by adhering to animals, and vehicle undercarriages. Invasive thistles can form dense infestations that exclude livestock, native plants and animals, and limit recreational access. There are many weedy members of the thistle tribe, three of which are high priority invasives on MMWD lands.

Yellow starthistle (*Centaurea solstitialis*) is a deep-taprooted annual that produces many spiny, yellow flower heads from late spring through fall. Yellow starthistle invades summer-dry grasslands and rangelands in California and Oregon below 7,500 feet elevation (DiTomaso and Gerlach 2000). Introduced in the 1850s, yellow starthistle now infests between 10 and 15 million acres in California (DiTomaso et al. 2007). Dense infestations displace native plants and animals, and significantly deplete soil moisture reserves in annual grasslands in California. Yellow starthistle is poisonous to horses, interferes with grazing, reduces land value, and limits access to recreational areas (DiTomaso and Gerlach 2000).

Distaff thistle (*Carthamus lanatus*) is a taprooted, spiny annual with yellow flowers, which grows up to four feet tall and blooms from late spring through fall. It can form dense infestations in grasslands, and is expanding in the coast ranges of California. Its current distribution in California is limited, though it may become more severe (Cal-IPC 2006a). In areas of Australia with a Mediterranean climate similar to California, distaff thistle is among the most widespread and troublesome weeds (Burrill 1994). Methods of controlling these thistles include:

Possible Techniques

Foliar applications could be used to treat thistles. Herbicide selection would be determined on a site by site basis. Transline plus surfactant, (Sylgard is preferred) is the preferred treatment where selectivity and efficacy are the primary consideration. Environmental concerns at specific locations may determine what alternate herbicides and surfactants are used. Where there are scattered plants, individual spray applications could be made. Spot applications could be made using any of the herbicides under consideration. For areas where infestations are heavy, foliar applications at the rate of 4 ounces per acre of Transline would be made. The timing of the application is critical as the plant is vulnerable from the seedling stage to about 6 inches (bolting stage), prior to bud formation. Aquamaster or Garlon would be used if plants are beyond bud formation. Scythe, Matran and acetic acid could be used on the annual thistles at all growth stage prior to seed set, as well when selectivity is not an issue.

**Table 7
Technique Feasibility for Non-Broom Target Weeds**

Method	Target Weed	Objective	Lethal	Efficiency	Cost	Efficacy	Non-target Impacts	Worker Health/Public Safety	
Prescribed Burning	Annual thistles (yellow star thistle, distaff thistle) ¹	Lethal control	Adults - Yes Seedlings-Yes	High efficiency for large scale (>5 acres) removal	High initial cost, dropping as area increases	Extreme variability in effects, impacts and likelihood for implementation	Can benefit certain species/vegetation; increases invasion potential for other exotics; converts habitats to grassland	Smoke inhalation/air quality hazards; fire, equipment and operation hazards to fire crews; escaped wildfire potential	
	Annual grasses (Medusahead, barbed goat grass)	Lethal control	Adults - Yes	High efficiency for large scale (>5 acres) removal	High initial cost, dropping as area increases	Extreme variability as species tend to occur in rocky areas resulting in uneven burn. Can leave large unburned areas full of weeds	Can benefit certain species/vegetation; increases invasion potential for other exotics; converts habitats to grassland	Smoke inhalation/air quality hazards; fire, equipment and operation hazards to fire crews; escaped wildfire potential	
	Biennials (purple starthistle, teasel)	Biomass removal - Pretreatment	No	High efficiency for large scale (>5 acres) biomass removal	High initial cost, dropping as area increases	Likely will not kill adult plants	Can benefit certain species/vegetation; increases invasion potential for other exotics; converts habitats to grassland	Smoke inhalation/air quality hazards; fire, equipment and operation hazards to fire crews; escaped wildfire potential	
	Perennial grasses - grasslands (Harding grass, tall fescue)	Biomass removal - Pretreatment	Adults - No	High efficiency for large scale (>5 acres) biomass removal	High initial cost, dropping as area increases	Variable. Burns can either stimulate shoots or damage depending on seasonality. Will not kill adult plants, may stimulate regrowth.	Can benefit certain species/vegetation; increases invasion potential for other exotics; converts habitats to grassland	Smoke inhalation/air quality hazards; fire, equipment and operation hazards to fire crews; escaped wildfire potential	
	Perennial grasses - woodland - (<i>Ehrharta</i> grass)	Not recommended - fire stimulates additional growth							
Torch Flaming	Annual thistles (yellow star thistle, distaff thistle)	Not recommended - high fire hazard if timed to achieve high kill		Annual thistles (yellow star thistle, distaff thistle)	Possible initial removal of small patches (YST only), but not recommended	Adults- No Seedlings-Yes	Efficient on small patches (<1 acre)	Cost effective on small scale (<1acre)	
	Annual grasses (Medusahead, barbed goat grass)	Not recommended - high fire hazard if timed to achieve high kill							
	Biennials (purple starthistle, teasel)	Unknown, but possible	Adults- No	Unknown	Unknown	Unknown	Negligible	Smoke inhalation/air quality hazards; fire, equipment and operation hazards to fire crews; escaped wildfire potential	
	Perennial grasses - grasslands (Harding grass, tall fescue)	Not recommended - does not kill roots, which resprout							
	Perennial grasses - woodland - (<i>Ehrharta</i> grass)	Not recommended - fire stimulates additional growth							

¹ Yellow star thistle can at times act as a short-lived perennial.

**Table 7
Technique Feasibility for Non-Broom Target Weeds**

Method	Target Weed	Objective	Lethal	Efficiency	Cost	Predictability of Results	Non-target Impacts	Worker Health/Public Safety
Pulling/Digging	Annual thistles (yellow star thistle, distaff thistle)	Initial removal of small patches	Adults - Yes Seedlings - Yes	Efficient on very small patches (<1 acre)	Cost effective on small scale <1 acre	Effective as plants susceptible during long spring/summer growing period	Negligible	Ergonomic impacts to workers at larger scale
	Annual grasses (Medusahead, barbed goat grass)	Initial removal of small patches	Adults - Yes	Efficient on very small patches (<1 acre)	Cost effective on small scale <1 acre	Effective as plants susceptible during long spring/summer growing period	Negligible	Ergonomic impacts to workers at larger scale
	Biennials (purple starthistle, teasel)	Initial removal of small patches	Adults - Yes Seedlings - Yes	Efficient on very small patches (<1 acre)	Cost effective on small scale <1 acre	Effective as plants susceptible after plants bolt but before seedheads are produced	Negligible	Ergonomic impacts to workers at larger scale
	Perennial grasses - grasslands (Harding grass, tall fescue)	Initial removal of small patches	Adults - Yes Seedlings - Yes	Efficient on small patches (<1 acre) , larger areas with excavator	Cost effective on small scale <1 acre	Effective as plants susceptible during long winter/spring growing period	Negligible unless heavy equipment used	Ergonomic impacts to workers at larger scale
	Perennial grasses - woodland - (<i>Ehrharta</i> grass)	Not recommended -hand pulling or digging is reported as a successful short-term strategy, although these methods are extremely time-consuming. Soil disturbance associated with pulling and digging may result in a flush soon after initial plant removal.						
Mowing	Annual thistles (yellow star thistle, distaff thistle)	Initial removal and follow-up control	Adults - Yes Seedlings - No	Efficient at small to medium scale (1-5 acres)	Cost effective on small - medium scale	Not effective as plants only susceptible 1 week a year	Negligible	Wildfire ignition risk in summer
	Annual grasses (Medusahead, barbed goat grass)	Initial removal and follow-up control	Adults - Yes Seedlings - No	Efficient at small to medium scale (1-5 acres)	Cost effective on small - medium scale	Not effective as plant susceptible only a short period during year	Negligible	Negligible
	Biennials (purple starthistle, teasel)	Biomass removal/Pretreatment	No	Efficient at small to medium scale (1-5 acres)	Cost effective on small - medium scale	Effective for biomass removal	Negligible	Negligible
	Perennial grasses - grasslands (Harding grass,tall fescue)	Biomass removal/Pretreatment only	Adults - No Seedlings - No	Efficient at small to medium scale (1-5 acres)	Cost effective on small - medium scale	Effective -can occur anytime spring, summer fall	Negligible	Negligible
	Perennial grasses - woodland - (<i>Ehrharta</i> grass)	Not recommended - excessive soil disturbance facilitates the germination of seeds in the seed bank						

**Table 7
Technique Feasibility for Non-Broom Target Weeds**

Method	Target Weed	Objective	Lethal	Efficiency	Cost	Predictability of Results	Non-target Impacts	Worker Health/Public Safety
Tarping/Mulch	Annual thistles (yellow star thistle, distaff thistle)	Not recommended - would also kill native species as unable to cover selectively due to intermixing with grasses						
	Annual grasses (Medusahead, barbed goat grass)	Not recommended - would also kill native species as unable to cover selectively due to intermixing with grasses						
	Biennials (purple starthistle, teasel)	May be effective control for teasel	Potentially	Unknown	Unknown	Unknown	Non-selective impacts to most native annual and perennial seedlings	
	Perennial grasses - grasslands (Harding grass, tall fescue)	Seedling/Resprout control in small areas as follow-up to hand removal	Adults - No Seedlings - <50%	Efficient at small scale (<1 acre) near roads	High cost for labor and synthetic/natural materials and delivery	Effective - can be implemented most of the year	Non-selective impacts to most native annual and perennial seedlings	Negligible
	Perennial grasses - woodland - (<i>Ehrharta</i> grass)	Seedling/Resprout control in small areas as follow-up to hand removal	Adults - <50% Seedlings - <50%	Efficient at small scale (<1 acre) near roads	High cost for labor and synthetic/natural materials and delivery	Effective - can be implemented most of the year	Non-selective impacts to most native annual and perennial seedlings	Negligible
Grazing	Annual thistles (yellow star thistle, distaff thistle)	Suppression, Initial treatment for reducing populations	Adults - 50-80% Seedlings - No	Efficient in ag. areas where infrastructure present	Low costs in ag. areas where infrastructure present	Not effective - timing key for any control; poor timing results in population enhancement/expansion	Non-selective, natives can be severely impacted	Negligible
	Annual grasses (Medusahead, barbed goat grass)	Suppression, Initial treatment for reducing populations	Adults - 50-80% Seedlings - No	Efficient in ag. areas where infrastructure present	Low costs in ag. areas where infrastructure present	Not effective - timing key for any control; poor timing results in population enhancement/expansion	Non-selective, natives can be severely impacted	Negligible
	Biennials (purple starthistle, teasel)	Not recommended for purple starthistle. Recommended for teasel at Nicasio	Unknown	Efficient in ag areas where infrastructure present	Low costs in ag areas where infrastructure present	Unknown	Non-selective, natives can be severely impacted	Negligible
	Perennial grasses - grasslands (Harding grass, tall fescue)	Not recommended for Harding grass; unknown impact on tall fescue	Adults - No	Efficient in ag. areas where infrastructure present	Low costs in ag. areas where infrastructure present	Unknown	Non-selective, natives can be severely impacted	Negligible
	Perennial grasses - woodland - (<i>Ehrharta</i> grass)	Not recommended - unkown effectiveness						

**Table 7
Technique Feasibility for Non-Broom Target Weeds**

Herbicide	Annual thistles (yellow star thistle, distaff thistle)	Initial control, lethal	Adults - No pre bud yes Seedling/rosette - yes	Efficient on all levels	\$20 per acre for chemical, labor can range from \$75 to \$100/acre	Timing essential - plant vulnerable approximately seedling to 6 inches bolt for selective treatments	Density dependnent, can be significant depending on herbicide choice	Potential toxicity
	Annual grasses (Medusahead, barbed goat grass)	Initial control, lethal	Adults - yes but not practical, seedlings yes	Efficient on monocultures, not so effective on individual occurences	\$10 to \$12 per acre for chemical, labor can range from \$75 to \$100/acre	Timing; seedling to tillering	Considerable	Potential toxicity
	Biennials (purple starthistle, teasel)	Initial control, lethal	Adults - No pre bud yes Seedling/rosette - yes	Efficient on all levels	\$20 per acre for chemical, labor can range from \$75 to \$100/acre per application	Timing essential - plant vulnerable approximately seedling to 6 inches bolt for selective treatments (biennial thistle may require 2 applications per season)	Density dependnent, can be significant depending on herbicide choice	Potential toxicity
	Perennial grasses - grasslands (Harding grass, tall fescue)	Initial control, lethal	Adults-yes, seedlings yes	Efficient on monocultures, individual on a case by case basis	\$10 to \$12 per acre for chemical, labor can range from \$75 to \$100/acre	Timing; seedling to tillering	Considerable	Potential toxicity
	Perennial grasses - woodland - (<i>Ehrharta</i> grass)	Initial control, lethal	Adults-yes, seedlings yes	Efficient on monocultures, individual on a case by case basis	\$10 to \$12 per acre for chemical, labor can range from \$75 to \$100/acre	Timing; seedling to tillering	Density dependnent, can be significant depending on herbicide choice	Potential toxicity

Note: Biological controls are not included in this table and will be discussed in more detail in the weed report. While these are certain insects that affect thistles and other target weeds, none are lethal at a large scale.

*This table focuses on the high priority weeds of concern on the watersheds. Additional weed species of concern will be addressed at a later date. Broom is addressed separately.

2. Annual Grasses Control Techniques

Annual grasses are members of the grass family (*Poaceae*) that complete their life cycle (germination through death) in one year or growing season. Introduced, annual grasses are widespread in California and dominate most of the grassland vegetation in the state. Invasive annual grasses out-compete native grassland plant species through superior growth rates and prolific seed production. Reproduction is entirely by seed, which is dispersed by adhering to the coats of animals, machinery, vehicles, or clothing. The dominant annual grasses in California were introduced in the eighteenth century, and quickly spread throughout the state. Some non-native annual grasses are expanding their ranges in California due to the removal of periodic fire from rangelands (DiTomaso et al. 2001).

Medusahead (*Taeniatherum caput-medusae*) is a slender annual grass that out-competes native grasses and forbs (Kan and Pollak 2000). Once established it can reach densities of 2,000 plants per square meter. After seed-set, the silica-rich plants persist as a dense litter layer that suppresses other plants and contributes to fire danger in summer. Mature medusahead is unpalatable to livestock because of its high silica content.

Barbed goatgrass (*Aegilops triuncialis*) is an introduced annual grass that is spreading throughout California grasslands. When mature, it is unpalatable for livestock. It has barbed seedheads that break apart and tenaciously adhere to fur or clothing. In grasslands, Barbed goatgrass reduces the abundance of native perennial bunchgrasses and competes with more desirable introduced annuals, as well as native forbs. Unlike many other introduced annual grasses found in California, this species appears to do well on serpentine soils that are generally resistant to the spread of annual grasses and therefore are thought of as refugia for native plants (DiTomaso et al. 2001).

Possible Techniques

Foliar applications could be used for the control of grasses, including use of glyphosate (at a rate of not more than 1 quart per acre), Scythe (at not more than 1 gallon per acre), Matran (at not more than 1 gallon per acre), and/or acetic acid (at not more than 3 gallons per acre). Species concerns and environmental concerns at specific locations would determine which herbicide and surfactant is used. Where there are scattered plants, individual spray applications could be made, but typically this is not the case for annual grasses that tend to be intermixed with other grasses. The treatments are lethal at all stages of growth, however, prior to seed set is the best time for this application. Garlon and Transline will not be used as these herbicides are not active on grasses.

3. Perennial Grasses Control Techniques

Perennial grasses are members of the grass family (*Poaceae*) that live more than two years or growing seasons. Perennial Eurasian grass species are increasingly common invaders in the north coast prairies of California. Invasive perennial grasses pose a unique management challenge. Unlike annual grasses, they resprout readily after being cut, grazed, or burned. Many native grassland species are perennials, so broad control of invasive perennials affects native perennials as well. Because invasive perennial

grasses tend to have higher relative growth rates than native perennial grasses (Thomsen et al. 2001), broad controls tend to impact native perennial grassland species more severely than invasive perennial grass species.

Ehrharta grass (*Ehrharta erecta*) is a low-growing, light green grass that spreads in moderately moist places in coastal California. It has been observed to grow in a variety of habitats and soils, but is most often invasive in woodland and forest understory. It is one of the few weed species to date to invade Douglas Fir and Redwood forests. Ehrharta grass spreads both vegetatively, and by copious production of small seeds. It develops a dense turf that makes it difficult for seeds of other species to germinate (Pickart 2000).

Tall fescue (*Festuca arundinacea*) is a dense, two to three foot tall, dark green grass, which reproduces both vegetatively and by seed. Although it can be invasive in native grasslands, shrublands, and woodlands, it has been widely planted as forage and turf grass (Batcher 2005). Tall fescue prefers deep, moist soils, but is also tolerant of winter flooding, summer drought and a range of soil depths and textures (ibid). Tall fescue can vigorously outcompete native grassland species. Large stands of tall fescue create a dense thatch that can inhibit germination of grasses, forbs and woody plants. Studies have shown that tall fescue produces allelopathic compounds that inhibit the growth of other plants (Anderson et al. 1989, Wade 1989)

Harding grass (*Phalaris aquatica*) is a three to four foot tall, perennial bunchgrass with blue-grey leaves. It is widespread in California, where it has been used for forage and revegetation after fires (Harrington and Lanini 2000). Harding grass reproduces by seed. Established stands of Harding grass can produce up to 40,000 seeds per square meter per year (Reddy et al. 1996). Seeds are dispersed short distances by wind and animals, and long distances by human activity. Harding grass out-competes and displaces native grassland species. When dry in summer, stands of Harding grass create a fire hazard.

Possible Techniques

A foliar application of glyphosate is the best chemical method of control (at not more than 2 quarts per acre). Where there are scattered plants, individual spray applications could be made. The treatment is lethal to all stages, from seedling to tillering. The best timing for this application is prior to seed set through the summer, when translocation to the rhizomes and underground growth structure is most prevalent. The applications are efficient on heavy stands or monocultures. Treating individual plants is effective but not as efficient.

4. Biennials Control Techniques

Biennial plants complete their life cycle (germination through death) in two years or growing seasons (generally flowering only in the second) and are non-woody (Hickman 1993). Plants categorized as biennials can also behave like annuals in favorable conditions, growing to maturity and flowering in one year, or as perennials in unfavorable conditions, taking 3-4 years to complete their life cycle.

Purple starthistle (*Centaurea calcitrapa*) is an annual to perennial plant with a mounding growth habit and heads of purple flowers surrounded by long, stout, sharp-pointed spines (Randall 2000). Under favorable conditions, purple starthistle can germinate and flower within one year. Under less favorable conditions, it can take over two years to grow and flower. Purple starthistle is a pest of pastures, and is a major problem in the Bay Area. Dense stands of mature plants can make areas inaccessible to livestock or humans.

Teasel species (*Dipsacus fullonum* and *Dipsacus sativus*) are tall (3-5'), spiny plants which superficially resemble thistles. Teasels have rigid, spiny flowerheads at the top of long stalks that sprout from basal rosettes of large, flat leaves. Teasel grows in moist, open, habitats, although they can grow in dry conditions as well. Teasels usually invade disturbed habitats such as fallow fields, pastures, ditches, and roadsides. However, they have been observed to invade higher quality natural communities including prairies, seeps, and sedge meadows (Cal-IPC 2004). If left unchecked, teasels can quickly form large monocultures excluding all native vegetation. Stands of teasel can become dense and impenetrable to humans or livestock. Little is known about controlling teasel. It is evident from field observations at Nicasio Reservoir that areas where livestock have been excluded are being rapidly invaded by teasel. Therefore, cattle grazing does at least suppress teasel invasion.

Possible Techniques

Foliar applications could be made for control of these species. All herbicides proposed for use in the plan have some level of activity on these species. Transline plus a surfactant, (Sylgard would be preferred) is the preferred treatment where selectivity and efficacy are the primary consideration. Environmental concerns at specific locations may determine which other herbicide and surfactants are used. Aquamaster is equally effective, but is non-selective. Transline is effective from rosette to pre-bud stage. Aquamaster is effective through seed set. Where there are scattered plants, individual spray applications could be made. For areas where infestations are heavy, foliar applications at the rate of 4 to 6 ounces per acre for Transline and 1 quart per acre of Aquamaster would be used. Either surfactant could be used at a concentration of 0.25 to 0.5% by volume. To be effective in the control of biennials, two applications per growing season would be required.

5. Comparison of Techniques

Table 7 compares the techniques for the four guilds of weeds. It includes columns that describe:

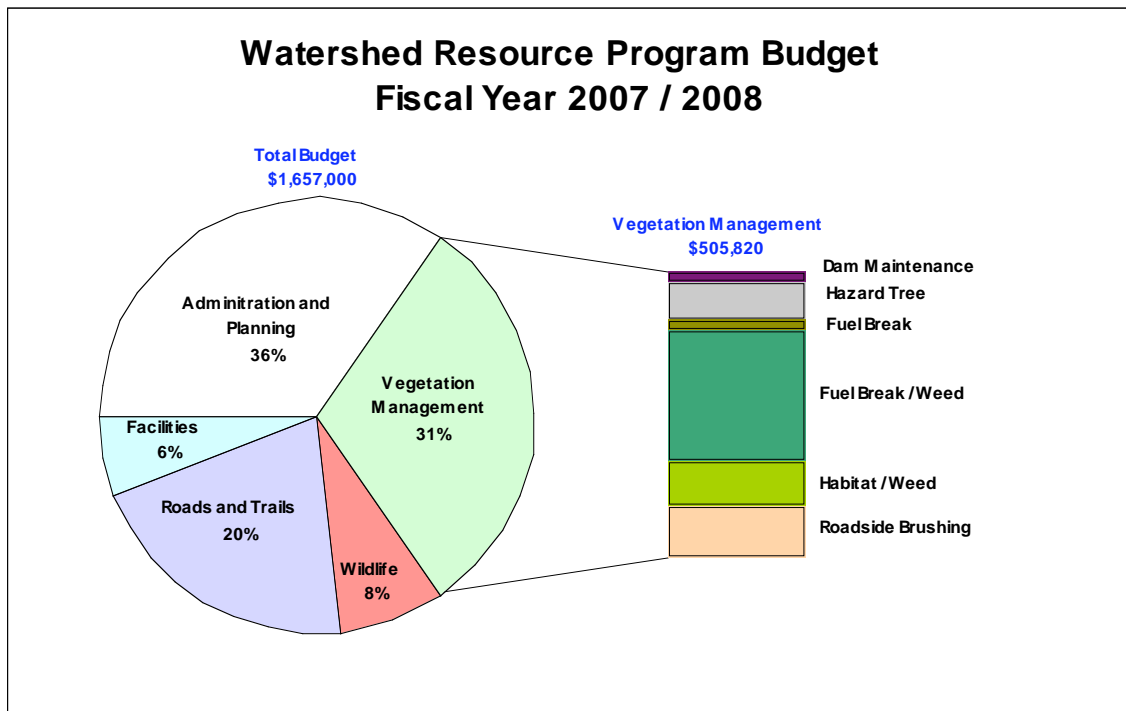
- The objective of using the technique;
- How lethal the technique is for the target weed species;
- The cost range for applying the technique;
- The predictability of efficacy;
- Non-target adverse impacts;
- Worker safety and public health impacts; and drinking water quality impacts.

F. MMWD Labor Requirements and Costs for Past Broom Control Projects

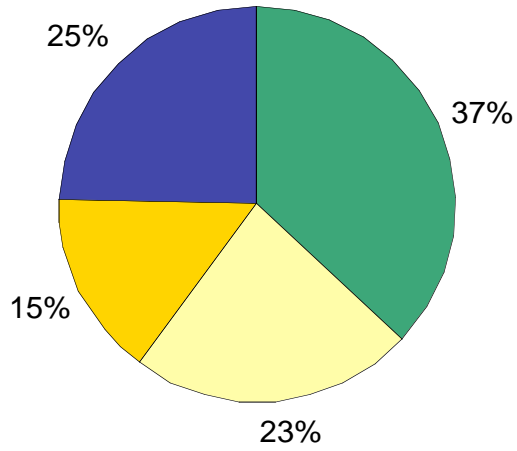
1. Introduction

MMWD staff has calculated the time and costs for conducting vegetation management, including broom control. These estimates are being rechecked and finalized for use in the final VMP. The sections below summarize the data as collected and summarized to date. There is little information in the literature about the precise labor costs for these types of treatments. Other agencies that attended the broom workshop have been requested to provide any similar data, but to date no specific data have been received. Again, these data, as well as agency comments on this report, will be used in developing the final plan.

This section starts with a breakdown of the Watershed Resource Program Budget for 2007/2008. The total MMWD budget for 2007/2008 was \$57,117,616. The Vegetation Management budget for 2007/2008 was approximately 0.8% of the total budget.

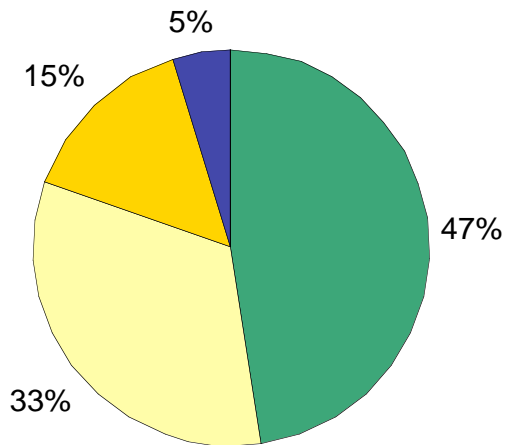


**Vegetation Management Fiscal 2006 / 2007
Person Hours by Labor Source**

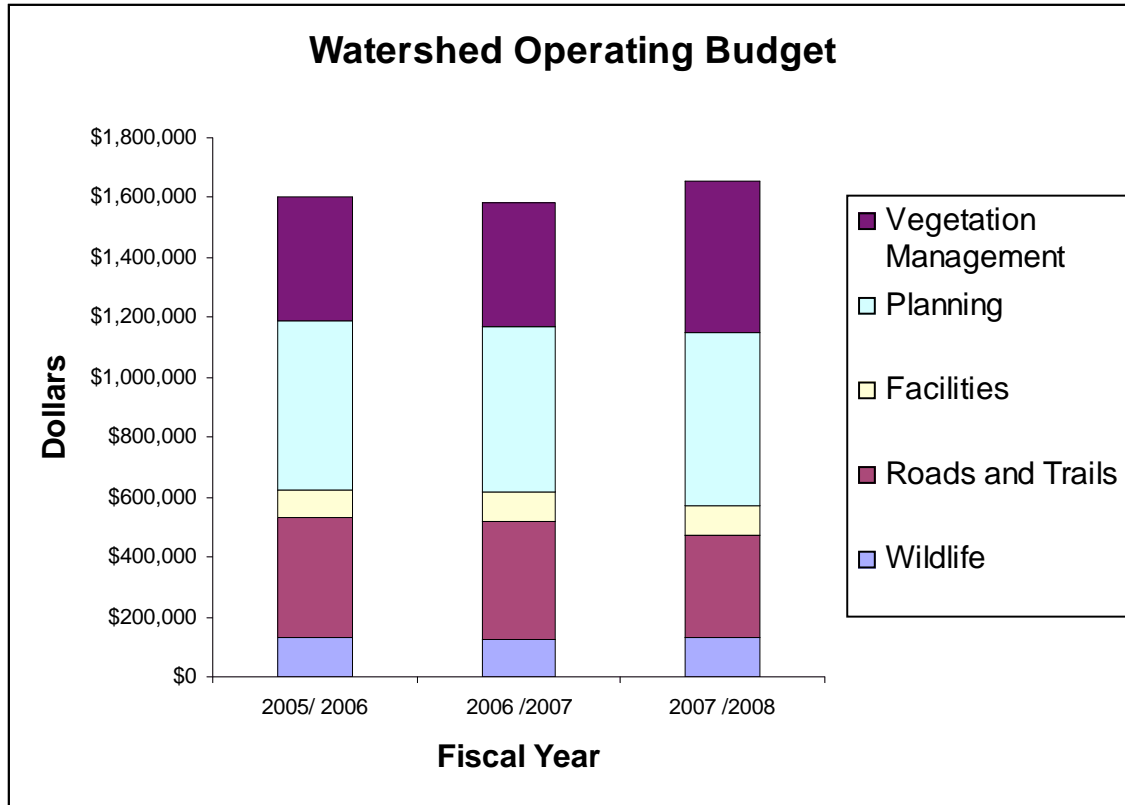


■ MMWD Staff ■ Contractors ■ Adult Offenders Work Program ■ Volunteers

**Vegetation Management Fiscal 2006 / 2007
Acres Treated by Labor Source**



■ MMWD Staff ■ Contractors ■ Adult Offenders Work Program ■ Volunteers



**Table 8
Acreage Treated in 2006/2007**

Labor Source	Person Hours	Acres Treated
MMWD Staff	4,885	130
Contractors	3,065	89
Adult Offenders Work Program	2,010	41
Volunteers	3,265	13
Total	13,225	273

Source: MMWD

2. Potential Labor Resources

Vegetation management on the watersheds is conducted by MMWD staff, private contractors, Adult Offender Work Program crews (AOWP), and volunteers. In Fiscal Year 2004/2005, 31% of vegetation management was done by contractors, 29% by MMWD staff, 21% by AOWP, and 29% by volunteers. There is a substantial difference in the productivity of these different labor sources. The sections below summarize the work done by these four labor sources.

According to the District's adopted IPM Program Handbook, the application of herbicides as part of the IPM Program would need to be done under the supervision of a person

with a Qualified Applicator Certificate (QAC). The Handbook describes the requirements for applicators. Application would be done by qualified MMWD staff or contractors with the appropriate QAC supervision. Volunteers and adult offenders/probationary works have never been nor are likely to be permitted to apply herbicides.

Although volunteers and AOWP crews would not be applying herbicides (if herbicides are incorporated into the IPM Program) data regarding their productivity are provided so the reader can see the full range of resources available to the District to conduct all the various parts of the IPM Program.

Volunteers

Since 1996 (and earlier, but with records from 1996 on), MMWD has conducted an ambitious volunteer program to remove broom and other invasive plants as well as to do other projects on the watersheds. Between 1996 and 2007, volunteers expended 15,696 hours removing broom and other invasive plants from 37 different sites. The annual volunteer hours expanded significantly when the Americorps program was initiated on the watershed in 2002. In 1996, volunteers worked 764 hours, while in 2006, the number of hours worked had expanded to 3,562 hours.

MMWD has generated Tables 10 and 11 based on monitoring of these volunteer efforts. Table 9 shows the production rates in removing broom for adult volunteers and Table 10 for school children volunteers. Volunteers are not permitted to apply herbicides on the watersheds.

**Table 9
Adult Volunteer Productivity**

Broom Life stage	Stems pulled in 5 minutes	Stems pulled in 1 hour	Stems per acre	Person hours to clear 1 acre	Volunteer events to clear 1 acre
Resprouting stumps	5	60	50,000	830	33
Adult 10-12 ft. high	25	300	90,000	300	12
Yearling 1-3 ft. high	100	1,200	110,000	92	3.5

Source: MMWD

**Table 10
School Group Productivity**

Broom Life Stage	Stems pulled in 5 minutes	Stems pulled in 1 hour	Stems per acre	Person hours to clear 1 acre	School events to clear 1 acre
adult 10-12 ft high	5	60	95300	1588	16

Source: MMWD

Volunteer labor is an important resource for MMWD. However, the actual amount of broom removal that is accomplished by volunteers is low. A typical volunteer event for broom removal attracts about 10 to 15 people. As Table 9 shows, it takes 8 such events to clear one acre of adult broom plants. Coordinating and overseeing these events

typically requires one staff member for each 10 volunteers for the time they are in the field (typically 4 hours) and 8 additional hours of MMWD staff time to coordinate, advertise, and manage.

As an example, if 500 volunteers turned out and worked 4 hours two days a year. MMWD would be able to treat about 13 acres of adult plants a year.

AOWP

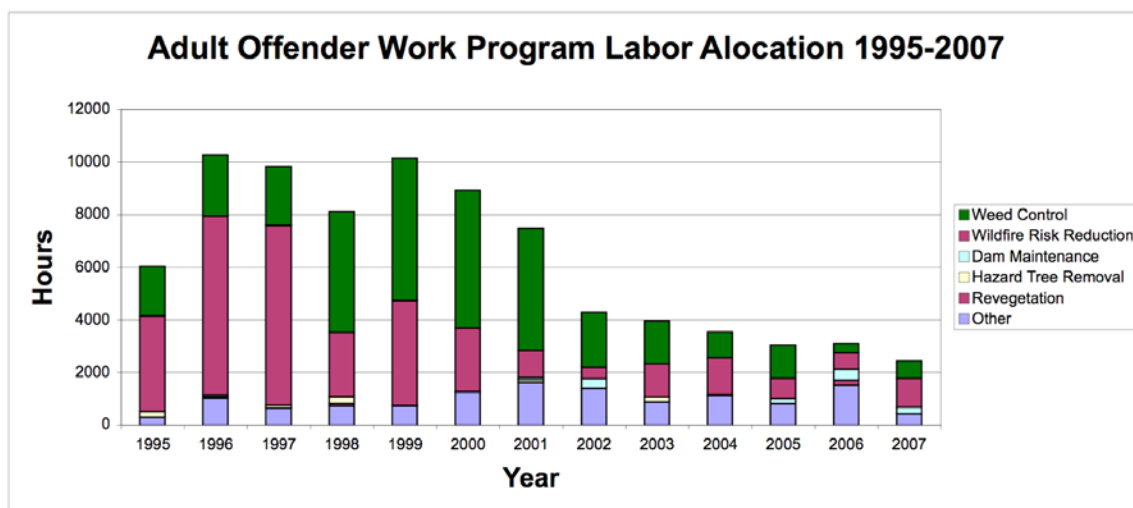
MMWD works with the Marin County Probation Department to allow people enrolled in the Adult Offenders Work Program (AOWP) to meet their probation requirements on the watersheds. People in AOWP were convicted of a crime but allowed to work for various organizations in the County in lieu of a county jail term. Since the inception of AOWP crews working at MMWD, there has been a marked decline in the number of available workers. Beginning in 2002 AOWP crews were reduced to weekends only. Availability has continued to decline. The average crew size is currently 5 people, and they work under the direction of MMWD staff. Table 11 shows the number of hours spent on vegetation management and other activities between 1995 and 2007. Crews are currently available an average of 82 crew days per year and an average of 3,289 hours per year. Average percent of AOWP time dedicated to broom control (2002-2007) is 30%. Available hours of AOWP time for broom control is 984 hours. Herbicides are not applied by adult offenders.

Table 11

AOWP Hours Spent on All Work On MMWD Property

Category	Sum of Person Hours													Total
	Year													
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	
Dam Maintenance		80		24	24		96	368		56	192	420	240	1,500
Hazard Tree Removal	216	64	112	248			96		192					928
Revegetation				88		16						184		288
Weed Control	1,880	2,312	2,248	4,608	5,408	5,232	4,656	2,088	1,630	976	1,256	352	664	33,310
Wildfire Risk Reduction	3,640	6,800	6,840	2,440	3,992	2,424	1,024	432	1,256	1,384	782	628	1,104	32,746
Other (Non-Veg.-Related)	288	1,008	640	720	712	1,248	1,616	1,384	872	1,112	800	1,508	424	12,332
Total	6,024	10,264	9,840	8,128	10,136	8,920	7,488	4,272	3,950	3,528	3,030	3,092	2,432	81,104

Source: MMWD



Contractors and MMWD staff

Professional contractors and MMWD staff are trained to remove broom and treat vegetation, plus they are doing the work as a paid occupation. Not surprisingly, the productivity rates are higher than for volunteers and adult offenders. Table 12 describes the average time and cost it takes to treat an acre of broom. Table 12 is preliminary, as it is based on analysis of labor data for the last three years. It will be updated to include labor records back to 1996.

Table 12
Summary of Average Labor Demands and Costs for Broom Treatment Techniques

Activity Description	Crew	Person Hours an Acre	Labor Cost Per Acre	Equipment cost per acre	Total Cost Per Acre
Prescribed burning	MMWD				\$1,500
Propane flaming	Contract	50.00	1,245.50	N/A	\$1,246
	MMWD Americorps	80.00	879.20	700.00	\$1,579
	MMWD staff	65.00	1,609.10	568.75	\$2,178
Terra torch	MMWD only	7.00	140.00	525.00	\$665
Mowing with hand tools, initial	Contract	149.63	3,727.37	N/A	\$3,727
Mowing with hand tools, follow up	MMWD only	24.00	537.61	130.00	\$668
	Contract	19.87	494.97	N/A	\$495
Mowing with heavy equipment (excavator), follow up	MMWD only	9.00	269.91	363.75	\$634
Hot Foam	MMWD staff	111.00	2,747.85	915.75	\$3,664
Hand-pulling, initial clearing	MMWD / Americorps	567.00	1,510.63	1,030.91	\$2,542
	MMWD and AOWP crew	385.00	2,041.83	802.08	\$2,844
Hand-pulling, follow up	MMWD / Americorps	147.00	391.64	267.27	\$659
	MMWD and AOWP crew	125.00	662.93	260.42	\$923
	Contract	60.07	1,496.24	N/A	\$1,496
Grazing (goats)	MMWD only	8.00	264.06	933.33	\$1,197
Mulching	MMWD and AOWP crew	40.00	212.14	83.33	\$295
Spot herbicide only	MMWD only	6.00	216.84	45.00	\$262
	Contract	4.00	160.00	N/A	\$160
Mowing (follow up level) with hand tools followed by spot herbicide	MMWD only	30.00	754.45	915.75	\$1,670
	Contract	24.00	654.97	N/A	\$655

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Persons Contacted

In addition to the input at the broom workshop (see Appendix A for the attendees), the consulting team received input from:

Alvarez, Maria	GGNRA
Bossard, Carla	St. Mary's College
Carruthers, Ray	USDA-ARS Western Regional Research Center
Colson, Cameron	California Compliant
Creque, Jeff	Land Stewardship Consultation
Douglas, Cheryl	DKLA Landscape Architects
Herr, John	USDA-ARS Western Regional Research Center
Hyland, Tim	California Department of State Parks
Klein, Janet	MMWD
May, Loran	Loran May and Associates
Moore, Ken	Wildwork.org
Roessler, Cindy	Midpeninsula Regional Open Space District
Salcedo, Nick	MMWD
Swezy, Mike	MMWD
Swope, Sara	USDA-ARS Western Regional Research Center

Report Preparers

Bob Brenton	Certified Pest Control Adviser (Brenton VMS)
Leonard Charles, Ph.D.	Project Manager (Leonard Charles and Associates)
Erin Conlisk, Ph.D.	Herbicide Risk Assessment (Pesticide Research Institute)
Mark Heath	Weed Control Expert (Shelterbelt Builders)
Ann Howald	Senior Biologist (Garcia & Associates)
Susan Kegley, Ph.D.	Herbicide Risk Assessment (Pesticide Research Institute)
Marion Moses, M.D.	Physician
Lynn Milliman	Environmental Analyst (Leonard Charles and Associates)
Eric Wrubel	Biologist (Garcia & Associates)

With the ongoing input and advice from MMWD staff including Janet Klein, Mike Swezy, and Nick Salcedo

Appendix A - Broom Control Workshop

Attendees at the Broom Control Workshop Held On February 6, 2008

Maria Alvarez	GGNRA
Pamela Beitz	East Bay Regional Parks
Giselle Block	USFWS-San Pablo Bay NWR
Carla Bossard	St Mary's College
Bob Brenton	Brenton VMS
Nancy Brownfield	East Bay Regional Parks
Leonard Charles	Leonard Charles and Associates
Jacoba Charles	Leonard Charles and Associates
Erin Conlisk	Pesticide Research Institute
Christina Crooker	Golden Gate Parks Conservancy
Bruce Delgado	BLM
Cheryl Douglas	DKLA Landscape Architects
Sharon Farrell	Golden Gate Parks Conservancy
Mike Fobert	West Coast Wildlands
Sonya Foree	SFPUC
Alison Forrestel	Point Reyes National Seashore
Susan Fritzke	GGNRA
Ellen Hamingson	Point Reyes National Seashore
Mark Heath	Shelterbelt Builders
Pete Holloran	UCSC
Ann Howald	Garcia and Associates
Tim Hyland	Cal. State Parks
Doug Johnson	Cal-IPC
Janet Klein	Marin Municipal Water District
Josh Knox	Shelterbelt Builders
Mischon Martin	MCOSD
Loran May	Loran May and Associates
Cheryl McCormick	Santa Lucia Conservancy
Lynn Milliman	Leonard Charles and Associates
Ken Moore	Wildwork.org
Maria Morales	Safe Solutions
Jim Mort	Mid Peninsula Open Space
Ingrid Parker	UCSC
Rick Parry	Mid Peninsula Open Space
Wendy Poinso	GGNRA
Cindy Roessler	Mid Peninsula Open Space
Bobbi Simpson	National Park Service
Mike Swezy	Marin Municipal Water District
Aileen Theile	East Bay Regional Parks
Don Thomas	SFPUC
Lynn Webb	Jackson State Forest
Eric Wrubel	Garcia and Associates

The following was the agenda for that workshop:

Broom Control Workshop
6 February 2008
Fort Cronkhite, Marin County, Calif.

9:00-9:45 participants	Welcome Introductions	Sue Fritzke all
	Background and goals Workshop format & desired outcomes	Janet Klein Pete Holloran
9:45-10:30	New broom control techniques Bossard, Janet Klein, & Ken Moore	Carla
10:30-10:45	Break	
10:45-12:00	Broom control techniques [breakout groups] <ul style="list-style-type: none">● prescribed burning● conventional & “alternative” herbicides● mowing & grazing● mulching & solarizing & competitive planting● hand removal & propane flaming	
12:00-1:30	Working lunch: Broom control techniques Group discussion	Sue Fritzke & Sharon Farrell
1:30-2:30	Broom control techniques continued [breakout groups]	
2:30-2:45	Break	
2:45-3:30	Answering frequently asked questions and Scaling up: Integrated broom control strategies across landscapes [breakout groups and general discussion]	
4:15-4:30	Conclusion: next steps	Janet Klein

Appendix B
MMWD Integrated Pest Management Policy and Handbook

Marin Municipal Water District

Integrated Pest Management Program Handbook

September 2003

With Update August 2005

**On August 10, 2005 the Marin Municipal Water District Board of Directors
approved the suspension of the use of pesticides on
Watershed lands.**

I. Integrated Pest Management Overview

The Marin Municipal Water District formalized an Integrated Pest Management (IPM) policy in September of 2003, committing the District to a pest management approach on its own property that minimizes the use of toxic chemicals and gets rid of pests by methods that pose the least risk to public and environmental health. This policy is designed to manage terrestrial pests on District owned lands and buildings. This handbook was created to describe how IPM policy is to be implemented at the District. **Water quality treatment is governed by other rigorous state and federal mandates and is not addressed by this handbook.**

The Marin Municipal Water District owns and manages several hundred structures including offices, treatment plants, water storage tanks, and pumping stations located throughout central and southern Marin County. In addition the District manages over 20,000 acres of watershed lands, landscaped areas and other property. In order to properly maintain these lands and facilities as well as provide for the safety and health of District employees and the general public, the District manages a number of plants, animals, and microbes that are collectively referred to as "pests". Pests are living organisms that interfere with the District's ability to provide safe drinking water to the public, reduce the District's ability to meet management objectives at specific District facilities, threaten the ecological health of the District's watershed lands, or that jeopardize health or safety of District employees and the general public.

Integrated pest management (IPM) is the blending of effective, economical, and environmentally sound pest control methods into a single but flexible approach to manage pest populations within acceptable limits. Those who practice IPM begin by analyzing the nature and the source of the pest problem. They then rely on a range of preventive and treatment strategies that can be a combination of cultural, physical, mechanical, or biological treatments. Only the least-toxic chemical pesticides should be used, and always as a last resort.

IPM sharply reduces pesticide use. This helps alleviate a threat to humans, wildlife and beneficial organisms. Its use improves water quality, avoids soil contamination, and keeps hazardous chemicals out of the food chain.

II. Integrated Pest Management Policy: Board Approved September 02, 2003.

The District is responsible for implementing pest control management practices for approximately 22,000 acres of watershed lands, right-of-ways, facilities, grounds and other sites located throughout the District's service area. The District is committed to using the most environmentally safe practices for effective pest control to ensure protection of the public and District employees, and to protect potable water sources, other natural resources, and District properties and assets.

The District employs an Integrated Pest Management (IPM) Program - an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, and modification of cultural practices. IPM means that pest problems will be addressed with the least possible hazard to people, property and the environment by using methods that are safe, effective and economically feasible. Chemicals are used as a last resort only

after monitoring indicates they are needed according to established guidelines. The least toxic and most target-specific treatments are chosen.

IPM Committee

An IPM Committee has been established to maintain a consistent approach to pest management throughout the District, and to monitor the use of herbicides and other pesticides. The IPM Committee shall at least annually review the IPM Program, and update IPM guidelines for determining the most appropriate pest control methods for particular situations. The committee shall designate one or more persons to monitor, on a monthly basis, changes in pesticide research and regulation and monitor new products to insure current information is available for Committee review.

The District's IPM Committee meets at least annually with the following responsibilities:

- Review Certified Pest Control Advisor recommendations;
- Review IPM practices to ensure consistency among District work groups and compliance with regulatory requirements;
- Review chemical usage requests, plans for the use of new chemicals and plans for applications within environmentally sensitive areas;
- Review effectiveness of control methods and revise guidelines; and
- Respond to public concerns.

Representation on the IPM Committee includes staff with the following expertise or responsibility:

Water Quality
Facilities Management
Landscape Management
Watershed Management
Public Information
Environmental Compliance
Vegetation Ecology
Wildlife/Aquatic Ecology

IPM Guidelines

The IPM Guidelines address the following subject areas for each chemical approved for use:

- Continuing education/staff training for identification of pests, non-toxic management options, and proper handling and application of chemicals;
- Notification requirements for specific areas of application;
- Action thresholds for individual pest species;
- Monitoring guidelines to determine pest levels and treatment effectiveness;
- Acceptable Best Management Practices with objective criteria for use;
- Research and experimentation with new methods and strategies; and
- System for record keeping and reporting.

Excluded Chemicals

Pesticides classified as Toxicity Category I (“Danger” on label) and Category II (“Warning”) by U.S. Environmental Protection Agency will not be used for District purposes under any circumstances.

III. IPM Program Organization

IPM Coordinator: The District IPM Coordinator is an MMWD employee who is knowledgeable in state regulations pertaining to pesticide use and reporting as well as plant and animal pest control in a variety of settings. The role of the IPM Coordinator is to ensure the District’s IPM program is implemented in a safe and professional manner that is consistent with all state regulations; to facilitate the dissemination of new information and treatment strategies; and to coordinate the activities of the IPM Committee and Working Groups. The District will seek to develop additional staff to fill the role of IPM program coordinator as needed.

IPM Committee: The District IPM Committee is comprised of supervisors and managers and meets at least annually with the following responsibilities:

- Review IPM practices to ensure consistency among District work groups and compliance with regulatory requirements;
- Review requests for the use of new chemicals and plans for applications within environmentally sensitive areas;
- Review effectiveness of control methods and revise guidelines; and
- Respond to public concerns.

IPM Working Groups: Working groups are comprised of on-the-ground IPM practitioners as well as members of the IPM Committee. Working groups meet at least biannually with the following responsibilities:

- Develop and update best management practices/least toxic alternatives for managing specific pests;
- Develop long-term treatment plans and maintenance schedules for facilities, managed landscapes, and natural area with a goal of maintaining pests at a tolerable level using methods that are both cost-effective and cause the least harm to both humans and the environment.
- Develop and update use guidelines for all chemicals approved for use under the District’s IPM policy.
- Conduct annual trainings for both IPM practitioners and other District staff whose job duties or work areas come into contact with pests.
- Submit to the IPM Committee for review: chemical usage requests, approval requests for new chemical, and exemption requests for chemical applications in sensitive areas;
- Evaluate pest management tasks, compliance, and reporting performed by contractors; and
- Complete periodic evaluations and chemical use reports; and
- Maintain meeting minutes.

IPM Coordinator 2003-2004: Roger Bucholtz, Facilities and Landscape Management Supervisor, Licensed Pest Control Advisor in Insect, Mites, and other invertebrates; and Plant pathogens. Qualified Applicator's Certificate in Landscape Maintenance, Plant Agriculture, and Forest.

IPM Committee Membership 2003-2004

Water Quality	
Water Quality Lab Supervisor	Larry Grabow
Water Treatment Operations Superintendent	Phil Heiman
Water System Operation & Technical Maintenance	
Superintendent of Water System Operation	Bob Cook
Facilities and Landscape Management	
Support Services Manager	Walt Mahoney
Support Services Supervisor	Roger Bucholtz
Watershed Management, Vegetation Ecology, and Wildlife/Aquatic Ecology	
Fisheries Biologist	Greg Andrew
Vegetation and Wildlife Resource Specialist	Mike Swezy
Public Information	
Public Information Officer	Libby Pischel
Environmental Compliance and Risk Assessment	
Environmental Services Coordinator	Eric McGuire
Safety & Risk Assessment Officer	Bob Sotelo

Working Group Membership 2003-2004

Facilities IPM Working Group	
Gardner	Augustin Gerena
Mechanical & Electrical Supervisor	John Mayer
Warden	Phil Johnson
Landscape and Natural Areas IPM Working Group	
Gardener III	Augustin Gerena
Gardener	John Greany
Vegetation Ecologist	Janet Klein
Watershed Maintenance Supervisor	Jim Long

Working Group Meeting Dates

Working Group	Meeting Date
Landscape and Natural Areas IPM Working Group	March 17, 2004
Facilities IPM Working Group	March 23, 2004
Landscape and Natural Areas IPM Working Group	Sept. 17, 2004

IV. Target Pests and Pest Management Strategies

What is a pest? A pest is a plant, animal, or microorganism that has a negative effect on humans. Both native and non-native species can be considered pests, but the need to manage a species as a pest depends on the specifics of a location and situation. For example, acorn woodpeckers are considered pests only where their food-storage

behavior undermines the structural integrity of District buildings, and poison oak is considered a pest plant only when it limits employee access to District facilities or recreational access along narrow trails.

Pest Plant Species: The problems posed by pest plants include reducing safe worker access to District facilities, reducing visibility along roadsides and right-of-ways, increasing fuel load and the threat of catastrophic wildfire, and reducing biological diversity in natural areas. The pest plant species of greatest concern to the District include:

- acacia
- bluegum eucalyptus
- Coulter pine
- eupatorium
- fennel
- French broom
- horehound
- Italian thistle
- jointed goat grass
- knobcone pine
- Monterey pine
- Napa thistle
- pampas grass
- panic veldtgrass
- pennyroyal
- poison hemlock
- poison oak
- purple starthistle
- redhot poker
- Scotch broom
- Spanish broom
- teasel
- veldtgrass
- yellow starthistle

Additional vegetation such as weedy grasses and dandelions may also be treated as pests at specific locations.

Pest Animal Species: The problems posed by pest animals in the context of District operations and facilities management include contaminating food and drinking water, spreading disease, damaging gardens, and damaging buildings and other structures. The pest animal species of greatest concern and most commonly managed by the District include:

- ants
- aphids
- cockroaches
- mice
- rats
- scale
- snails
- thrips

wasps

Under specific circumstances, the District also manages a number of other animal species in order to protect structures or ecosystem health. Animal species in this category include gophers, acorn woodpeckers, cliff and barn swallows, turkeys, starlings, painted turtles and eastern sliders, rattle snakes, muskrats, deer, feral pigs, starlings and bats.

Treatment Strategies:

Cultural Controls. Cultural practices can reduce pests by making their environment less favorable. For example, sanitation is an important step in pest management. Every pest found in the home, garden, or office represents a breakdown of sanitation procedures. Proper disposal of garbage, clearing up clutter in offices and basements, and removing weeds in gardens all contribute to removing food and shelter for pests.

Physical Controls. Physical controls keep insect pests from places where they're not wanted. Barriers, such as vent and window screens or caulking, will help exclude health and nuisance pests like rats, mice, flies, and mosquitoes from pump houses and remote offices. Various traps can be used to catch a variety of pests, including cockroaches, ants, and mice.

Biological Control. Biological controls include the practice of releasing natural enemies to control a target pest species or improving habitat in a way that allows a predator species to flourish. Building nest boxes to attract barn owls, for instance, can be an effective way to combat rodent populations.

Mechanical Controls. Mechanical controls are direct measures that either kill the pest or make the environment unsuitable for their entry, dispersal, or survival. Mowing and manual removal can reduce small-scale weed infestations. Handpicking can be used to get rid of snails, slugs, and caterpillars. A strong spray of water will dislodge aphids and mites from plants in offices and demonstration gardens.

Prescribed Burning. In natural areas, carefully timed and managed fires can reduce invasive plant species to levels that can be more easily controlled by other methods.

Chemical Controls. Chemical pesticides represent only a single control strategy, are used only as a last resort, and are always used in concert with other non-chemical strategies. Only the least-toxic chemicals are used for controlling pests. To the fullest extent possible, chemical pesticides are used for spot treatments rather than for broadcast applications. (Spot treating means treating only the specific problem plants, rather than broadcasting chemicals over a large area.) IPM practitioners must use chemical pesticides that are selective and apply them only when the pest is present and at a susceptible stage. Chemical applications must be done in accordance with label instructions and all federal, state and local regulations.

<p>Threshold for Chemical Pesticide Use: Chemical pesticides are used only when adequate control of specific pest in a specific location cannot be adequately and safely achieved by any other method.</p>

V. Accepted Pesticides List

What is a Pesticide?

A pesticide is any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest. Pests can be insects, mice and other animals, unwanted plants (weeds), fungi, or microorganisms like bacteria and viruses. Though often misunderstood to refer only to *insecticides*, the term pesticide also applies to herbicides, fungicides, and various other substances used to control pests. Under United States law, a pesticide is also any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant.

U.S. EPA Office of Pesticide Programs 14feb97

The following list represents the pesticide products currently accepted for use by the Marin Municipal Water District's IPM practitioners, provided other methods strategies are in place and have provided insufficient levels of pest control. The list will be updated on an as-needed basis to reflect the availability of new products, research, and non-chemical pest control strategies. Use guidelines have been developed for each product and include limitations with regard to location, applicator, application rate, and target pest. In all cases, restrictions on use as determined federal and state regulation as well as per label instruction are to be followed.

Excluded Chemicals

Pesticides classified as Toxicity Category I ("Danger" on label) and Category II ("Warning") by U.S. Environmental Protection Agency will not be used for District purposes under any circumstances.

Pesticides classified as EPA Toxicity Category III ("Caution") but not included on the following list may be used only if an IPM practitioner submits a request to the IPM Committee and receives project-specific approval.

Accepted Pesticides

<u>Product Name</u>	<u>Active ingredient</u>
Garlon 4	triclopyr
Pendulum 3.3 EC	pendimethalin
Roundup Pro Herbicide	glyphosate
Platte Kleen-up Pro	glyphosate
Transline	clopyralid

**CY_KICK CS	cyfluthrin
**Merit 75WP	imidacloprid
Conrac All-Weather Blox	bromadiolone
Pathfinder II	triclopyr
Safer insecticidal soap concentrate	potassium laurate
Victor Poison Free Wasp/HO	mint oil

**use restricted to professional contractor

VI. Pesticide Use Guidelines

General Guidelines for Pesticide Applications:

- All pesticide applications will be conducted under the supervision of a Qualified Applicator Certificate (QAC).
- All MMWD personnel handling pesticides will complete appropriate in-house and field training that addresses safety, regulations, application methods, proper reporting, and accident response.
- All MMWD personnel handling pesticides must wear personal protective equipment (PPE), including a fresh long-sleeved cotton jumper, rubber boots, socks, rubber gloves, and goggles. Additional PPE maybe required for specific chemicals.
- Pesticides will be mixed and applied per label instruction

Additional Guidelines Rodenticides:

- For any situation where applications must be placed outside of buildings, only a pesticide contractor may use product. Contractor must only use tamper proof and high-grade rodent stations that will not allow access to unauthorized personnel or non-targeted animals.
- Using only at sites that show signs of rodent activity and then only using bait until there are no signs of rodents.
- Wherever possible, try to exclude rodents from pump facility by using whatever mechanical needs available (i.e. sealing doors, expandable foam in holes, etc.)

Additional Guidelines for Herbicide Applications in the Mt Tamalpais Watershed and Other Natural Areas:

- Internal notification list: Assistant GM/Environmental and Engineering Services Division Manager, Facilities & Watershed Division Manager, Public Information Officer, Resources Specialist, Superintendent of Watershed Resources
- Within drainages areas of reservoirs currently used for drinking water supply, no herbicides will be applied within a quarter mile of reservoir.

- No herbicides will be applied within 100 feet of a perennial stream or an intermittent drainage with flowing water.
- All entry points leading into the application area will be posted during the duration of the application and the duration of any “restricted entry period” as indicated on the label.
- Applications will be suspended immediately if there is evidence of drift or volatilization due to wind or high temperatures.
- The minimum amount of herbicide necessary to complete vegetation management objectives will be used. The quantity used will be minimized by:
 - reduction of plant surface areas by mowing or pruning target vegetation prior to treatment;
 - scheduling treatments to correspond to the most vulnerable life stage of the target species; and
 - using precision, spot applicators.
 - using dyes to demark treated and untreated areas.

Exemptions to Guidelines

Exemptions to these guidelines may be warranted and will be evaluated on a case-by-case basis. Requests for usage of chemicals not on the approved list, addition of new chemicals to the approved list and use of approved chemical applications in sensitive areas otherwise excluded by these guidelines must be submitted to the IPM Committee for review and approval.

VII. Pesticide-Specific Guidelines

Specific guidelines are provided in TABLE 1: MMWD ACCEPTED PESTICIDE LIST AND CHEMICAL SPECIFIC GUIDELINES.

For each pesticide, the guidelines include a target organism list, thresholds for use, use restrictions, recommended application method, recommended application rate, restricted entry interval, notification requirements, and additions/clarification to the standard Personal Protective Equipment (PPE) listed in the previous general guidelines (section VI).

VIII. Pesticide Labels and MSDS

Labels and Material Safety Data Sheets for all accepted and EPA-registered pesticides can be found in the following directories:

**F:common/IPM/Handbook/labels/
F:common/IPM/Handbook/MSDS/**

IX. Reporting Program

State Mandated Reporting of Pesticide Use

Monthly reports shall be filed with the County Agricultural Commissioner for applications classified as “Agricultural”, including all applications publicly accessible watershed lands as well as applications in and immediately adjacent to fuel breaks and publicly accessible utility right of ways.

A copy of the state reporting form can be found at:

F: Common/IPM/Handbook/state monthly summary pesticide use report state.pdf

Internal Reporting of Pesticide Use

Each working group that uses pesticides or contracts for pesticide applications shall keep records of all pest management activities in a centralized log. Each record shall include the following information:

- The target pest;
- The type and quantity of pesticide used;
- The site and acreage of the pesticide application;
- The date the pesticide was used;
- The name of the pesticide applicator;
- The application equipment used; and
- Prevention and other non-chemical methods of control used.

F: Common/IPM/application log.xls

Each working group is responsible for submitting a year-end pesticide use report to the IPM Committee.

Public Reporting

Pest management records shall be made available to the public upon request.

VII. Licensing, Training, and Education

Licensing

MMWD personnel supervising pesticide applications must maintain a valid California Department of Pesticide Regulation Qualified Applicator Certificate within the most appropriate category for the type of pest control they are responsible for (typically “landscape maintenance” or “right-of-way”). Per state regulation, these personnel must accumulate at least 20 hours of approved continuing education every two years before certificate renewal. Four of the 20 hours must cover the topic of pesticide laws and regulations.

MMWD personnel with Qualified Applicator Certificates may not make recommendations or supervise applications outside of their licensed category.

Training

All MMWD personnel handling pesticides will complete appropriate training. Employees applying herbicides will receive 6 hours annually of in-house and field training that includes:

- a review of labels and material safety data sheets for materials they will handle
- a review of all appropriate Pesticide Safety Information Series sheets (Series N),
- a review of state regulations,
- application methods,
- proper reporting, and
- accident response.

Per state regulation, MMWD will maintain records of employee training for a minimum of 2 years.

Education

Members of the IPM Committee and IPM Working Groups will provide periodic trainings and workshops for District employees and the general public, with the purpose of educating others in least-toxic methods for control pest species in the workplace, home, and larger community.

TABLE 1: MMWD ACCEPTED PESTICIDE LIST AND CHEMICAL SPECIFIC GUIDELINES

Product Name (Active Ingredient) Manufacturer	EPA Registration #	Target Organisms	Threshold for Use	Use Restrictions	Application Method	Application Rate	Restricted Entry Interval	Notification	PPE
Herbicides									
Garlon 4 (triclopyr BBE) Dow AgroScience	62719-40-ZB-62719	Woody species including French, Spanish, and Scotch broom, acacia, poison oak, hawthorn, non-native pines, eucalyptus.	In fuel breaks, restoration sites, and around tanks where preferred techniques (rx fire, mowing, grazing) have been unable to kill resprouts and hand pulling is infeasible. In facility areas where vegetation poses fire hazard or other safety concerns and where other techniques are infeasible.	Do not use when temperature exceed 82 degrees Fahrenheit due to high volatilization potential. Do not apply within ¼ mile of a reservoir used for drinking water production or 100 feet of a water-bearing drainage. (NOTE: This MMWD water-quality buffer exceeds current EPA no-spray buffers for salmonid bearing streams.)	Basal bark method -Thoroughly wet lower 30 cm of one side of target stem with 20 to 30% solution. For actively growing stems less than 8 cm in diameter, thoroughly wet a 5 cm band around the entire diameter of the stem. Cut stump method-For both fresh and old stumps, thoroughly wet the entire stump surface with 20 to 30% solution.	Use 20 to 30 % solution mixed with an oil-surfactant. Not to exceed 8 quarts per acre.	12 hours following application.	Applications within 100 feet of right-of-ways and trails shall be posted during operations and for the 12 hour restricted entry period.	standard
Pathfinder II (triclopyr) Dow AgroScience	62719-176	Woody species including French, Spanish, and Scotch broom, Acacia, poison oak, hawthorn, non-native pines, eucalyptus.	In fuel breaks, restoration sites, and around tanks where preferred techniques (rx fire, mowing, grazing) have been unable to kill resprouts and hand pulling is infeasible. In facility areas where vegetation poses fire hazard or other safety concerns and where other techniques are infeasible.	Do not use when temperature exceed 82 degrees Fahrenheit due to high volatilization potential. Do not apply within ¼ mile of a reservoir used for drinking water production or 100 feet of a water-bearing drainage. (NOTE: This MMWD water-quality buffer exceeds current EPA no-spray buffers for salmonid bearing streams.)	Both basal bark and cut stump methods may be used. Mix and apply per label instructions. Minimize drift by avoiding windy conditions, and adjusting droplet size.	Ready-to-use; no mixing required. No application limitations given on the label.	12 hours following application.	Applications within 100 feet of right-of-ways and trails shall be posted during operations and for the 12 hour restricted entry period.	standard
Pendulum 3.3 EC (Pendimethalin) BASF Corporation	241-340-AA-241	Annual grasses and certain broadleaf weeds in non-cropland areas by pre-emergent application.	In facility and landscape areas when area to be sprayed is known to have susceptible weeds and other means of control are not cost effective.	Landscape areas in residential/urban zones only. Use landscape fabric or mulch where possible. Limit to high priority areas, including new plantings and areas too dangerous for handweeding.	Apply with backpack sprayer or large tank sprayer. Mix and apply per label instructions. Minimize drift by avoiding windy conditions and adjusting droplet size.	Ranges from 1.3 to 4.8 ounces per 1000 sq. ft depending on site conditions. Not to exceed 7.2 pints per acre on any given site.	24 hours following application.	Applications shall be posted during operations and for the 24 hour restricted entry period.	standard plus Chemical-resistant gloves, such a barrier laminate, butyl rubber ³ 14 mil, nitrile rubber ³ 14 mils, neoprene rubber ³ 14 mils, or viton ³ 12 mils
Roundup Pro Herbicide (glyphosate) Monsanto or Platte Kleen-up Pro (glyphosate)	524-475-ZA-524 or 288-366-6573	Woody and herbaceous pest species including French broom, Scotch broom, acacia, fennel, cape ivy, vinca, poison oak, teasel, Italian thistle, annual grasses.	In fuel breaks, restoration sites, and around tanks where preferred techniques (rx fire, mowing, grazing) have been unable to kill resprouts and hand pulling is infeasible. In facility areas where vegetation poses fire hazard or other safety concerns and where other techniques are infeasible.	Do not apply within ¼ mile of a reservoir used for drinking water production or 100 feet of a water-bearing drainage. In natural areas, applications restricted to post-growing season for annual species (typically mid June through late October) to minimize damage to non-target species.	Apply with backpack sprayer or large tank sprayer. Mix and apply per label instructions. Minimize drift by avoiding windy conditions and adjusting droplet size. Where possible, target plants will be mowed or pruned prior to application in order to minimize chemical used.	Use 2% solution for actively growing woody vegetation, 1.5% solution for herbaceous vegetation, 50% for cut stump (not preferred method). Not to exceed 340 ounces per acre per year.	12 hours following application.	Applications within 100 feet of right-of-ways and trails shall be posted during operations and during the 12 hour restricted entry interval.	standard
Transline (clopyralid) Dow AgroScience	62719-259	Broadleaf weeds including yellow starthistle, purple starthistle, and distaff thistle.	In fuel breaks, roadsides and natural areas where observed infestation exceeds hand-pulling capacity and prescribed burning or repeat mowing (3 times per growing season) is not feasible.	Do not apply on sandy loam or sand soils. Do not apply where groundwater table is close to the surface. Do not apply within ¼ mile of a reservoir or 100 feet of a water-bearing drainage. Do not apply within 100 feet of rare, threatened or endangered member of the pea, sunflower, or tomato family.	Apply to post-emergent broadleaved herbs when target species (thistles) are in rosette or pre-bolting stage. Small infestations should be spot-treated with precision backpack sprayers. Broadcast applications of dense stands require notification of the IPM committee.	between 8 and 10.6 ounces per acre. Not to exceed 10.6 ounces per acre.	12 hours following application.	Applications within 100 feet of right-of-ways and trails shall be posted during operations and for the 12 hour restricted entry period.	standard
Insecticides									
CY_KICK CS (cyfluthrin) Whitmire Micro-gen Research Laboratories Inc	499-304	Ants, carpenter ants, wasps and termites	Whenever a distinct line of ants is noticed in or around District Offices.	As of July 28, 2004, use of this product at MMWD is restricted to professional contractors working under the direction of a District representative.	Per label instructions and contractor specifications.	Per label instructions and contractor specifications.	When dry.	Email will be sent to people working in areas where applications are to take place.	Per label instructions and contractor specifications
Eco Exempt Jet (2-Phenethyl Propionate, rosemary) Ecosmart Technologies	Exempt	Wasp, Yellow Jackets, Hornets, and spiders	Whenever a nest is on District land and there is a possibility that an employee or consumer may get stung.	Only employees with Qualified Applicators licenses, or who have been trained to recognize a Honey Bee from Yellow Jacket may Apply. In the case of Honey Bees, the District will make every effort possible to remove Honey Bees and relocate, by use of Professional Bee Keeper. Do not use inside a structure. Contractor must be called for any structural applications.	Per label instructions and contractor specifications.	Per label instructions and contractor specifications.	None.	None.	Per label instructions and contractor specifications
Merit 75WP (imidacloprid) Bayer Agricultural Products	432-1314	Aphids, Scales and Thrips	When more than 10% of shrub or tree shows signs of infestation	As of July 28, 2004, use of this product at MMWD is restricted to professional contractors working under the direction of a District representative.	Per label instructions and contractor specifications.	Per label instructions and contractor specifications.	24 hours following application or when dry.	Applications shall be posted during operations and for the 24 hour restricted entry period.	Per label instructions and contractor specifications
Safer insecticidal soap (potassium laurate) Safer Inc.	42697-1	Aphids, scales, mealy bugs, spider mites, psyllids, thrips, and whitefly	Any house plant or ornamental plant located near district offices that shows signs of more than 10% percent infestation.	Do not apply in enclosed spaces or buildings; transport office plants to a well-ventilated, outdoor location for applications.	Apply product to wet all infested branches and leaves, follow label instructions. Mix and apply per label instructions. Minimize drift by avoiding windy conditions and adjusting droplet size.	Per label instructions.	Entry (defined here as limited to touching of plant) will be restricted within treatment areas for 24 hours following application.	Applications shall be posted during operations and for the 24 hour restricted entry period.	standard
Rodenticide									
Contrac All-Weather Blox (bromadiolone) Bell Laboratories	12455-79-AA-12455	Rodents	At treatment plants, administrative offices, and pump sites where it has been established that rodents have damaged equipment, or have the potential to damage equipment that is vital for water system distribution.	Any situation where bait must be placed outside of buildings, only a pesticide contractor may use product. Contractor must only use tamper proof and high-grade rodent stations that will not allow access to unauthorized personnel or non-targeted animals.	Product must only be applied inside locked facility and placed inside appropriate bait stations. Some situations may call for putting product inside electrical components without bait station, this method is approved only if there is no way public or unauthorized personnel can access areas, and that all personnel that have access to such facility are trained on hazards of product.	Per label instructions	None.	None.	standard