Agricultural Pesticide Use
Best Management Practices for Agricultural Pesticide Use

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In association with: Colorado Department of Agriculture
Agricultural Chemicals and Groundwater Protection Advisory Committee

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Best Management Practices for Agricultural Pesticide Use

Pesticides are widely used to protect crops and livestock from losses due to insects, weeds, and diseases. Colorado uses about 1% of the 900 million pounds of conventional pesticide applied annually in the United States. The Environmental Protection Agency (EPA) has estimated that 76% of the total pesticide use nationally is for agricultural production, with the remaining 24% used in the urban, industrial, forest, and public sectors. These chemicals have helped to increase agricultural production with reduced labor. However, problems associated with improper pesticide use have led to human illness, wildlife losses, and water quality degradation.

The major groups of pesticides include insecticides, herbicides, and fungicides. Because herbicides are the most widely used class of agricultural and urban use pesticides, they are the pesticides most frequently found in ground and surface water. The ability to detect pesticides in the environment has greatly improved in recent years. The development of extremely sensitive detection methods has led to the discovery that commonly used management practices may lead to small amounts of pesticides that contaminate ground and surface water supplies. Since we depend on these water supplies for drinking water, pesticide users need to exercise a high level of care and sound pesticide use management to avoid contamination.

This guide addresses Best Management Practices (BMPs) for preventing nonpoint source contamination of water resources by agricultural pesticides. Contamination from normal pesticide application is called nonpoint contamination, since a single point of contamination cannot be identified. Point source contamination would include spills of concentrated chemicals at storage, mixing, or loading sites. These point source problems are addressed in the document BMPs for Pesticide and Fertilizer Storage and Handling (Bulletin #XCM-178).

Since pesticides are an important tool for most farming operations, and cleaning up contaminated groundwater is extremely difficult, producers need to evaluate their use of pesticides and adopt BMPs that are appropriate for their crops and site. Fortunately, a number of crop management and pesticide application practices can be used to reduce potential contamination of water supplies.

Government Regulations and Policy

The federal government has enacted several laws to control pollution of water resources. Among these are the Safe Drinking Water Act; the Clean Water Act; the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA); and the Food Quality Protection Act (FQPA). All pesticides are regulated through FIFRA, and producers should understand that the chemical label is, in effect, the law. In most cases, the precautions on the chemical label are adequate to protect water resources from contamination above a regulatory standard. However, it is possible for a pesticide to reach ground or surface water resources even when used according to the label instructions. Chemicals that have a higher potential to move to groundwater are identified on the label by a “Groundwater Advisory Statement.” This statement is usually located in the precautionary statements on the label. Producers should take special care when using these chemicals on sites with conditions that increase the chance of leaching or runoff (Table 1).

Rather than impose overly restrictive measures on farmers and related industries, Colorado has elected to encourage the voluntary adoption of BMPs that suit the agricultural chemical user’s specific managerial constraints while still meeting environmental quality goals. Voluntary adoption of these measures by agricultural chemical users will help maintain the quality of water resources, improve public perception of the industry, and perhaps reduce the need for further regulation and mandatory controls.

Groundwater Monitoring

In 1990, the Colorado legislature passed Senate Bill C.R.S. 25-8-205.5(1), which introduced Colorado’s
Agricultural Chemicals and Groundwater Protection Act. This Act declares that the public policy of Colorado is to protect groundwater and the environment from impairment or degradation caused by improper use of agricultural chemicals, while allowing for their proper and correct use. The Act also requires the Colorado Department of Agriculture (CDA) to conduct a statewide groundwater monitoring program and aquifer vulnerability analyses. Since 1992, the CDA has been working in cooperation with the Colorado Department of Public Health and Environment (CDPHE) and Colorado State University Extension to implement the Agricultural Chemicals and Groundwater Protection Program (GW Program). The Program acquires groundwater samples from monitoring, irrigation, and domestic wells throughout the state. These samples are analyzed for a suite of over 100 active ingredients from pesticides registered in Colorado. All well samples are also analyzed for nitrate - nitrogen.

Pesticide and nitrate analysis results from the groundwater monitoring program are available on the Agricultural Chemicals and Groundwater Protection Program Water Quality Database, found at http://ids-nile.engr.colostate.edu/webkit/Groundwater/.

The database can quickly and easily be queried based on any number of criteria, including county, region, conservancy district, well use, water quality parameters (i.e., nitrate, pesticide), and year. It also includes a statewide summary of sampling results. The web site features an interactive map of Colorado that displays statewide sampling results for tested water quality parameters. The map below (Figure 1) shows the general location of all wells sampled in the state from 1992 to 2008 by the GW Program.

Pesticide analysis results for monitoring conducted from 1992 to 2008 indicate that the highest numbers of wells with pesticide detections are located in the South Platte River Basin. A total of 225 wells have been monitored in the South Platte River Basin, of which 56% are located in Weld County. Of the 125 wells in Weld County, 94% have tested positive for pesticide at some point in time. Other areas of the state with a significant number of pesticide detections included the Front Range, Arkansas Valley, and San Luis Valley, with 20%, 11%, and 11% of wells, respectively. The most frequently detected pesticides were atrazine and its breakdown products, prometon, and metolachlor. The EPA has established primary drinking water standards or health advisory levels for a number of pesticides. Primary drinking water standards are

Table 1. Commonly used pesticides with groundwater advisory statements

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<th>Trade name</th>
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referred to as maximum contaminant levels (MCLs) and represent the highest amount of a contaminant allowed in public water systems. Only six of the wells that tested positive for a pesticide exceeded an established human health drinking water standard.

These results seem to be promising, given the small number of pesticide detections that exceeded an established health standard or advisory level. However, the existence of any amount of pesticide in groundwater may be an indication of future problems. Continuation of groundwater sampling and testing by the Program will help to identify present and future problem areas of the state so that stakeholders can focus their educational and management activities in regions where it is most needed.

Pesticide Fate in the Environment

Pesticides meet a variety of fates after application. They may evaporate, be broken down by sunlight, or be carried away to surface water before reaching their targets. After reaching the soil, they may be taken up by plants, adsorbed to soil particles, broken down by soil microorganisms, or, in some cases, be moved off-target to water resources (Figure 2). The fate of pesticides in the environment depends upon a number of factors, including:

- site characteristics
- pesticide properties
- pesticide use practices

Typically, the majority of applied pesticide is degraded by soil microbes. However, some pesticides and pesticide breakdown products may reach ground or surface water if the appropriate BMPs are not implemented. Applicators should always evaluate their pest problems and the characteristics of their site to select the control measure with the least potential for environmental hazard. Biological controls and treatment cost effectiveness pertaining to economic thresholds should be examined. Some pesticide treatments may not be environmentally or economically wise to perform. See page X on Integrated Pest Management (IPM).

Site Features

Soil Characteristics
Soil properties and water management can significantly affect pesticide movement in the environment. The most significant soil properties influencing pesticide behavior are:

- organic matter content
- texture
- structure and macropores
- moisture content
- pH

Soil organic matter (SOM) content is an important soil property affecting pesticide adsorption. Adsorption refers to the adherence of a compound in the soil due to opposite charged particles attracting one another. Pesticides can be held in soil onto organic matter or clay particles by the process of adsorption.
Pesticides are strongly attracted to the surface of organic matter and are less likely to leach in soils that are high in organic matter. Applicators working on soils with less than 1% organic matter should be aware of the possibility of pesticide leaching.

Soil texture refers to the proportion of sand, silt, and clay particles in the soil. Texture affects the surface charge and the surface area for pesticide adsorption. Soils with higher clay content have a greater ability to adsorb pesticides, but they are more susceptible to runoff and need to be managed accordingly. Sandy soils leach more readily and provide fewer sites for pesticide adsorption. Soils with a high sand content should be managed carefully, with minimal use of persistent or very mobile pesticides.

Soil structure - the way soil particles are aggregated - significantly affects water movement and may allow pesticides to move through the profile before they can be adsorbed or degraded. Large soil cracks or openings (macropores) caused by heaving, roots, or soil animals can cause rapid pesticide movement, even in fine soils with high organic matter. Soils characterized by high numbers of macropores are poor candidates for chemigation because the chemical can move rapidly downward below the root zone. Unfortunately, these soil factors are difficult, if not impossible, for a producer to change. However, specific soil characteristics can alert producers to the likelihood of pesticide runoff or potential leaching at their sites.

One of the most significant factors affecting runoff or leaching is the soil moisture condition at the time of pesticide application. In the semi-arid climate of Colorado, producers often can manage pesticide application and irrigation to avoid conditions leading to pesticide loss. Pesticides with medium or high mobility should not be applied to a saturated soil or just prior to a heavy irrigation. Alternative pest management strategies should be considered when the soil moisture status increases the probability of runoff or leaching.
In addition to soil properties, other features of the application site can affect the potential for pesticide movement. The site characteristics of greatest concern include:

- depth to groundwater
- proximity to surface water
- topography
- aquifer and overburden characteristics
- climate and irrigation

Distance to water is one of the most important site features to consider when evaluating pest management decisions. When the water table is close to the soil surface (less than 30 feet), contamination of groundwater is much more likely than when groundwater resources are deep. Surface water proximity should also be considered prior to pesticide application. Observe a setback or buffer zone located a safe distance from wells, streams, ponds, and lakes (Figure 4), and do not apply pesticides in these zones. The actual setback required will depend on the slope, the mobility of the chemical, and the likelihood of runoff. For sensitive areas directly adjacent to surface water bodies, contact your local USDA Natural Resources Conservation Service (NRCS) office for information regarding buffer strips.

Figure 2. Factors influencing pesticide transport and its impact on water quality.

Figure 3. Pesticides will exist in the soil water solution, in soil air, or adsorbed onto soil particles.
As shown in Figure 5, groundwater sensitivity to pesticide contamination varies greatly across Colorado due to depth to water table, permeability of materials overlying aquifers, and availability of recharge for transport of contaminants (irrigation). The mapped areas are predominately agricultural, where the bulk of pesticides are used in an irrigated setting. Pesticide applicators should exercise extreme caution when mixing and/or applying pesticides in these sensitive areas, particularly when selecting pesticide products to use in areas mapped as medium or highly sensitive to leaching. However, because field scale properties can vary, this map should be used only as a starting point for further consideration. In sensitive areas, applicators should seriously consider whether to use pesticides with groundwater advisory statements (See Table 1 for a list of pesticides with groundwater advisory statements).

The permeability of subsurface layers affects the rate of groundwater recharge and subsequent contamination if any pesticide is carried in percolating water. Regions with highly permeable materials, such as those found over alluvial aquifers in Colorado, are particularly susceptible to contamination. These vulnerable areas merit careful pesticide selection and application methods, especially where irrigation may result in excess water for leaching.

### Determining Pesticide Loss Potential

Pesticide applicators should evaluate all soil, site, and pesticide properties to determine the relative hazard to water resources that pesticide applications may pose. Table 2 lists factors that applicators should consider so that they can select pest management measures that are least likely to impact ground or surface water.

### Pesticide Leaching and Runoff

For sites that are vulnerable to leaching, exercise caution when considering pesticides that are poorly adsorbed or that have long persistence in the environment. When possible, select chemicals with low toxicity, short half-lives, and high adsorption. This information is usually available from your chemical dealer, Extension agent, or crop adviser. Several computer models have been developed to predict pesticide movement and to help applicators select the most appropriate pest management strategy.

A Windows based pesticide-screening tool (WIN-
PST) is available through the USDA Natural Resources Conservation Service (NRCS). WIN-PST utilizes pesticide properties and Soil Survey Geographic (SSURGO) Database information to evaluate potential pesticide leaching below the crop root zone and pesticide movement with water and eroded soil off fields. WIN-PST also considers the impact of depth to water table, larger soil pores (macropores), rainfall probability, pesticide application area, method and rate, and effects on no-target organisms. This program is available for download at www.wsi.nrcs.usda.gov/products/W2Q/pest/winpst31.html, and SSURGO soils information is available through the NRCS Soil Data Mart link found at http://soils.usda.gov/. WIN-PST assistance is also available through your local NRCS Field Office.

Runoff

Pesticides have routinely been found in surface waters receiving agricultural runoff, particularly after heavy spring rainfall or surface irrigation. This suggests that the management of pesticides should focus on good practices at the time of application. Additionally, land management practices, such as reduced tillage, strip tillage, and no-till, are important for protecting surface water quality. Grass filter strips and waterways should be established on fields that drain directly to streams and lakes. Contact local NRCS personnel for buffer strip design criteria to protect surface water from pesticide runoff (Figure 4).

Conservation tillage practices that increase the amount of crop residues on the soil surface can reduce runoff volume and velocity, which results in less erosion and less pesticide movement. Strongly adsorbed chemicals, such as paraquat, tend to adhere tightly to soil particles and will move on eroding sediments. Reduced tillage systems are highly recommended on all erosive soils. However, in some cases increased macro porosity and infiltration, coupled with increased herbicide use, may favor pesticide leaching. Where groundwater is shallow and domestic wells are nearby, these trade-offs should be assessed.

Figure 5. Relative sensitivity of Colorado groundwater to pesticide contamination.
Pesticide Properties

Chemical properties of a pesticide cannot be changed by applicators, but they should be considered in order to select the most appropriate product when chemical control is necessary. Table 3 lists properties such as degradation rate, adsorptivity, solubility, and volatility. Values for these properties are of special interest because they influence the likelihood of off-target effects.

The degradation rate of a pesticide, measured as the half-life, indicates how long the chemical persists in the environment. Persistence is significant, because the longer a chemical remains in the environment the greater the probability the chemical will move to off-target locations (like surface and groundwater) or injure non-target organisms.

The major pathways of pesticide degradation are microbial breakdown, photolysis (breakdown by sunlight), and hydrolysis (chemical breakdown). These pathways are influenced by the chemical structure of the pesticide compound, as well as by soil temperature, pH, moisture, and microbial populations. Soil microbes, including bacteria, fungi, and actinomycetes, are the major degradation pathway for most pesticides. Because microbes tend to be most active in the upper portions of the root zone, once a pesticide moves below this level it may be stable long enough to reach groundwater.

Adsorptivity is a measure of how strongly a pesticide is attracted to the negative charges on soil particles. Strongly adsorbed pesticides are less likely to leach, especially on soils with high organic matter or high clay content. However, they may be more prone to end up in surface water if soil erosion occurs because of wind or water. Adsorptivity is usually expressed as the Kd or KOC of the compound. The higher the number, the more strongly adsorbed the pesticide will be.

Solubility, usually expressed in parts per million (ppm), describes the tendency of a pesticide to dissolve in water. While solubility may influence the amount of a chemical carried in macropore flow, it is generally not as significant as the adsorptivity of a chemical in predicting chemical movement through soil.

Volutatility is the rate at which a chemical evaporates when in contact with air. Volatile pesticides can vaporize and move by vapor drift. Pesticides can injure non-target organisms and impact surface waters when they vaporize and move off-target.

Pesticide properties only indicate the probability of leaching or runoff; soil, site, and management factors must also be considered. Even if pesticide properties indicate very little environmental risk, they may still end up in water supplies if other factors favor movement. However, in most cases good management will keep water contamination to a minimum. Pesticide information and application risk criteria can also be acquired from http://npic.ornst.edu/ingred/products.html

Pesticide Use Practices

Although pesticide use is a standard practice in most agricultural operations, most producers are adopting an Integrated Pest Management (IPM) approach. IPM techniques can reduce pesticide use to the minimum amount necessary, yet still maximize profits. IPM combines chemical control with Prevention, Avoidance, Monitoring and Suppression (PAMS) activities to form a
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comprehensive program for managing pests. This approach emphasizes preventive measures to maintain pests below the economic threshold while using the minimum amount of pesticide necessary.

Prevention is the practice of keeping a pest population from infesting a field or site and includes such tactics as using pest-free seeds and transplants, preventing weeds from reproducing, irrigation scheduling to avoid situations conducive to disease development, cleaning tillage and harvesting equipment between fields or operations, using field sanitation procedures, and eliminating alternate hosts or sites for insect pests and disease organisms.

Avoidance may be appropriate when pest populations exist in a field or site, but a cultural practice avoids pest impact to the crop. Examples include crop rotation, choosing cultivars with genetic resistance to pests, using trap crops or pheromone traps, choosing cultivars with maturity dates that may allow harvest before pest populations develop, and not planting areas of fields where pest populations are likely to cause crop failure.

Monitoring and identification of pests should be performed as the basis for suppression activities. Monitoring can include surveys or scouting programs, trapping, or weather monitoring and soil testing where appropriate. Records should be kept of pest incidence and distribution to help determine the most appropriate crop rotation, economic thresholds, and suppressive action. Proper pest identification and using the correct pesticide at the time of maximum pest susceptibility is foundational to an effective IPM program.

Suppression of pest populations becomes necessary to avoid economic loss if monitoring indicates that prevention and avoidance tactics are not successful. Suppression activities include cultural, physical, biological and chemical controls.

Changing your pest management strategy to an IPM program may involve modifying tillage, fertility, cropping sequence, and sanitation practices. This may require some experimentation and perhaps even professional advice. Additional information, practical guidelines and tools for using IPM are available in the High Plains IPM Guide (http://highplainsipm.org) and at the Western IPM Network (http://www.wrpmc.ucdavis.edu/).

<table>
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<tr>
<th>Trade Name</th>
<th>Active Ingredient Name</th>
<th>Ground Water Advisory</th>
<th>Solubility (mg/L)</th>
<th>Soil Adsorption (Koc mL/g)</th>
<th>Soil Half-Life (days)</th>
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Key:
- PLP = Pesticide Leaching Potential
- PSRP = Pesticide Soluble Runoff Potential
- PARP = Pesticide Adsorbed Runoff Potential
- H = High
- I = Intermediate
- L = Low
- VL = Very Low
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Pesticide Application Practices

When pesticides are required to control pests, it is important to use application techniques that minimize potential water quality impacts. All commercial applicators should be certified through the Colorado Department of Agriculture (CDA) and remain current in new pest management techniques and developments. Certification through CDA is required for all commercial applicators and for distribution and application of Restricted Use Pesticide (RUP) products. Information about CDA’s Pesticide Applicator Program is available at: https://www.colorado.gov/pacific/agplants/pesticides

A separate licensing category exists for private applicators who apply an RUP. Any person who uses or supervises the use of an RUP on property owned or leased by the applicator or the applicator’s employer must be a licensed private applicator. A licensed private applicator may apply RUP’s for another producer for agricultural commodity production only if the compensation is limited to the trading of personal services between the applicator and the other producer. Certification for private applicators is conducted by CDA.

Pesticides should be applied at a time when they will be most effective against the crop pest. Pest cycles are influenced by temperature and moisture conditions. In many cases, pests under dormant or stressed conditions may not be susceptible to pesticide treatments. Lower pesticide rates reduce the total amount of chemicals in the environment; therefore, apply the lowest labeled pesticide rate that adequately controls pests. Rotate pesticides among chemical families to minimize pest resistance. IPM does not rely on continuous use of a single pesticide or pesticide family (Table 4). Avoid pesticide applications during adverse weather, especially windy and wet conditions. Do not apply volatile chemicals such as 2,4-D ester or methyl parathion under high temperature conditions.

The application method used to apply pesticides can influence leaching or runoff potential. Soil injection or incorporation makes the pesticide more available for leaching, but less likely to cause surface water contamination. In general, pre-plant and pre-emergence treatments on clean tilled soil are more subject to surface loss than post-emergence treatments, when crop cover reduces runoff. Foliar insecticide and post-emergence herbicide treatments may reduce the potential for chemical movement because of rapid absorption by plants. Additionally, many of the foliar or post-emergence chemicals are less persistent and can sometimes be used effectively at lower rates.

Banding herbicides over the crop row is a BMP that can significantly reduce chemical costs while maintaining yields. Many producers are using a 10- to 15-inch band, reducing total herbicide use by 50% or more. Banding may require an extra cultivation and slightly more management, but it does not involve sophisticated equipment or a large investment. Existing application and tillage equipment usually can be modified. Spot pesticide treatments in the pest-affected areas of a field can also control pests to within economic levels with much less chemical than broadcast applications. The reduced amount of pesticide used under band and spot applications can result in higher returns and less pesticide for potential leaching or runoff.

Precision Farming Technology

Precision farming systems include information, technology, and decision support. In pest management, information can include the collection and mapping of pest populations in fields. Mapping of pests can be done manually or using technology such as a global positioning system (GPS) and geographic information systems (GIS) software. These maps, combined with known economic threshold levels for each crop, can be used to determine where spraying is necessary. A tractor equipped with the software, corresponding map, and a GPS unit can then be used to selectively spray the field. This requires that the GIS map, the GPS unit, and the tractor’s sprayer unit all be connected so the boom will turn on and off as needed. A primary benefit of using GPS/GIS technology includes application maps for record keeping.

Lightbar navigation and/or auto-steer are another form of precision farming technology that can be used when applying pesticides. The lightbar consists of a row of LEDs (light-emitting diodes), a GPS receiver, and a microprocessor. This technology
helps guide the applicator and reduces application overlap, overspray, and application costs.

**Application Technology**

Advances in pesticide application technology reduce pesticide use and increase application efficiencies. Precision farming technology enables accurate pesticide applications using GPS-controlled navigation. Application rate efficiencies are also improved with advanced boom flotation, nozzle design, sprayer electronics and controls, computer control with GPS and GIS, direct injection, and chemical mixing.

**Advances in Nozzles**

Advances in nozzle design allow pesticide applicators to choose nozzles that match their needs. Application rate improvements are influenced by increases in plant coverage and more effective crop canopy penetration and pesticide adherence to plant surfaces. Air induction (inclusion) nozzles increase spray droplet size by mixing air into the spray solution, which lowers drift potential. When these droplets strike the spray target they release energy stored in bubbles, spreading out the droplet onto the target surface. This increases application efficiency and effectiveness. Angled nozzles enable under-canopy pesticide applications, making targeted applications effective. Advances in broadcast nozzle designs provide more uniform coverage with a broad range of operating pressures. Also, spray droplet size and spray patterns can now be adjusted from the cab to match application types and environmental conditions.

Modern materials used in boom construction allow for lighter-weight equipment with greater strength and flexibility. Boom suspension controls allow the operator to adjust boom float to match field conditions, which isolates the boom from the sprayer and allows flotation. This improves application efficiency by providing a more even application.

**Chemical Mixing**

Modern electronics has improved application accuracy with electronic flow meters, pressure gauges, speed sensors, and system computers. GPS with direct injection allows for targeted spraying. Sensor controlled systems engage application when the target is seen by the sensor, which is useful in orchards and reduces the amount of materials applied. Chemical mixing for spray applications has been a source of operator chemical exposure. Modern equipment designs offer chemical induction systems to enable liquid and dry chemical to be loaded into the system via a separate chemical tank as opposed to traditional tank mixing procedures. This enhances operator safety by improving chemical handling procedures, and it decreases carryover from improper cleaning of mixing tanks when changing rates or products.

Advances in sprayer technologies have improved pesticide application efficiencies and effectiveness, reduced operator exposure to chemicals, and reduced over applications of product, which ultimately increases producer profitability. Operator safety should be paramount in any IPM program; advances in equipment design and functionality facilitate operator safety.

**Calibration and Equipment Maintenance**

Effective pesticide use requires uniform application of the correct amount of chemical and carrier. Under-application usually results in poor control,
which may require retreatment. Over-application of pesticide seldom increases control and may result in crop damage and needless environmental risk in addition to being illegal.

Calibrate spray equipment prior to each application and maintain all equipment according to the manufacturer’s recommendation. Check hoses, booms, tanks, and nozzles regularly for uneven wear and leaks or drips.

Information on proper calibration of field sprayers is available from a number of sources. Check with your local chemical dealer, crop consultant, or Extension agent for help calibrating your equipment properly. Also, the following links will direct you to equipment calibration and maintenance web sites:

Equipment calibration:
http://waterquality.colostate.edu/pestrecordbook.shtml

Equipment cleaning/maintenance:
• http://extensionpublications.unl.edu/assets/pdf/g1770.pdf

Recordkeeping

Keeping accurate records of all agricultural chemicals applied on your site will help you make informed management decisions. By law, records of all restricted use pesticides (RUP) must be maintained by operators for at least three years in Colorado (see https://www.ams.usda.gov/rules-regulations/pesticide-records). You can maintain records of non-restricted chemicals on the same form as the required records with minimal additional effort. This information has further value for use with crop and pest modeling programs and economic analyses. Records must be kept for all RUP applications and must include:

• brand or product name
• EPA registration number
• total quantity of pesticide applied
• application date
• location of restricted use pesticide applications (not farm address)
• crop commodity, stored product, or site treated

• size of treatment area
• name of the certified private applicator performing and/or supervising the application
• certification number of the private applicator

Other useful information to record includes:

• weather data and irrigation water applied
• description of pest problems
• application rate of chemical and carrier
• equipment calibration data

Colorado State University Extension and several other organizations have developed record-keeping forms for restricted use pesticides. Computer software is also commercially available to help producers and applicators maintain high-quality records. Please visit http://waterquality.colostate.edu/pestrecordbook.shtml for pesticide record-keeping forms and spreadsheets.

Summary

Pesticides are currently an important component of most agricultural pest management strategies. The IPM approach can help producers minimize water quality impacts and manage pests economically. A number of BMPs are effective in reducing pesticide runoff and leaching. Additional benefits of these BMPs include reduction of soil erosion and nutrient losses.

Selection of least toxic chemical controls should be coupled with knowledge of site and chemical interactions. Sites with vulnerable water resources require selection of pesticides least likely to move off-target, or alternative pest management measures. Proper management of soils, water, and pesticides by agricultural producers can help reduce adverse water quality impacts.

Note: The pesticide label always supersedes any educational material such as this publication. Always read and follow label instructions precisely. Data presented in this publication on commercial products are for educational purposes only. Reference to commercial products does not imply endorsement, nor is criticism implied of products not mentioned.
BMPs for Agricultural Pesticide Use

General BMPs

1. Obtain thorough training and the appropriate certification prior to applying any pesticide.

2. Always follow pesticide label directions and read all instructions, particularly precautionary statements, prior to chemical mixing and application. All pesticide applications must follow label specifications and must be applied only to the crops for which the product is registered for use.

3. Keep accurate and timely pest and pesticide records. See Pesticide Recordkeeping Form for suggested format (Table 4).

4. Consider the effects of pest control measures on the environment and non-target organisms. Minimize chemical reliance by rotating crops and using physical, biological, or cultural pest management controls whenever feasible.

5. Follow refuge requirements for biotech cultivars to avoid resistance development in target pests.

Pesticide Selection BMPS

6. Avoid the overuse of preventive pesticide treatments. Base pesticide application decisions on site-specific pest scouting and indicators of economic return.

7. Select least toxic and less persistent pesticides when feasible.

8. Avoid overuse of herbicides with common modes of action (Table 4). Chemicals within the same family have similar modes of action and should be rotated to avoid weed resistance particularly with herbicide tolerant cultivars.

9. Consider pesticide and target site characteristics to determine suitability of the pesticide at that location. Knowledge of pesticide persistence, mobility, and adsorption should be included in pesticide selection (Table 3). Chemical applicators should know the characteristics of the application site, including soil texture, organic matter, topography, and proximity to ground and surface water. Contact your local NRCS office for further information about the soils on your site and possible pesticide interactions.

Pesticide Application BMPs

10. Maintain application equipment in good working condition and calibrate equipment frequently to ensure that pesticides are applied at recommended rates. Replace all worn components of pesticide application equipment, especially nozzles, prior to application.

11. Ensure that the pesticide applicator knows the exact field location to be treated. Post warning signs around fields that have been treated, in accordance with local, state, and federal laws. Follow the established re-entry interval as stated on the pesticide label.

12. Employ application techniques that increase efficiency and allow the lowest effective labeled application rate. Use band and spot applications of pesticides where appropriate to reduce environmental hazards and treatment costs.

13. Avoid unnecessary and poorly timed application of pesticides. Optimize pesticide rate, timing, and placement to avoid the need for re-treatment.

14. Avoid overspray and chemical drift, especially when surface water is in close proximity to treatment area. Avoid applications if wind speed favors drift beyond the intended application area. Increasing nozzle size and lowering boom pressure will increase droplet size and help reduce drift. Always recalibrate following equipment adjustments or modifications.

15. Time pesticide application in relation to soil moisture, anticipated weather conditions, and irrigation schedules to achieve the greatest efficiency and reduce the potential for off-
site transport. Avoid pesticide application when soil moisture status or scheduled irrigation increases the possibility of runoff or deep percolation. After application, manage irrigation to reduce the possibility of erosion, runoff and/or leaching, which may transport pesticide from the target site.

16. Establish buffer zones so pesticide is not applied within 50–100 feet of wells and surface water. Apply pesticides in a manner that will minimize off-target effects.

17. Apply pesticides in a manner that will minimize off-target effects.

18. Avoid repetitive use of the same pesticide or pesticides of similar chemistry and modes of action to reduce the potential for pesticide resistance development and shifts in the pest spectrum.

19. Ensure that backflow prevention devices are installed and operating properly on irrigation systems used for applying pesticides.

20. Use GPS/GIS technology, where appropriate, to aid in pest mapping, pesticide application precision and record keeping.

Pesticide Safety BMPs

21. Read and follow label safety directions, maintain appropriate Material Safety Data Sheets (MSDS), and become certified prior to applying restricted use pesticides.

22. Wear the appropriate protective equipment specified on the pesticide label to minimize unnecessary exposure to pesticide. Be sure to clean protective gear after each day’s use.

23. Provide emergency hand and eye wash facilities for personnel working in chemical storage, mixing, and treatment areas. Develop a safety plan that includes information about poison centers and emergency treatment centers. Post emergency response phone numbers in highly visible places near areas where chemical handling occurs.

24. Know what to do in case of accidental pesticide poisoning. Have an emergency response kit available when handling pesticides. Check the product label for instructions and call the nearest poison center in the event a pesticide is swallowed or when pesticide exposure has occurred. Product labels often include a telephone number where expert information is also available. Take the pesticide label to the attending physician if you need treatment.

25. Follow all Worker Protection Standard (WPS) requirements and postings as specified by the label under “Directions for Use or Agricultural Use Requirements,” which includes requirements for personal protective equipment, restricted entry and posting.

26. Program emergency response numbers into your cell phone when involved with pesticide handling.

Rocky Mountain Poison and Drug Center
Denver, Colorado
1-800-222-1222
www.rmpdc.org

For more information about pesticide management or specific inquiries about BMPs, contact Colorado State University Extension or visit www.csuwater.info. CSU publications, programs, and specialists are available to help you answer questions about water quality.

Related source material from Colorado State University Extension

Fact Sheet 5.003 Sprayer Calibration Fundamentals
Fact Sheet 5.021 Agricultural Protective Equipment
XCM-178 Best Management Practices for Pesticides and Fertilizer Storage and Handling
XCM-176 Best Management Practices for Crop Pests
XCM-202 Pesticide Record Book for Private Applicators
Glossary

**Adsorption**
The process by which atoms, molecules, or ions are taken up from the soil solution or soil atmosphere and retained on the surfaces of solids through chemical or physical binding.
Defined by an adsorptivity constant called Koc.

**Backflow**
Flow in the reverse direction of normal or desired flow.

**Buffer zone**
An area set aside from chemical applications and designed to hold influx of substances due to wind and water erosion by physical and chemical detainment.

**Calibration**
The process of adjusting equipment to deliver the desired amount of a substance when application occurs.

**Chemigation**
The application of pesticide through an irrigation system.

**Conservation tillage**
A tillage system that uses specially designed equipment to retain crop residue on the soil surface to lower erosion potential and aid in water conservation.

**Degradation rate**
The amount of time it takes for the half life of a substance to occur.

**Fungicide**
A chemical product or biological organism used to kill or inhibit fungi or fungal spores.

**Half life**
Length of time it takes for the quantity of a substance to decay to half its original mass.

**Herbicide**
A chemical product designed to kill unwanted plants.

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Colorado Pesticide Information Retrieval System

CEPEP Fact Sheet: The Pesticide Label
http://wsprod.colostate.edu/cwis79/Factsheets/Sheets/103pesticidelabel.pdf

CEPEP Fact Sheet: Understanding the Material Safety Data Sheet
http://wsprod.colostate.edu/cwis79/Factsheets/Sheets/104MSDS.pdf

Colorado Department of Agriculture
http://www.colorado.gov/ag
(303) 869-9000

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CEPEP Fact Sheet: The Pesticide Label
http://wsprod.colostate.edu/cwis79/Factsheets/Sheets/103pesticidelabel.pdf

CEPEP Fact Sheet: Understanding the Material Safety Data Sheet
http://wsprod.colostate.edu/cwis79/Factsheets/Sheets/104MSDS.pdf

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**Insecticide**
A chemical product designed to kill unwanted insects.

**Leaching**
Movement of a chemical downward through the soil.

**Macropores**
Large soils pores formed by cracks, root holes, worm channels or other physical or biological mechanisms that can be responsible for rapid infiltration and percolation of water and dissolved chemicals below the rootzone.

**Nonpoint contamination**
Contamination that occurs when a single identifiable point of contamination is not defined.

**Nontarget organism**
An organism, such as a plant, insect, animal, or microbe, that is not the target of pesticide application but is present within the management area.

**Off-target location**
An area that is not within the application management area but is still impacted by the pesticide.

**Overspray**
Pesticide application that occurs where not intended or planned in an area adjacent to a treatment area.

**Pesticide detection**
The detection of a pesticide in a sample.

**Percolating water**
Water moving or seeping downward through the soil from precipitation and/or irrigation.

**Point-source contamination**
Contamination that occurs where a single point of contamination can be identified.

**Pre-emergence treatment**
The application of pesticide to the soil or plant residue prior to crop emergence.

**Restricted Use Pesticide (RUP)**
A pesticide that is not available for use by the general public due to its acute human toxicity, accident history, potential for or history of groundwater contamination, toxicity to vulnerable nontarget plants or animals, or is a fumigant or carcinogenic or mutagenic product.

**Solubility**
A measure of how much substance can solubilize in a given amount of water.

**Vapor drift**
The movement of a pesticide in its gaseous state from the point of application.

**Volutility**
The measure of a pesticide’s proneness to vaporize through evaporative processes as influenced by temperature, relative humidity, and solar radiation.