Runoff and Leaching

There are three physical properties which, when combined with site conditions such as climate and geology, determine the runoff and leaching potential of a herbicide. They are:

- **Persistence -** Persistence is the length of time a chemical stays active. It is measured by its half-life. The longer the half-life of a chemical, the more persistent it is. The half-life is affected by many variables, including sunlight, microorganisms, chemical degradation, etc.

- **Soil Adsorption -** Soil adsorption is the tendency of a chemical to bind to soil particles. Soil adsorption is expressed as K (oc)= conc. adsorbed/conc. dissolved/% organic carbon in soil.

- **Solubility -** Solubility is the tendency of a chemical to dissolve in water. Solubility is expressed as the amount of a chemical dissolved in a known amount of water measured in mg/l (ppm).

Herbicides have to be relatively persistent in order to have either leach or runoff potential (non-persistent herbicides do not stay active long enough to create a risk). If a herbicide has a high soil adsorption, it is more likely to run off with soil movement. If it has low soil adsorption, it is more likely to leach down through the soil. If a herbicide is highly soluble in water, it is more likely to leach; with low solubility, it is more likely to run off. Table 1 shows how the various factors combine for leach or runoff potentials. See the Herbicide Ecological Toxicities and Characteristics for the physical properties and off-site movement potentials (leaching and runoff) for each herbicide.

Table 1 - Runoff and Leach Potential

Main Physical Properties	Leach Potential	Runoff Potential
Persistence	**Persistent** *half-life greater than 100 days*	**Persistent** *half-life greater than 100 days*
Soil Adsorption	**Low soil adsorption** *K(oc) less than 500*	**High soil adsorption** *K(oc) greater than 500*
Solubility	**High solubility** *greater than 30 mg/l*	**Low solubility** *less than 30 mg/l*

Even if a herbicide has runoff or leaching potential, the likelihood of it reaching a water body also depends on site characteristics such as climate and geology. For example, if a persistent herbicide with a high potential for leaching to groundwater were used at a site with low annual precipitation, and the depth to groundwater was over 30 m (98 ft.), the overall potential for that herbicide ever to reach groundwater before complete degradation is quite low. Conversely, the same herbicide, applied at a site with high annual rainfall, coarse underlying soils, and groundwater depths less than 30 m (98 ft.) would have a higher relative potential of reaching groundwater. No one factor can be used to anticipate the ultimate behavior of a herbicide. By understanding these factors, following label instructions and restrictions and applying herbicide-free buffers, applicators can virtually eliminate the potential of herbicides reaching water bodies.

Herbicides used at the level and intensity typical for Bonneville vegetation management does not tend to pose substantial risks of leaching into groundwater. In western Oregon and Washington, the many soil microorganisms and high precipitation levels combine to degrade and/or dilute herbicides to the level where little or no trace would occur in groundwater. In other portions of Bonneville's service area, low precipitation, combined with deep groundwater aquifers, prevents herbicides from reaching ground water (BLM, 1985: p. 40).

Application technique can also have a slight impact on leaching and runoff potential. Applications that are applied to an area (broadcast and aerial techniques) tend to also have herbicide applied to soils and are more likely to run off or leach than techniques that apply herbicide to the plant only (spot or localized techniques).

Drift

Herbicides can also reach non-target resources through drift—the airborne movement of herbicides beyond the intended contact area. The three primary factors that contribute to drift are as follows: (1) application technique, (2) weather conditions, and (3) applicator error. Aerial and broadcast applications are more likely to reach water through drift, because the herbicide is sprayed from a helicopter/plane or through a large hose and must settle through the air to reach the target. Spot and localized applications are less likely to cause drift because these applications are targeted to specific plants and the volume of herbicide sprayed through the air is less.

Wind speeds and air temperatures (and their effect on herbicide evaporation) affect the potential for herbicides to drift. With winds over 5 mph and/or high temperatures, drift is likely.

The Spray Drift Task Force has two excellent publications for reading at:

Ground Application

Aerial Application

A word about "dead calm" application conditions. Herbicide applications should NOT be made during dead calm conditions. Dead calm most likely means a temperature inversion is present. Under these conditions spray droplets may become suspended in the air and then move to non-target areas as the winds pick up. Temperature inversions occur mostly in the early morning and late evening. Check local weather agencies or use smoke to determine if an inversion is present. Smoke will spread horizontally if an inversion is present.

Buffer Zones

Buffer zones are generally protective areas surrounding or adjacent to resources needing special attention. Resources can include, but are not limited to: domestic water sources, riparian areas, public school property, recreation areas, residential areas, habitat for threatened/endangered species, sole source aquifers, etc. The width or circumference of a buffer depends on the action taking place that affects the resource needing protection. Many states have guidelines in place for the establishment of buffer zones when logging, road building, and when other development takes place. In addition to the buffer zones already established by other agencies, BPA has adopted the following buffer zones, shown in Tables 2, 3, and 4, to protect special resources during vegetation management work at BPA facilities:

Table 2 - Buffer Widths to Minimize Impacts on Non-Target Resources

Herbicide/Adjuvant Ecological Toxicities and Characteristics	Buffer Width from Habitat Source per Application Method (i.e., stream, wetland, or sensitive habitats)				
	Spot	Localized	Broadcast[1]	Aerial[2]	Mixing, Loading, Cleaning
Practically Non-toxic to Slightly Toxic	Up to Edge[3,4]	Up to Edge[3,4]	10.7 m[3,4] (35 ft.)	30.5 m[4] (100 ft.)	30.5 m[5] (100 ft.)
Moderately Toxic, or if Label Advisory for Ground/ Surface Water	7.6 m[3,4] (25 ft.)	10.7 m[3,4] (35 ft.)	30.5 m[3,4] (100 ft.)	76.2 m[4] (250 ft.)	76.2 m[5] (250 ft.)
Highly Toxic to Very Highly Toxic	10.7 m[3,4] (35 ft.)	30.5 m[3,4] (100 ft.)	Noxious weed control only. Buffer as per local ordinance.	Noxious weed control only. Buffer as per local ordinance.	76.2 m[5] (250 ft.)

[1] Using ultra low volume (ULV) nozzles with orifice size and spray pressure set to produce droplets at a minimum of 150 microns, boom or nozzle heights at the lowest possible height, and cross-wind speed of less than 10 mph. [2] Using ULV nozzles with orifice size and spray pressure set to produce droplets at a minimum of 150 microns, minimizing air shear relative to nozzle angle and aircraft speed, boom length at 70% or less of wingspan/rotor, swath adjustment not to exceed 60 feet based on maximum cross-wind speed of less than 10 mph, minimum safety clearance application height, and herbicide tank mixture dynamic surface tension is less than 50 dynes/cm[3].
[3] Goodrich-Mahoney, J.W., Determination of the Effectiveness of Herbicide Buffer Zones in Protecting Water Quality, Electric Power Research Institute, Report No. TR-113160, September 1999. [4] Calculated from: A Summary of Ground Application Studies, Spray Drift Task Force, 1997. [5] BPA Best Management Practice

Table 3 - Herbicide-free Zones for Rights-of-way, Substations, Electric Yards, and Non-electric Facilities

Zone	Buffer Width
Agricultural Irrigation Source of Any Kind (Wet or Dry)	15m (50 ft.) from each bank (linear) or well (radius) for any herbicide.
Domestic/Public Drinking Water Well	50m (164 ft.) radius for any herbicide having a ground/surface water advisory* 15m (50 ft.) radius for any other herbicide
Domestic/Public Drinking Water Intakes/Spring Developments	For slopes <10% 50-m (164- ft.) radius for any herbicide having a ground/surface water advisory* 15-m (50-ft.) radius for any other herbicide For Slopes >10% <30% 150-m (492-ft.) radius for any herbicide having a ground/surface water advisory* 50-m (164-ft.) radius for any other herbicide For slopes >30% 300-m (984-ft.) radius for any herbicide having a ground/surface water advisory* 100-m (328-ft.) radius for any other herbicide
Sole Source Aquifers	As per local aquifer management plan.

*as stated on the label

< means "less than"   > means "more than"

Table 4 - Additional Herbicide-free Zones for Substations, Electric Yards, and Non-Electric Facilities

Zone	Buffer Width
Secondary Containment Liners, Vaults, and Lagoons	2-m (6-ft.) radius for any herbicide having a ground/surface water advisory* Up to edge of containment feature for any other herbicide
Storm Drains that Discharge Offsite	2-m (6-ft.) radius for any herbicide having a ground/surface water advisory*, or, if moderately/highly/very highly toxic to any aquatic vertebrate or invertebrate Up to edge of drainage feature for any other herbicide