B.C. IRRIGATION MANAGEMENT GUIDE

Chapter 2

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LIMITATION OF LIABILITY AND USER'S RESPONSIBILITY

The primary purpose of this B.C. Irrigation Management Guide is to provide irrigation professionals and consultants with a methodology to assess the irrigation system performance and manage the system effectively.

While every effort has been made to ensure the accuracy and completeness of these materials, additional materials may be required to complete more advanced assessments. Advice of appropriate professionals and experts may assist in completing assessments that are not covered in this Guide.

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2 ENVIRONMENTAL CONCERNS OF IRRIGATION WATER SUPPLY

Water supply for irrigation in British Columbia may be from a number of sources including groundwater, surface water, and other sources supplied by a municipality or other water purveyor. Issues with respect to water supply and irrigation include both quality and quantity. Good quality irrigation water is required to ensure food safety; and water must be in sufficient quantity to meet the crop's needs.

2.1 Water Quality

Primary environmental concerns about irrigation water supply systems are water quality and quantity. Water of poor quality may impact the operation of an irrigation system, and can affect irrigation practices with respect to soil quality and food safety. Fish and other aquatic organisms may in turn be affected by irrigation practices. The Canadian Water Quality Guidelines outline the recommended levels of waterborne chemicals and pathogens for various uses including agriculture, irrigation and livestock. Provincial jurisdictions may develop their own guidelines or criteria (e.g., British Columbia Water Quality Guidelines).

Water Quality Concerns

The primary activities concerning water quality are:

- cross-connection among water supply lines carrying contaminants that pollute the water supply

- well construction (e.g., lack of sealing), location (e.g., down-gradient from contaminated source), or abandoned wells that cause groundwater pollution
- disturbances to watercourses during installation and maintenance of intake screens that may result in water pollution and habitat loss
- irrigation with water of poor quality that contaminates edible crops with pathogens, or causes salt build-up in the soil
- application of fertilizers and other chemicals that may lead to water or soil pollution
- water containing silt and algae or chemicals dissolved in the water that may clog micro-irrigation systems

Water Contaminants

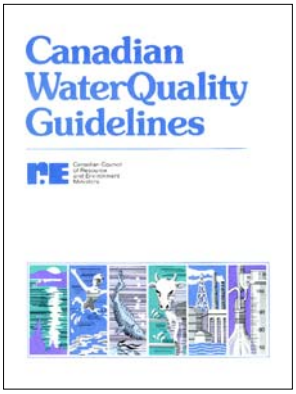
Excessive irrigation can cause contaminants to enter the watercourse or aquifers by leaching through the soil or overland runoff. Heavy soils that have low infiltration rates are susceptible to runoff if the irrigation system applies water at a rate greater than the applied water can infiltrate the soil. If there are contaminants on the soil surface or in the path of the runoff, these contaminants could end up in watercourses.

Total Ammonia

Ammonia (NH_3) plus ammonium (NH_4^+) is referred to as total ammonia, and both exist in urine, manure, fertilizer and compost. Water containing elevated levels of total ammonia may be toxic to fish and other aquatic organisms. The ammonium form is more harmful to aquatic organisms compared to ammonium.

Micronutrients and Metals

Specific metals of concern include arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel and zinc. Elevated metal concentrations can directly kill fish and other aquatic organisms, or accumulate in tissues, making them unfit for human consumption. Sources of metals include manure, waste oil, hydraulic fluids and fertilizers. Woodwaste leachate, by virtue of its acidity, can increase the rate of metal release from the soil as well.



Nitrate Ion (NO_3^-)

The total ammonia nitrogen in manure or fertilizer converts to nitrate (NO_3^-) in soil. Nitrates are easily leached from the soil because they do not attach to soil particles as ammonium does. Once nitrates are out of the root zone, they continue moving to groundwater and surface water. Nitrates in groundwater are often an early indication of contamination elsewhere.

Canadian Water Quality Guidelines

Nutrients

Elevated nutrient levels in a watercourse can be caused by manure or fertilizer entering a watercourse directly, by contaminated water flowing from fertilized fields, or by nutrient-rich soil being eroded from croplands. The most common effects of eutrophication in surface water

are massive blooms of algae and depleted oxygen levels. Blue-green algae in sufficient quantities are toxic to livestock.

Blue-Green Algal Blooms in Lakes

Pathogens

Many organic wastes including manure contain microorganisms, such as bacteria, viruses and other parasites. Some of these microorganisms may be pathogenic (disease-causing) to animals of the same or different species. Many diseases are transmissible between animals and humans, and water can be a pathway for the transmission of infection. Pathogen contamination of shellfish beds is not uncommon, rendering shellfish unfit for human consumption.

Pesticides

Pesticides, such as fungicides, insecticides and herbicides, hold great potential to pollute both surface water and groundwater. Water polluted by pesticides can be the result of application drift, leaching, erosion of contaminated soil, spills and direct introduction. Pesticide-contaminated water can cause harmful effects on aquatic organisms, animals and humans.

Petroleum

Petroleum, antifreeze, paints, solvents, hydraulic fluids and other oil-based substances can cause direct and indirect harmful effects on watercourses and groundwater. Some negative impacts caused by petroleum products in water include destruction of fish-food organisms, such as algae and other plankton, smothering of fish spawning areas, reduced photosynthetic rate in plants, and poor stream aeration. In addition, petroleum products can taint the flavour of fish-food products.

Solids

Solids exist either in dissolved or suspended form in water. Both forms may include nutrients and metals, can elevate the biochemical oxygen demand (BOD) of water, and cause long-term damage. Some types of dissolved solids, such as ammonia, can be toxic to fish.

Suspended solids are primarily silts and clays, but can also include oils, pathogens, woodwaste components, and other materials attached to particles in the water. Suspended solids in watercourses can clog fish gills, affect fish vision and, upon settling, fill up pore spaces between pebbles; thereby, destroying spawning grounds or smothering the eggs of aquatic organisms.

Woodwaste Leachate

Woodwaste (e.g., sawdust, shavings, chips, hog fuel, bark) can cause negative impacts on ground and surface water. Woodwaste leachate entering surface water causes indirect effects. Reduced oxygen levels, due to high biochemical oxygen demand (BOD) and chemical oxygen demand (COD), lower photosynthetic rates in aquatic plants. The colour of woodwaste leachate also reduces light transmission; thereby,

photosynthesis. In addition, woodwaste leachate is acidic, facilitating the unwanted movement of metals and nutrients out of the soil and into receiving waters.

Oxygen in Water

Oxygen Demand

Materials with high oxygen demand (e.g., manure, silage, fruit, vegetables and composting juices) use dissolved oxygen in water directly as they decompose. Increased nutrient levels in water can also indirectly cause high oxygen demand by encouraging the growth of aquatic plants and microorganisms. After these organisms die, natural decay may accelerate the oxygen depletion to levels below that required by fish and aquatic organisms.

Dissolved Oxygen

Dissolved oxygen is a measurement of the amount of oxygen dissolved in water. The oxygen percent saturation level is a function of altitude and water temperature. If wastes with high oxygen demand or high nutrient levels are allowed to enter watercourses, dissolved oxygen levels will drop. Reduced oxygen levels are harmful to fish and aquatic organisms.

Water Temperature

Elevated water temperature has direct and indirect impacts on water quality and the organisms that live in the water. As water temperature increases, its oxygen-holding capacity decreases and can become harmful to fish and aquatic lives. The thresholds of watercourse temperature are set to protect fish. Indirectly, elevated water temperature contributes to the growth of aquatic organisms, which upon death, accelerates oxygen depletion.

Irrigation with Water of Poor Quality

Irrigating with water of poor quality can not only harm or contaminate crops, but may also harm the environment. Salts, heavy metals and pathogens make their way into the soil, and may be taken up by crops or may build up in the soil to unacceptable levels. Irrigation system uniformity can also be affected by poor water quality if sprinklers or drip emitters are plugged. Poor uniformity can lead to higher application rates, resulting in runoff. Implement the following practices:

- know the quality of irrigation water
- protect soils from salt accumulation
- protect food crops from contamination
- monitor system performance to ensure uniformity is maintained

Soil Contaminants

Boron. Boron is essential for the normal growth of plants; however, concentrations greater than 2 ppm may be toxic to certain plants, especially if a large quantity of irrigation water is being used.

Nutrients. Over-application of chemical fertilizers or manure through fertigation may lead to excess nutrient concentrations in soil. An over-

abundance of any one nutrient can be toxic to plants, soil and biota and can reduce crop yield. Excess nutrients not utilized by plants can leach from the root zone into the water. The application of wastes or fertilizers containing excess metals may result in an unwanted accumulation of metals in the soil.

Pathogens. Most pathogens, such as bacteria, viruses and parasites, die off rapidly when exposed to sunlight. However, some pathogens can remain infectious in soils for many years; others can be transferred among plants, soils and animals.

Pesticides. Soil can be polluted with pesticides as a result of excessive application rates and inappropriate application methods. The extent of contamination depends largely on the characteristics of the pesticide, particularly its persistence and solubility. Soil contamination can eliminate beneficial insects, inhibit crop growth, and reduce viable crop varieties. In addition, domestic animals and wildlife may be harmed when feeding on contaminated crops or when ingesting soil particles that contain pesticides. A particular risk to humans is that pesticide accumulation in plant and animal products can make foods unfit for human consumption.

Salts. Soluble salts in soil, which can impact crops, are measured by electrical conductivity (EC) in deci-siemens per metre (dS/m). Crop species vary with respect to the salt levels that they can tolerate. When the EC of soil is below 2 dS/m, they are considered to be affected by salt. Salt concentration in the root zone is influenced by the total dissolved solids in irrigation water. Applying irrigation water with high salt concentration can cause salt build-up in the root zone. Salt build-up can affect plant germination, growth, yield, and soil physical characteristics. The salt tolerance level can vary greatly among crops. Crops are generally broken into three sensitivity groups based on how well they perform for given ranges of salt concentration:

1. sensitive (0 to 4 dS/m)
2. highly tolerant (4 to 8 dS/m)
3. very highly tolerant (greater than 8 dS/m)

Soil above 4 dS/m is said to be saline, reducing yield potentials of a wide range of crops.

Salt impacts on soil are also measured as a sodium adsorption ratio (SAR). When SAR exceeds 13, soil structure is generally degraded, evidenced by hard cloddy or crusted surface and reduced water infiltration (due to loss of soil particle aggregation). In addition, sodium levels begin to become toxic to plants. Farmers in the B.C. Interior who have susceptible fields should be aware of the irrigation water and SAR levels of their soil.

Water Quality Issues in Sprinkler Systems

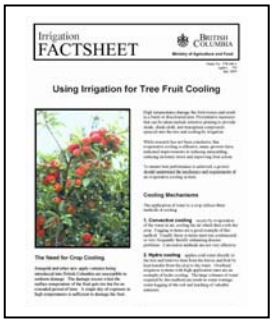
Water of poor quality can cause problems in sprinkler systems, such as plugging intakes, screens and nozzles, and depositing pathogens, chemicals or precipitates on crops.

Pathogens. Pathogens are a concern for all farms that have irrigation systems or crop-washing operations. Many surface water supplies in B.C. may contain pathogens that are of risks to human health. Septic fields, animal manure, milk house wastes and wildlife are all sources of pathogens that can enter surface water or groundwater. Many water supplies for irrigation and crop washing are from agricultural drainage ditches. While ditches are often prone to poor water quality, all surface water sources may contain pathogens.

➔ **Assessment of Irrigation Water Quality, Chapter 4**

If water is tested positive for pathogens, use a water treatment system to prevent contamination of food products, or consider using a drip system that does not apply water directly to the crop.

Treating Irrigation and Crop Wash Water for Pathogens

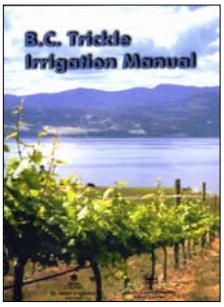


Precipitates. Overhead irrigation may leave a calcium carbonate on fruits and vegetables if the water supply has high levels of calcium and carbonate. Iron may also stain plants and fruit products. If precipitates are problems, the water should be tested and an alternate system used to prevent precipitates from forming.

Using Irrigation for Tree Fruit Cooling

Coloured Water. High levels of tannins in the water can cause discoloration of berries and fruits if applied by an overhead irrigation system. If it is not possible to find another water source or to clean up the current water supply, consider using a drip irrigation system. The drip system requires a good filtration system to prevent the system from clogging.

Water Quality Issues in Trickle Systems



Filtration. Water supplies that contain large amounts of sediments, suspended solids and/or organic materials can plug drip emitters. Nutrients in the water that promote algae growth can also be a concern. Adequate filtration and, in some cases, water treatment are required to ensure that drip systems operate properly.

B.C. Trickle Irrigation Manual, Chapter 10

Precipitates. Carbonate and bicarbonate ions combine with calcium and magnesium in the water to form a calcium carbonate precipitate that can plug drip systems. Iron, manganese and other chemicals may also form precipitates and become an issue.

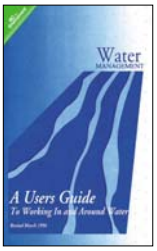
B.C. Trickle Irrigation Manual, Chapter 11

Protection of Water Quality

Water Intakes

Intake Construction

Installing an intake requires working adjacent to or in a watercourse. An irrigation intake requires a water licence which allows works to be done



in a surface water source. Any work that causes changes in and about a watercourse and is not authorized by a water licence requires an approval from MWLAP and Fisheries and Oceans Canada.

A Users Guide to Working In and Around Water

Intake Maintenance

Every irrigation diversion or intake that is taking water from a water source that is frequented by fish must be screened with an appropriate screen that will prevent the passage of fish into the intake or diversion. Section 30 of the Fisheries Act requires that the maintenance of the intake screen authorized by a water licence must be conducted in a manner and during a period that minimizes impacts on water quality for existing licensed users and fish.

Backflow Prevention

Surface and groundwater sources may be contaminated by any farm practice that allows backflow of contaminated water to return to the water source. Implement the following practices:

- Maintain a 30-cm (suggested) air gap between the water supply line and any tank containing a substance other than potable water. This prevents non-potable water from backflowing into the water supply.
- Install a backflow prevention device on water lines that can come into contact with contaminated water.

Chemigation, Frost Protection and Crop Cooling, Chapter 9

Leachate

Excessive irrigation may cause dissolved nutrients to move through the soil and pass the root zone where they are no longer available for plant. If water with soluble fertilizers is leached and moves beyond the plant's root zone, it is likely to end up in a groundwater or surface water source. Since surface water and groundwater often serve as a source of drinking water, its contamination with substances, such as pesticides and nitrates, poses a serious health hazard to humans. Groundwater contamination is difficult and costly to clean up; therefore, must be prevented by using acceptable practices.

Pumps

Combustion engine pumps located near watercourses or water bodies may contaminate the water if fuel spills or leaks reach the watercourse. To minimize the possibility of water contamination, use secondary containment for such fuel tanks. ***Note:*** **A small quantity of petroleum products can cause extensive water pollution.**

Implement the following practices for above- and below-ground tanks:

- locate tanks away from yard drains, ditches, wells and watercourses
  - 30 m from wells (*Health Act*)
  - 15 m from any watercourse (suggested)
- support tanks with non-combustible materials (i.e., metal)


Farm Mechanization FACTSHEET

FARM STORAGE AND HANDLING OF PETROLEUM PRODUCTS

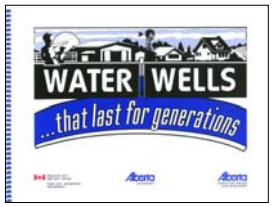
- construct storage tanks in accordance with accepted engineering practices
  - size spill containment to hold the tank volume plus a risk factor of 10%, or the largest tank volume plus a risk factor of 10% for multiple tanks
- use an anti-siphoning device in the discharge line of the tank unless a self-closing nozzle is provided
- ensure no overflow occurs when filling the tank
- ensure no drips, leaks or overflow occur when dispensing fuel
- protect tanks from direct collision by vehicles

Farm Storage and Handling of Petroleum Products

Wells


Water Supply FACTSHEET

GUIDELINES FOR MINIMUM STANDARDS IN WATER WELL CONSTRUCTION PROVINCE OF BRITISH COLUMBIA



Environmental concerns related to wells are associated with contaminants entering groundwater either because of improper well construction or abandoned wells. Tests should be performed annually to ensure well water is potable and nitrate levels are acceptable. Possible additional concerns revolve around withdrawal rates of well water that could decrease flow of affected watercourses. The province of British Columbia has new Groundwater Protection Regulations that requires the certification of well drillers and well construction standards to be adhered to.

Guidelines for Minimum Standards in Water Well Construction

Water Wells...that Last for Generations

Well Protection Toolkit (http://wlapwww.gov.bc.ca/wat/gws/well_protection/acrobat.html)

Well Construction

Locate and construct wells to prevent seepage of both contaminated runoff and contaminated shallow groundwater. Implement the following practices:

- locate new wells at least 30 m from storage and preparation areas for fertilizers, pesticides, petroleum products, manure, silage, etc. (*Health Act*)
- locate wells in high areas, wherever possible, to prevent runoff from collecting around the well head and seeping into the water supply
- construct wells with durable materials
- construct well casings 0.3 m (suggested) above the level of surrounding land
- construct well casings above 100-year flood levels (suggested)
- ensure good sealing of wells by grouting casings at ground level
- cap casings securely to exclude rodents and insects
- use a pitless adapter installed in the well casing where water lines may freeze (rather than terminating the casing in the ground below frost level)
- construct upland berms to prevent contamination of wells

- grade land areas near wells to direct surface water flows
- plant and maintain grass covers around well heads to slow down, and filter any nearby runoff

Abandoned Wells

Seal wells no longer in use to protect the aquifer. Groundwater can be easily polluted if runoff flows into or around well casings. Seal materials should not compromise human health or quality of drinking water, and should be more impervious than the native soils adjacent to the well. Seek professional advice if there is any doubt about sealant.

Well Location

Of particular concern are wells near watercourses where water levels are sensitive to water withdrawal rates. Pumping from such wells should be discouraged or minimized when water levels are critically low.

2.2 Water Quantity

Water Quantity Concerns

The primary water quantity concerns are:

- over-application of irrigation water that results in:
  - excessive use of water
  - leaching of contaminants into groundwater or surface water
  - overland flow leading to soil erosion
- groundwater withdrawals that results in:
  - lowering of water table
  - reduced groundwater input to surface water
- surface water withdrawals causing low stream flows, increased stream temperatures and velocities that impact fish and other water users

Water Withdrawal

Withdrawals of irrigation water are often in competition to other users of the water resource. Withdrawals that result in very low stream flows will impact fish and fish habitat. The Fisheries Act may impose low flow clauses at certain times of the year to protect fish. It is important that irrigation is carried out as specified on the water licence. A water licence from Land and Water B.C. Inc. is required for all surface water withdrawals.

Reduced water levels will typically exacerbate water quality concerns, and may allow predators' to access fish easier, and affect the proper function of fish exclusion/passage structures.

Surface water withdrawals require screened intakes to protect fish. Screens are to be designed with openings small enough to prevent fish

from entering (<2.54 mm). They are to have a surface area large enough to ensure flow velocity is low across the screen, preventing fish from being drawn against the screen.

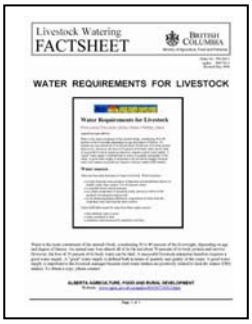
Withdrawal of surface water or groundwater may impact users other than those taking direct advantage of the water. Licences for surface water withdrawals are intended to prevent these conflicts. While groundwater is not licensed, its withdrawals should be based on the water use assessment described in Chapter 4.

Structures for Water Control

The construction of any structures, such as dams, ditches, water diversions, bridges and culverts located in watercourses are subject to fish protection regulations. These govern fish passage and timing, fish screening and by-pass facility. Prior to any work, ensure the fish requirements for the watercourse are known and regulations followed.

Management of Water Quantity

Knowledge of Farm Requirements


Livestock Watering
FACTSHEET
BRITISH COLUMBIA
WATER REQUIREMENTS FOR LIVESTOCK

Whether farm water originates from surface water, groundwater or is supplied by purveyors, all water use should not exceed the following suggested rates:

- for residential use, volume requirements are determined by peak daily use in litres per day (L/d)
- for livestock use, volume requirements are determined by peak daily use in litres per day per animal (L/d/animal)

  Water Requirements for Livestock
- for irrigation purposes, water requirements are determined by crop, climate, soil type and irrigated acreage; for annual volume in acre-feet per acre per year (ac-ft/acre/yr), and for peak withdrawal rates in gallons per minute per acre (gpm/acre)

  Peak Flow Rate Check and Annual Water Use Check, Chapter 4

It is in the best interest of a farm to use only as much water as necessary. Where possible, implement the following practices:


Water Conservation
FACTSHEET
BRITISH COLUMBIA
IRRIGATION TIPS TO CONSERVE WATER ON THE FARM

- conserve water use allowing other users access the water
- conserve existing water to reduce the cost of developing new sources
  - reduced water use means lower requirements for water storage or delivery
  - irrigation typically provides the greatest opportunities for water conservation on most farms

Irrigation Tips to Conserve Water on the Farm

Groundwater Use

Excessive withdrawal of groundwater at rates greater than what it can be replaced will lower the water table. This may impact water levels and the ability for neighbouring wells to obtain water, aquatic environments and flows in adjacent watercourses. Indications that the groundwater table is lowered include:

- the necessity to deepen wells to maintain water flows
- wells running dry when ample flow occurred previously
- nearby bodies of surface water experiencing reduced flows or depths

Implement the following practices:

- monitor water tables regularly by measuring the static water level in wells at the same time of the year (***Note:*** Some variation is normal.)
- if the water table is lowering progressively over time (***Note:*** It may be due to changing climate or off-farm conditions, or uses beyond control), reduce water withdrawal from the aquifer to a sustainable level at which the water table re-stabilizes

Surface Water Use

Producers using surface water must be aware of fish and licensing requirements. Excessive peak withdrawals may deplete water volume in a watercourse to a point where fish and fish habitat are impacted. Moreover, removing volumes of water over the course of a season in amounts greater than licensed/allowable may deplete systems to such an extent that supply is insufficient for downstream users.

Water Licence


Irrigation FACTSHEET

BRITISH COLUMBIA

UNDERSTANDING AN IRRIGATION WATER LICENCE

The Basics of a Water Licence

The use of surface water requires a licence to ensure water availability for all users, including fish and wildlife. Water licences specify various conditions, such as the purpose of water usage, the quantity of water, the amount of storage (if any), the time period it can be used, and the location of withdrawal and usage.

Understanding an Irrigation Water Licence

Annual Water Use

Water licences permit the use of an annual volume of water that must not be exceeded (*Water Act*).

Annual Water Use Check, Chapter 4

Irrigated Area

An irrigation water licence permits a specific acreage that may be irrigated, and this acreage should generally not be exceeded (*Water Act*).

Water Storage


Water Supply
FACTSHEET
BRITISH COLUMBIA
FARM WATER STORAGE

A water licence may permit water storage, such as a dam or dugout. In some regions, dugouts do not need to be licensed if the water stored is collected from on-farm runoff. If the dugout stores water coming from a watercourse, a water licence for storage and use is required. The maximum amount of water stored and when it is stored must comply with the water licence (*Water Act*).

Farms use dugouts and other storages to provide irrigation water, either as the sole source of water or to augment stream or groundwater supplies. Where stored water is the only source during the growing season, the storage facility must be large enough to provide the crop's water requirement for the entire season.

Farm Water Storage

Water Withdrawal Rates

Historically, water licences have not listed water withdrawal rates (e.g., a pumping rate). However, some recent irrigation licences may list a withdrawal rate in gallons per minute (gpm). These rates are calculated based on proper irrigation methods. When withdrawing water, implement the following practices:

- if the licensed withdrawal rate **is specified**, check that the rate being used does not exceed this amount (*Water Act*)
- if the licensed withdrawal rate **is *not* specified**, check that the rate does not exceed the calculated peak flow rate for the region
  Annual Water Use Check, Chapter 4
- follow fish clauses listed on the licence, if present (*Water Act*)
- reduce water withdrawal if required to maintain natural base flow (*Fisheries Act*)

Intake Maintenance

The maintenance of intake works authorized by a water licence must be conducted in a manner and during a period that minimizes water quality impacts on existing licensed users and fish.

2.3 Fish Protection

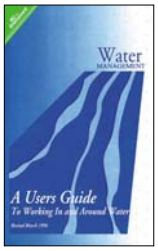
To protect fish and other aquatic organisms, implement the following practices:

- follow the suggestions mentioned previously to protect water quality, quantity and fish habitat
- withdraw water at the licensed rates
- use properly sized fish screens on all water intakes where appropriate
- consider off stream storage to augment the irrigation system flow requirement during periods of low stream flows

Fish Passage at Weirs, Dams, etc.

Water control structures, such as reservoir dams, weirs, flood boxes and pump stations on fish-bearing watercourses, may require fish passage structures. Such structures are specific to fish species requirements, and should be selected after consultation with MWLAP and Fisheries and Oceans Canada.

Habitat Disturbance during Intake Installation

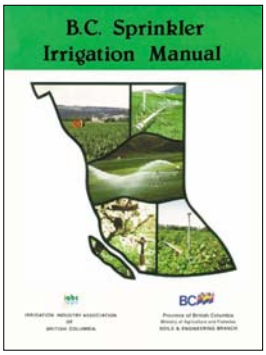


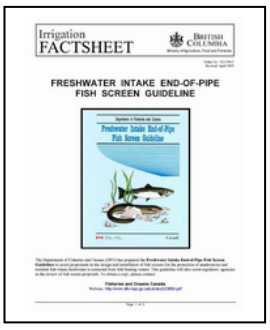
Under the *Water Act*, changes in or about a stream require approval from MWLAP and, in some cases, from Fisheries and Oceans Canada. Refer to the publication "A Users Guide to Working In and Around Water" for a complete listing of the types of work and the required approvals.

Agricultural Watercourse Maintenance Guide

A Users Guide to Working In an Around Water

Fish Screening at Water Intakes





While intakes are usually screened to prevent debris from entering pipes, specific guidelines have been developed for fish-bearing watercourses. The guidelines contain information on appropriate screen sizes for the intake flow rates. The following can be used to determine general compliance:

- ensure sufficient total screen area to match the flow rate
  → **Assessment of System Intake, Chapter 4**
- use screen mesh sizes with clear openings that do not exceed 2.54 mm
- use screen mesh with open areas of no less than 50% of the total screen area

B.C. Sprinkler Irrigation Manual

Freshwater Intake End of Pipe Fish Screen Guideline