Guidelines for Mitigation Translocations of Amphibians: Applications for Canada's Prairie Provinces

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3 authors:

Lea Randall
Calgary Zoological Society
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Natasha Lloyd
Calgary Zoological Society
4 PUBLICATIONS 8 CITATIONS

Axel Moehrenschlager
Calgary Zoological Society
40 PUBLICATIONS 386 CITATIONS

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Disclaimer

This document intends to provide general information about beneficial management practices and amphibian translocation standards. The information within comes from a variety of sources, and will be updated as we gain a greater understanding of the risks and benefits of amphibian mitigation translocations, and as improved methods develop. We welcome feedback on the document to make ongoing improvements. Please send comments or suggestions to lear@calgaryzoo.com. It remains the responsibility of the reader to follow all applicable laws and regulations, and to adhere to the permit conditions of the relevant jurisdictions.

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Executive Summary

Expanding human development (e.g., resource extraction, renewable energy projects, agriculture, and urbanization) can result in alteration or loss of habitat for wildlife, including amphibians. Amphibians are sensitive to disturbances from human activity due to their complex life cycles, sensitivity to environmental contaminants, limited capability to move long distances or across barriers, and varying seasonal habitat requirements.

Activities such as building or maintaining roads, culverts or bridges, excavating, draining waterbodies, prescribed burning, harvesting timber, or growing crops and raising livestock, can result in physical injury or death of amphibians, or may negatively influence their development or reproduction. Effects of these activities on amphibians and their populations can also be indirect, reducing habitat quality or connectivity, and preventing individuals from moving between habitats or populations.

Mitigation translocation involves moving amphibians that would otherwise be destroyed or negatively affected by project activities to an alternate release site. Use of translocation as a mitigation measure to reduce impacts on amphibians from expanding human development is increasing, but it is not without risk—the practice can result in injury, death, stress and exposure to pathogens for the translocated animals or animals at the release site. Once released, amphibians may disperse from the release site, return to the project area, or may face increased competition, predation, or genetic incompatibility with naturally occurring conspecific or sympatric species at the site. Released amphibians may die if the habitat at the release site is unsuitable or disconnected from other required habitats. For these reasons, translocations should only occur when all other alternatives to avoid and minimize project impacts on amphibians are exhausted and if risks to individuals and populations are suitably addressed.

Beneficial management practices (BMPs), are practices, methods, or techniques that consistently shows results superior to those achieved by other means. In many cases, adhering to BMPs or using proactive measures such as installing barrier fencing, or temporary holding and release, can eliminate the need for mitigation translocations. If these measures alone are insufficient, we encourage the use of mitigation translocations—if appropriate planning is conducted, release activities minimize risks for amphibians and other species, and monitoring is sufficient to determine translocation effectiveness.

This document is the first to outline BMPs, standards, and protocols for mitigation translocation of amphibians within Canada's Prairie Provinces. As we are unaware of such guidelines for most global jurisdictions, general considerations within these guidelines may also serve as a useful resource for other regions in Canada, or beyond.

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Definition of Terms

BARRIER FENCE: A fence that either directs or deflects amphibians from project features or toward traps (e.g., drift fences), or encloses a property or workspace preventing entry (e.g., exclusion fencing).

BENEFICIAL MANAGEMENT PRACTICE: A management practice, method or technique that consistently shows results superior to those achieved with other means.

CONSERVATION TRANSLOCATION: The human-mediated movement of living organisms from one area, with release into another to yield a measurable conservation benefit at the levels of a population, species or ecosystem, and not only provide benefit to translocated individuals (IUCN/SSC 2013).

CROSSING STRUCTURE: A barrier or wall that prevents mortality for wildlife and restores habitat connectivity by guiding animals to cross under (e.g., underpasses or culverts) or over roads or other barriers (e.g., overpass, bridges or viaducts).

EMERGENCY TRANSLOCATION: An unexpected or unplanned mitigation translocation that typically occurs when surveys have not been conducted, or did not detect amphibians when they were present, or when amphibians move unexpectedly into a project area.

MITIGATION: An action that avoids or reduces the severity of impact of activities on amphibians in the project area.

MITIGATION TRANSLOCATION: A translocation that involves moving amphibians that would otherwise be destroyed or negatively affected by project activities to an alternative release site (also called salvage translocation).

PROJECT: Any planned development or activity intended to achieve a particular purpose through time, at a given location, within the context of resource extraction, renewable energy, agriculture, urbanization, or other purpose.

RELEASE SITE: The location into which an animal is translocated and released.

RISK: The combination of the probability of a threat occurring, combined with the severity of its impacts (IUCN/SSC 2013).

SETBACK DISTANCE: The distance required to provide a buffer between project activities and environmentally sensitive habitats or special areas worthy of protection due to their landscape function, wildlife or cultural value, to preserve water quality, and provide wildlife habitat.

SINK HABITAT: Sub-optimal habitat where mortality exceeds reproduction or emigration exceeds immigration.

SOURCE SITE: A location from which an animal is translocated.

TEMPORARY HOLDING: The confinement of amphibians in appropriate containments at a project site for a limited amount of time (e.g., less than five days) while a project is underway, followed by release into the same habitat.

THREAT: Activities or processes that have caused, are causing, or may cause the destruction, degradation, or impairment of the organism being assessed (Salafsky et al. 2008).

TRANSLOCATION: The human-mediated movement of living organisms from one area, and release into another (IUCN/SSC 2013).

VISUAL ENCOUNTER SURVEY: A systematic search of a focal habitat for amphibians by survey personnel.

1 Introduction and Scope

These guidelines are intended for industry, consultants, and government agencies in Alberta, Saskatchewan, and Manitoba who may need to move amphibians that would otherwise be destroyed, or negatively affected by project activities to an alternative release site—a practice called mitigation translocation (from here forward called translocation). The scale of the translocation could range from moving a single amphibian out of harm's way of equipment to moving entire populations.

The primary consideration of any translocation should be to protect amphibian species of conservation concern, and the secondary consideration should be to safeguard amphibians of any species in the project area or release site.

Activities such as building or maintaining roads, culverts or bridges, excavating, draining waterbodies, prescribed burning, harvesting timber, or growing crops and raising livestock, can result in physical injury or death of amphibians, or may negatively influence their development or reproduction. Effects of these activities on individual amphibians and their populations can also be indirect, reducing habitat quality or connectivity, and preventing individuals from moving between habitats or populations.

Translocations should only occur when all other alternatives to avoid and minimize project impacts on amphibians are exhausted and if risks to individuals and populations are suitably addressed. The use of beneficial management practices to alter the method, timing or location of project activities to avoid impacts to amphibians may eliminate the need for translocation. Other ways to avoid translocation include halting the project, excluding amphibians from the project area using barrier fencing, temporary holding at the project site or longer-term holding at a licensed facility, or other means. *See **Section 4: Translocation Avoidance and Beneficial Management Practices.***

Translocation is not without risk, and where evaluated, failure rates are high. Published reports estimate that fewer than 40% of amphibian conservation translocations are considered successful (i.e., a self-sustaining population has been established) (Dodd and Seigel 1991, Seigel and Dodd 2002, Germano and Bishop 2009). *See **Section 5: Mitigation Translocation Risks and Challenges.***

A translocation decision tree is included in ***Section 7: Mitigation Translocation Decision.***

A translocation plan, including a well-designed strategy for follow-up monitoring may be required for some industries and jurisdictions. *See **Section 8: Mitigation Translocation Plan***, following the suggested procedures (*See **Section 9: Mitigation Translocation Procedures).***

The guidelines in this document apply to amphibian mitigation translocations for the species listed in ***Appendix 1: Status of Amphibian Species***. Temporary holding and release of amphibians at the project site during construction or maintenance activities should also follow these guidelines.

2 Stages of Mitigation Translocation

STAGE 1: Amphibian Detection Surveys

Conduct amphibian detection surveys at the project site with sufficient rigor to determine with confidence the presence or absence of all amphibian species, and to assess how many animals may require translocation.

Refer to applicable provincial survey guidelines and protocols—*see **Section 3: Amphibian Detection Surveys.***

STAGE 2: Translocation Avoidance

Explore ways to avoid translocation by following beneficial management practices, temporary holding at the project site or longer-term holding at a licensed facility, or through other means.

*See **Section 4: Translocation Avoidance and Beneficial Management Practices.***

STAGE 3: Identify Translocation Risks and Potential Release Sites

Identify risks of translocation to individuals and populations and select potential release sites.

*See **Section 5: Mitigation Translocation Risks and Challenges** and **Section 6: Select Potential Release Sites***.

STAGE 4: Translocation Decision

Following outcomes of Stage 2 and Stage 3, and considering all risks and ways to avoid translocation, decide whether or not to translocate amphibians.

*See **Section 7: Mitigation Translocation Decision.***

STAGE 5: Translocation Planning

Develop a translocation plan that addresses all the key considerations and manages significant risks and uncertainties to maximize success of the translocation. Obtain any necessary permits or permissions. Create a post-release monitoring plan to assess the success or failure of the translocation.

*See **Section 8: Mitigation Translocation Plan** and **Section 10: Post-Release Monitoring and Reporting.***

STAGE 6: Translocation Implementation

Implement translocation plan and follow translocation procedures to minimize risk of disease transmission, stress, injury or death to amphibians from capture, handling, transportation, holding or release.

*See **Section 9: Mitigation Translocation Procedures.***

STAGE 7: Post-Release Monitoring and Reporting

Implement a monitoring plan, and submit data and associated reports to permitting authorities or conservation data centres, as required.

*See **Section 10: Post-Release Monitoring and Reporting.***

3 Amphibian Detection Surveys

Conducting rigorous amphibian surveys in the area to be impacted by project activities will determine which species and life stages of amphibians are present, and provide an estimate of the number of individuals that may need to be moved to start a new population or to significantly deplete a population. There are four levels of survey that depend on the goal of the project: presence-absence; abundance (=population index); population density; population size. A power analysis can be used to help determine the survey effort required. This information will help inform decision-making and development of a translocation plan, if required, or to measure the success of the translocation.

Only a biologist familiar with amphibian behaviour, species ecology, and recommended survey techniques should conduct surveys. Conducting repeat surveys and using multiple survey techniques increases the likelihood of detecting target amphibian species, and may decrease the need for emergency translocations.

3.1 Provincial Survey Guidelines and Protocols

Alberta:

Sensitive Species Inventory guidelines
https://www.alberta.ca

Saskatchewan:

Saskatchewan Amphibian Auditory Survey Protocol
http://www.saskatchewan.ca

Saskatchewan Amphibian Visual Survey Protocol
http://www.saskatchewan.ca

Manitoba:
Manitoba does not currently have specific amphibian survey guidelines but we encourage reviewing guidelines and protocols for Alberta and Saskatchewan.

*See **Appendix 2: Additional Resources** for information on Permits and Conditions.*

4 Translocation Avoidance and Beneficial Management Practices

Using alternate methods, modifying timing, or changing the location of project activities are all project management approaches that can help reduce or avoid impacts to amphibians, and may eliminate the need for translocation. Halting the project, temporary holding, or following beneficial management practices such as adhering to setback distances or excluding amphibians from project areas using barrier fencing can also prevent the need for translocation.

4.1 Timing and Location of Project Activities

To reduce the need for amphibian translocation, conduct activities where or when amphibians are not present or amphibians are less active and encounters are unlikely. Avoid scheduling projects during times when amphibians are present in habitats but unable to move to avoid disturbances, for example, when aquatic species or life stages are present in waterbodies or in overwintering habitat when animals are torpid.

4.1.1 High Amphibian Activity

Amphibians are ectothermic and environmental temperature is the primary regulator of body temperature and activity. Most amphibians have thin, moist skin that is prone to evaporative water loss (Hillman et al. 2009). For these reasons, amphibians in the Prairie Provinces tend to be most active in the spring, summer and fall when it is warm and wet.

Amphibians may be active during the day or night but tend to migrate and breed at night during periods of warm, wet weather (Wells 2007). Encounters with amphibians away from waterbodies are more likely to occur under these conditions or in moist or humid environments. Amphibian breeding and movement patterns may also vary with intensity of moonlight, or with the lunar cycle. Whether this increases or decreases activity depends on the species and is often poorly understood (Grant et al. 2013).

4.1.2 Low Amphibian Activity

During the spring, summer, or fall, activity on land tends to be lowest during hot, cool, windy and dry conditions, and activity in waterbodies tends to be lowest when temperatures are cool. Amphibian encounters are rare during the winter, but excavation, waterbody drainage, or repositioning construction materials or other objects, may reveal overwintering amphibians. Amphibians in torpor are especially vulnerable to disturbance, as they are inactive or capable of only minimal movement. It is therefore important to avoid disturbing habitats used for refuge or overwintering such as wetlands, animal burrows, coarse woody debris and other cover objects during times of low amphibian activity. Some aquatic species or life-stages of amphibians, such as neotenic salamanders or mudpuppies, may still be active in waterbodies during the winter.

See ***Appendix 3: Amphibian habitat and dispersal.*** Refer to amphibian guidebooks for species-specific habitat requirements, and ***Appendix 2: Additional Resources*** *for information on species biology*.

4.2 Maintain Healthy Riparian Zones

Project activities in or near waterbodies can result in poor water quality from release or runoff of chemicals, sedimentation or organic inputs from livestock. If uncontrolled, runoff from rainfall or snowmelt that originates in the project area can carry high sediment loads and contaminants into local waterbodies, resulting in a significant impact on water quality.

Maintaining a healthy riparian buffer zone can help trap sediments, excess nutrients, contaminants and other pollutants, before they reach a body of water. Riparian buffers can also slow down and temporarily store runoff, which promotes infiltration and deceases shoreline erosion and flooding downstream.

Additional practices that can help maintain healthy riparian zones, amphibian populations, and habitat include:

- Avoid placing roads near waterbodies. Using existing roads, trails, or cut lines to prevent additional disturbances to waterbody banks and riparian vegetation. *See **Section 4.9.1: Roads** for beneficial management practices**.***
- Avoid crossing the watercourse as much as possible.
- Adhere to setback distances. *See **Section 4.3: Observe Setback Distances.***
- Install effective erosion and sediment controls, bank and bed protection (e.g., silt fence, swamp mat and kits) before beginning the work, and maintain these interventions until work is completed or riparian vegetation has re-established.
- Pump sediment-laden water discharge into a vegetated area or settling basin.
- Use clean construction equipment on land, ice, or floating barges in ways that reduce disturbance to the banks of the watercourse.
- Contain and stabilize waste materials such as construction waste and debris above the high-water level.
- Avoid mowing and brushing in the riparian zone.
- Avoid using chemical in riparian areas and create an emergency spill response plan according to SDS regulations to quickly contain and clean spills from handling chemicals, accidents, refueling or servicing vehicles and equipment. *See **Appendix 2: Additional Resources** for more information on beneficial management practices and mitigation*.
- Limit pumping of groundwater in areas with spring fed wetlands to maintain water in nearby wetlands.
- Maintain natural surface water pathways and flow rates.

4.3 Observe Setback Distances

A Setback is the distance required to provide a buffer between project activities and environmentally sensitive habitats or special areas worthy of protection for their landscape function, wildlife or cultural value.

Wetland setbacks are buffers designed to protect and maintain wetland function by removing sediments and associated pollutants from surface water runoff, removing, detaining, or detoxifying nutrients and contaminants from upland sources, maintain the temperature and microclimate of a water body, and providing organic matter to the wetland. Buffers also maintain habitat for aquatic, semi-aquatic, and terrestrial wildlife, and can serve as corridors among local habitat patches, facilitating movement of wildlife through the landscape.

The following documents have approved setback distances for the respective jurisdictions; however, setback distances are subject to change with improved scientific knowledge.

All Prairie Provinces:
Petroleum Industry Activity Guidelines for Wildlife Species at Risk in the Prairie and Northern Region
http://www.canada.ca

Alberta:
Recommended Land Use Guidelines for Protection of Selected Wildlife Species and Habitat within Grassland and Parkland Natural Regions of Alberta
http://www.alberta.ca

Master Schedule of Standards and Conditions
http://www.alberta.ca

Saskatchewan:
Activity Restriction Guidelines for Sensitive Species
https://www.saskatchewan.ca

Manitoba:
Specific setback distances are not available for Manitoba, but we encourage review of the guidelines in Alberta and Saskatchewan as a useful reference. Endeavors

4.4 Avoid Additional Disturbances

Avoid unnecessary industrial and vehicle noise, ground vibration and artificial night lighting in areas of amphibian habitat as these stimuli may affect amphibian behaviours such as chorus behaviour and call rate, and may result in altered habitat selection, and decreased awareness of predators.

4.5 Avoid Transporting Invasive Species or Transmitting Disease

Movement of water, vehicles or other equipment, or animals can spread invasive species or diseases to release sites. This can lead to loss or alteration of amphibian habitat, increased predation or competition, disease outbreaks, or negative effects on other species or habitats.

*See **Appendix 4: Disinfecting Equipment and Hygiene.***

4.6 Avoid Creating Habitat Attractive to Amphibians

Project activities can unintentionally create habitat that may be attractive to amphibians, and result in amphibians colonizing the project area. For example:

- Soils compacted by heavy equipment or excavations that fill from surface runoff or infiltration of groundwater can form waterbodies that may be attractive seasonal habitats for amphibians.
- Soils disturbed through mechanical or other means, or spoil piles created during excavating may attract species of amphibians that prefer loose, crumbly soils for burrowing.
- Removal of natural tree and shrub canopies may create preferred foraging habitat and movement corridors for some amphibian species.

Prevent amphibian colonization of project areas by adjusting project timing, altering methods or using barrier fences. Other important considerations for preventing amphibian colonization include:

- Avoid creating waterbodies near natural waterbodies used by amphibians. *See **Section 4.9.4 Holding Ponds and Other Constructed Waterbodies** for potential beneficial management practices.*
- Promote adequate drainage of runoff from rainfall or snowmelt from the project site.
- Planned drainage or fencing (*see **Appendix 5: Barrier Fences***) of waterbodies that may be used by breeding or overwintering amphibians should occur before they arrive in the spring or return in the fall to prevent colonization and allow amphibians to locate suitable habitat nearby.

4.7 Avoid creating barriers to amphibian movement

In the Prairie Provinces, amphibians can make long-distance seasonal movements between breeding, overwintering, and foraging habitats—some species of frogs or toads can disperse up to 10 kilometres (Smith and Green 2005). Excavations, roadways and other linear developments can be barriers to amphibian movement, and effort must be made to identify and preserve natural amphibian movement corridors (Dodd and Smith 2003).

To facilitate amphibian movement between seasonal habitats and prevent the need for translocation:

- Avoid conducting project activities in or near waterbodies, gullies and moist areas with lush vegetation that may be used as movement corridors. *Adhere to **Section 4.3: Observe Setback Distances***.
- Avoid moving cover objects such as logs, snags and other debris in movement corridors that may be used for refuge during terrestrial movements.
- Avoid creating excavations or trenches that may create barriers to amphibian movement, or *follow potential beneficial management practices in **Section 4.9.3: Excavations and Trenches***.

- Amphibians may experience high mortality on roadways constructed along natural movement corridors between their seasonal habitats or near waterbodies, during seasonal movements and rainy weather. Avoid building roads in amphibian habitat or *follow potential beneficial management practices in **Section 4.9.1: Roads***.
- Build crossing structures such as underpasses or culverts designed for amphibians and construct barrier fences to facilitate amphibian movement under roads or other barriers.

*See **Appendix 2: Additional Resources** for more information on beneficial management practices and mitigation*.

4.8 Wetland Creation

Wetland drainage can cause an immediate loss of habitat and a permanent loss of some species from the local ecological community. Establishing a wetland at a site where one did not previously exist is a wetland mitigation practice used in some jurisdictions to compensate for wetlands that are degraded or destroyed. However, creating new wetlands without connectivity to other habitats, or located beyond the limited dispersal abilities of the affected amphibians may not benefit those populations and created wetlands.

There is evidence that created wetlands may be beneficial to certain species of amphibians, but not others (Smith and Sutherland 2010). This may be because the created wetland fails to duplicate all aspects of a naturally occurring wetland, which are characterized by organic soils, complex hydrology, nutrients, vegetation, and animal life that have developed over many years. *See **Appendix 2: Additional Resources** for information on waterbody restoration and habitat management*.

4.9 Potential Project Impacts and Beneficial Management Practices

Project activities that may affect amphibians include building roads or other infrastructure, extracting resources, excavating, draining waterbodies, prescribed burning, growing crops and raising livestock. Below are some examples of how these project activities may affect amphibians and some potential Beneficial Management Practices (BMPs) to help mitigate these effects.

4.9.1 Roads

Potential Project Impacts	Potential Beneficial Management Practices
Construction of new roads may cause loss or alteration of amphibian habitat. Roads can change surface and subsurface hydrology, reducing suitable amphibian breeding and overwintering habitat. Erosion from the surface or shoulder of unsealed roads can release sediment into nearby waterbodies, affecting aquatic amphibian species or life stages.	Use existing roads, trails, or cut lines to avoid additional disturbances to amphibian habitat (Pilliod and Wind 2008). Deactivate roads that are no longer needed (Pilliod and Wind 2008). Avoid placing roads in areas of amphibian habitat by adhering to setback distances.[1] Maintain healthy riparian zones.[2]
Vehicle noise from roads may cause changes to amphibian breeding behaviour such as chorus behaviour, call rate, and site selection.	Avoid placing roads in areas of amphibian habitat by adhering to setback distances.[1]
Road salt, dust control agents, fuels, lubricants and other contaminants from road surface runoff can enter nearby soil and waterbodies, resulting in chemical exposure for amphibians. The accidental release of fuels, lubricants, hydraulic fluids, coolant, and other substances from equipment and machinery during construction or maintenance of roads can pollute habitat used by amphibians.	Minimize the use of chemicals on or along roadways (Pilliod and Wind 2008). Quickly contain any spills and follow spill response plan. Maintain healthy riparian zones.[2] Avoid placing roads in areas of amphibian habitat. Adhere to setback distances.[3]
Roads can divide amphibian habitats, influencing amphibian life cycles, predation risk, dispersal and colonization success, and gene flow (Andrews et al. 2008).	Time road construction for when amphibians are not present or least likely to be encountered (Pilliod and Wind 2008).[3]

Amphibians may accidentally be injured or killed on roads by passing vehicles or road construction equipment during seasonal movements, or if they are attracted to the road. Amphibians are more likely to cross roads that separate seasonal habitats. Amphibians on or along roads may be at increased risk of predation. Road surfaces that retain heat may attract amphibians as substrates for thermoregulation. Road surfaces with insufficient drainage or that allow the accumulation of water along road-edges can also provide habitat attractive to amphibians.	Avoid placing roads between seasonal habitats to prevent amphibians from crossing road during seasonal movements. Temporarily close roads during seasonal movements (Pilliod and Wind 2008). Install barrier fences or crossing structures to prevent amphibians from crossing road surfaces (Pilliod and Wind 2008). Install road signs to warn motorists of the presence of amphibians and caution motorists to reduce speed (Pilliod and Wind 2008). Ensure that roads have sufficient drainage and that water does not accumulate in ditches to avoid attracting amphibians to roads. Dark road surfaces and those exposed to sunlight collect more solar energy and retain heat. If possible, avoid creating roads with these characteristics by creating roads with lighter surfaces or shaded by trees.
Vehicles and other equipment, can spread invasive plant or animal species, or diseases. This can lead to loss or alteration of amphibian habitat, increased predation or competition, negative effects on other species, or disease outbreaks.	Avoid transporting invasive species or disease. [4]
Construction or maintenance of culverts or bridges may lead to erosion and sedimentation, chemical exposure, or interfere with daily or seasonal movements.[5]	Follow BMPs for culverts and bridges[5]

1. *See **Section 4.3: Observe Setback Distances***
2. *See **Section 4.2: Maintain Healthy Riparian Zones***
3. *See **Section 4.1: Timing and Location of Project Activities***
4. *See **Appendix 4: Disinfecting Equipment and Hygiene***
5. *See **Section 4.9.2: Culverts or Bridges***

4.9.2 Culverts or Bridges

Potential Project Impacts	Potential Beneficial Management Practices
Increased water velocity downstream from culverts and loss of riparian vegetation near culverts and bridges can cause erosion and release of sediment into waterbodies, affecting aquatic amphibian species or life stages.	Avoid placing culverts in areas of amphibian habitat by adhering to setback distances.[1] Maintain natural hydroperiod and natural surface water pathways and flow rates to avoid causing erosion and release of sediment into waterbodies. Install effective erosion and sediment controls, bank and bed protection such as silt fence and swamp mat before beginning the work, and maintain these interventions until work is completed or riparian vegetation has re-established. Maintain healthy riparian zones.[2]
Accidental release of fuels, lubricants, hydraulic fluids, coolant, and other substances from equipment and machinery during installation, removal, or maintenance of culverts and bridges can pollute habitat used by amphibians.	Maintain healthy riparian zones.[2] Time construction or maintenance of culverts or bridges for when amphibians are not present or least likely to be encountered.[3]
Construction equipment can accidentally injure or kill amphibians.	Time construction or maintenance of culverts or bridges for when amphibians are not present or least likely to be encountered.[2] Install barrier fences or crossing structures to prevent amphibians from being injured or killed by construction equipment (Pilliod and Wind 2008).
Vehicles and other equipment can spread invasive plant or animal species, or diseases. This can lead to loss or alteration of amphibian habitat, increased predation or competition, negative effects on other species, or disease outbreaks.	Avoid transporting invasive species or spreading disease.[4]
Culverts with heavy water flow or blocked by debris or vegetation can be	Build culverts specifically designed for amphibian movement, if required.

barriers for amphibian dispersal and migration. Sudden removal of blockages can cause release of water and flooding in downstream areas, which may strand or transport aquatic species or life stages of amphibians.	Maintain culverts in good condition or avoid constructing culverts in areas of amphibian habitat. Gradually remove debris and other materials to prevent flooding and reduce the amount of sediment-laden water going downstream. Time maintenance of culverts for when amphibians are not present or least likely to be encountered.[2]
Rock used for reinforcing and armoring may be dirty or acid generating.	Obtain rock from above the high-water level and choose rock that is clean and non-acid generating

1. *See **Section 4.3: Observe Setback Distances***
2. *See **Section 4.2: Maintain Healthy Riparian Zones***
3. *See **Section 4.1: Timing and Location of Project Activities***
4. *See **Appendix 4: Disinfecting Equipment and Hygiene***

4.9.3 Excavations and Trenches

Potential Project Impacts	Potential Beneficial Management Practices
Excavations or trenches for underground infrastructure or utilities can change surface and subsurface hydrology, reducing suitable amphibian breeding and overwintering habitat. Excavations and trenches can create areas of standing water and sink habitat attractive to breeding or overwintering amphibians.[3]	Avoid placing excavations and trenches in areas of amphibian habitat by adhering to setback distances.[1] Maintain healthy riparian zones.[2] Prevent accumulation of water in excavations and trenches to avoid creating sink habitat.[3] Time project activities for when amphibians are not present or least likely to be encountered.[4] Use barrier fencing to prevent amphibian colonization of excavations and trenches.[5]
Construction equipment can accidentally injure or kill amphibians.	Time construction activities for when amphibians are not present or least likely to be encountered.[4]

	Install barrier fences or crossing structures to prevent amphibians being injured or killed by construction equipment (Pilliod and Wind 2008).
Vehicles and other equipment can spread invasive plant or animal species, or diseases. This can lead to loss or alteration of amphibian habitat, increased predation or competition, negative effects on other species, or disease outbreaks.	Avoid transporting invasive species or spreading disease.[6]
Excavations and trenches can divide amphibian habitats, which can influence amphibian life cycles, dispersal and colonization success, and gene flow (Andrews et al. 2008). Holes or excavations may trap amphibians resulting in injury or death or interfering with daily or seasonal movements.	Avoid excavating in areas of amphibian habitat or between amphibian seasonal habitats. Adhere to setback distances.[1] Avoid steep-sided excavations or trenches, or provide escape ramps to prevent trapping amphibians. Time project activities for when amphibians are not present or least likely to be encountered.[4] Use barrier fencing to prevent amphibians from falling into excavations or trenches.
Accidental release of fuels, lubricants, hydraulic fluids, coolant, and other substances from equipment and machinery used for excavating or constructing trenches can pollute habitat used by amphibians.	Time project activities for when amphibians are not present or least likely to be encountered.[4] Quickly contain any spills and follow spill response plan.

1. *See **Section 4.3: Observe Setback Distances***
2. *See **Section 4.2: Maintain Healthy Riparian Zones***
3. *See **Section 4.9.4: Holding Ponds and Other Constructed Waterbodies***
4. *See **Section 4.1: Timing and Location of Project Activities***
5. *See **Appendix 5: Barrier Fences***
6. *See **Appendix 4: Disinfecting Equipment and Hygiene***

4.9.4 Holding Ponds and Other Constructed Waterbodies

Potential Project Impacts	Potential Beneficial Management Practices
Ditches, dams, dugouts, storm water, or other holding ponds can change surface and subsurface hydrology, reducing suitable amphibian breeding and overwintering habitat. Amphibians may be attracted to settling ponds with harmful chemicals. Amphibians may attempt to breed in temporary waterbodies that may not allow enough time for larva to complete their metamorphosis.	Avoid constructing holding ponds and other constructed waterbodies in areas of amphibian habitat by observing setback distances.[1] Maintain natural surface water pathways and flow rates to avoid causing erosion and release of sediment into waterbodies and maintain natural hydroperiod. Maintain healthy riparian zones.[2] Time project activities for when amphibians are not present or least likely to be encountered.[3] Avoid the use of harmful chemicals in holding ponds or other constructed waterbodies. Use barrier fencing to prevent amphibians from colonizing holding ponds and other constructed waterbodies.[4]
Vehicles and other equipment can spread invasive plant or animal species, or diseases. This can lead to loss or alteration of amphibian habitat, increased predation or competition, negative effects on other species, or disease outbreaks.	Avoid transporting invasive species or spreading disease.[5]
Constructed waterbodies with steep sides and that lack escape ramps may trap amphibians, causing injury or death by drowning or starvation, and may interfere with daily or seasonal movements.	Use barrier fencing to prevent amphibians from accessing steep-sided holding ponds and other constructed waterbodies, or provide escape ramps.[4]

1. *See **Section 4.3: Observe Setback Distances***
2. *See **Section 4.2: Maintain Healthy Riparian Zones***
3. *See **Section 4.1: Timing and Location of Project Activities***
4. *See **Appendix 5: Barrier Fences***
5. *See **Appendix 4: Disinfecting Equipment and Hygiene***

4.9.5 Waterbody Drainage

Potential Project Impacts	Potential Beneficial Management Practices
The loss of waterbody features that act as movement corridors (e.g., creeks and streams) may reduce habitat connectivity, influencing amphibian life cycles, dispersal and colonization success, and gene flow (Andrews et al. 2008). Draining, redirecting or changing water levels in basins or channels can change surface and subsurface hydrology, reducing suitable amphibian breeding and overwintering habitat.	Avoid draining waterbodies and observe setback distances.[1] Maintain natural surface water pathways and flow rates to avoid causing erosion and release of sediment into waterbodies and maintain natural hydroperiod. Maintain healthy riparian zones.[2] Time waterbody drainage for when amphibians are not present or least likely to be encountered.[3] If there is alternate available habitat in the area, install barrier fencing before seasonal movements to breeding or overwintering habitats begin, to prevent amphibians from colonizing waterbodies that will be drained.[4] Establish a waterbody at a site where one did not previously exist to compensate for wetlands that are degraded or destroyed.[5]
Vehicles and other equipment can spread invasive plant or animal species, or diseases. This can lead to loss or alteration of amphibian habitat, increased predation or competition, negative effects on other species, or disease outbreaks.	Avoid transporting invasive species or spreading disease.[6]
Aquatic amphibian species or life stages may be injured or killed by changing water levels, or by equipment used during waterbody drainage.	Time waterbody drainage for when amphibians are not present or least likely to be encountered.[3] Use barrier fencing before seasonal movements to breeding or overwintering habitats begin to prevent amphibians from colonizing waterbodies that will be drained.[4] Adjust methods to minimize risk of amphibian injury or death.

1. *See **Section 4.3: Observe Setback Distances***

2. See **Section 4.2: Maintain Healthy Riparian Zones**
3. See **Section 4.1: Timing and Location of Project Activities**
4. See **Appendix 5: Barrier Fences**
5. See **Section 4.8: Wetland Creation**
6. See **Appendix 4: Disinfecting Equipment and Hygiene**

4.9.6 Agriculture

Potential Project Impacts	Potential Beneficial Management Practices
Converting natural habitat for agriculture, overgrazing and other agricultural practices may cause loss or alteration of amphibian habitat. High-intensity grazing may decrease vegetation and litter, resulting in increased predation and increased drying of the soil making it more difficult for amphibians to travel far from waterbodies. Using farm equipment in or near waterbodies, or allowing livestock access to waterbodies or riparian areas, can cause erosion and release sediment into waterbodies, affecting aquatic amphibian species or life stages. Removal of riparian vegetation due to farming activities or by grazing livestock can lead to increased predation and reduced prey availability for amphibians, and the loss or alteration of breeding habitat and sites to lay eggs.	Avoid agricultural activities in areas of amphibian habitat by adhering to setback distances, if possible.[1] Maintain healthy riparian zones.[2] Time agriculture activities for when amphibians are not present or least likely to be encountered, if possible.[3] Use livestock fences to restrict livestock access to waterbodies used by amphibians. It is particularly important to restrict access during the breeding season, or until larvae reach metamorphosis, or to limit duration or intensity of use (Pilliod and Wind 2008).[4] Leave riparian areas ungrazed or maintain vegetation above 10-20 cm (Pilliod and Wind 2008). Provide off-site watering sources for livestock.
Vehicles and other equipment can spread invasive plant or animal species, or diseases. This can lead to loss or alteration of amphibian habitat, increased predation or competition, negative effects on other species, or disease outbreaks.	Avoid transporting invasive species or disease.[5]
Agricultural equipment or vehicles can accidentally injure or kill amphibians.	Time agriculture activities for when amphibians are not present or least likely to be encountered, if possible.[3]

	Install barrier fences or crossing structures to prevent amphibians being injured or killed by agricultural equipment (Pilliod and Wind 2008).
Agrochemicals such as herbicides, pesticides, and fertilizers can accumulate through runoff in waterbodies used by amphibians. These substances and may be toxic to amphibians, or degrade into compounds that disrupt development or reproduction. Fertilizers and manure produced by livestock can increase nutrient levels in waterbodies, which can lower water quality and increase parasitic infection and disease risks for amphibians. Applying pesticides can reduce the abundance and diversity of invertebrate prey of amphibians.	Limit use of agrochemicals in amphibian habitat, particularly in the breeding or active season, and adhere to setback distances.[1,3] Restrict livestock access to waterbodies using fencing. Seasonally restricting access during the breeding season, or limiting duration or intensity of use, may be sufficient to reduce negative effects (Pilliod and Wind 2008).[4]
Salt blocks for livestock can contaminate nearby waterbodies, affecting aquatic amphibian species or life stages.	Adhere to setback distances.[1]
Livestock may trample amphibians, or their eggs and larva. Livestock may cause pugging on the edge of wetlands, creating holes that can trap larvae and other small amphibians.	Use livestock fences to restrict livestock access to waterbodies used by amphibians. It is particularly important to restrict access during the breeding season, or limit the duration and intensity of use (Pilliod and Wind 2008).[4]
Constructing roads for agriculture may cause injury, death, loss or alteration of habitat, exposure to chemicals, interfere with daily or seasonal amphibian movement, or cause changes to behaviour.[5]	Avoid constructing roads in areas of amphibian habitat or follow beneficial management practices in Section 4.9.1: Roads.[5]
Excavations or trenches for agriculture infrastructure may cause injury, death, loss or alteration of habitat, exposure to chemicals, interfere with daily or seasonal amphibian movement, or changes to behaviour.[6]	Avoid excavations or trenches in areas of amphibian habitat or follow beneficial management practices in Section 4.9.3: Excavations and Trenches.[7]

Creating dugouts for irrigation of crops or watering livestock may create sink habitat attractive to amphibians. This may lead to loss or alteration of habitat, trap amphibians causing injury or death, or otherwise interfere with daily or seasonal movements.[7]	Avoid creating waterbodies that are sink habitat that may inadvertently attract amphibians or follow beneficial management practices in Section 4.9.4: Holding Ponds and Other Created Waterbodies.[8]
Draining waterbodies can cause loss or alteration of habitat, injure or kill amphibians, or interfere with daily or seasonal movements.[8]	Avoid draining waterbodies or follow beneficial management practices in Section 4.9.5: Waterbody Drainage.[9]
Construction or maintenance of culverts or bridges may lead to erosion and sedimentation, chemical exposure, or interfere with daily or seasonal movements.[9]	Avoid constructing culverts or bridges in areas of amphibian habitat or follow beneficial management practices in Section 4.9.2: Culverts or Bridges.[10]

1. **See Section 4.3: Observe Setback Distances**
2. **See Section 4.2: Maintain Healthy Riparian Zones**
3. **See Section 4.1: Timing and Location of Project Activities**
4. **See Appendix 5: Barrier Fences**
5. **See Appendix 4: Disinfecting Equipment and Hygiene**
6. **See Section 4.9.1: Roads**
7. **See Section 4.9.3: Excavations and Trenches**
8. **See Section 4.9.4: Holding Ponds and Other Constructed Waterbodies**
9. **See Section 4.9.5: Waterbody Drainage**
10. **See Section 4.9.2: Culverts or Bridges**

4.9.7 Timber Harvest

Potential Project Impacts	Potential Beneficial Management Practices
Removing trees may cause changes to surface and subsurface hydrology, reducing suitable amphibian breeding sites and other habitats. Removing trees or other vegetation may create drier conditions with more variable temperature. Damage or loss of wet meadows, grassy areas or riparian areas may lead to reduced habitat connectivity, interfering with daily or seasonal amphibian movements.	Avoid timber harvest activities in areas of amphibian habitat such as wet meadows, grassy areas, or riparian areas, if possible. Leave wooded buffer surrounding breeding ponds. Adhere to setback distances.[1] Maintain healthy riparian zones.[2] Time project activities for when amphibians are not present or least likely to be encountered.[3]

Removing riparian vegetation may lead to erosion and release sediment into waterbodies, affecting aquatic amphibian species or life stages. Damage or loss of upland amphibian foraging habitat may result in reduced abundance and diversity of prey. Loss of cover objects such as logs, stumps, or other coarse woody debris may result in a loss of overwintering habitat or refuges during hot, cold, or dry conditions for amphibians.	Retain cover objects such as logs, stumps, or other coarse woody debris.
Amphibians may seek cover under brush piles and die if they are moved or burned.	Avoid constructing brush piles, burn immediately, or leave unburned as refuges for amphibians (MWPARC 2009).
Using forestry equipment in areas of amphibian habitat can cause soil compaction or erosion and sedimentation.	Avoid forestry activities in areas of amphibian habitat by adhering to setback distances, if possible.[1] Maintain healthy riparian zones.[2]
Forestry equipment or vehicles may accidentally injure or kill amphibians.	Time project activities for when amphibians are not present or least likely to be encountered.[3] Install barrier fences or crossing structures to prevent amphibians being injured or killed by forestry equipment (Pilliod and Wind 2008).
Vehicles and other equipment can spread invasive plant or animal species, or diseases. This can lead to loss or alteration of amphibian habitat, increased predation or competition, negative effects on other species, or disease outbreaks.	Avoid transporting invasive species or spreading disease.[4]
Constructing and using haul roads may cause injury, death, loss or alteration of habitat, exposure to chemicals, changes to behaviour, or interfere with daily or seasonal amphibian movement.[5]	Avoid constructing roads in areas of amphibian habitat or follow beneficial management practices in ***Section 4.9.1: Roads***.[5]

1. *See **Section 4.3: Observe Setback Distances***
2. *See **Section 4.2: Maintain Healthy Riparian Zones***
3. *See **Section 4.1: Timing and Location of Project Activities***
4. *See **Appendix 4: Disinfecting Equipment and Hygiene***
5. *See **Section 4.9.1: Roads***

4.9.8 Prescribed Burning

Potential Project Impacts	Potential Beneficial Management Practices
Prescribed burning to control invasive weeds, regenerate successional stages, or protect forest resources or urban developments may lead to habitat loss or alteration. Burning in upland foraging habitat may reduce insect prey abundance and diversity. Burning vegetation can increase nutrient levels, lower water quality, and increase parasitic infection and disease risks for amphibians. Burning cover objects such as logs, stumps, or other coarse woody debris may result in a loss of overwintering habitat or refuges during hot, cold, or dry conditions for amphibians. Burning riparian vegetation may cause erosion and release of sediment into waterbodies, affecting aquatic amphibian species or life stages. Prescribed burning may damage wet meadows, grassy areas, or riparian areas, leading to reduced habitat amphibian connectivity. Burning coarse woody debris or other cover objects may interfere with daily or seasonal movements.	Avoid prescribed burning in areas of amphibian habitat, if possible. Adhere to setback distances.[1] Maintain healthy riparian zones.[2] Time prescribed burning for when amphibians are not present or least likely to be encountered.[3] Avoid prescribed burns in wet meadows, grassy areas, or riparian areas that may be movement corridors. Avoid burning cover objects such as logs, stumps or other coarse woody debris.

Prescribed burning, burning brush piles or burning other coarse woody debris may cause direct injury or death to amphibians.	Time prescribed burning for when amphibians are not present or least likely to be encountered.[3] Avoid constructing brush piles, which may attract amphibians, burn brush piles immediately, or leave piles unburned to act as refuges (MWPARC 2009). Avoid burning cover objects (e.g., logs, stumps, or other coarse woody debris).
Fire retardants may contain chemicals that can negatively affect amphibians (Hoover et al. 2017).	Avoid using fire retardants in areas of amphibian habitat. Adhere to setback distances.[1]

1. *See **Section 4.3: Observe Setback Distances***
2. *See **Section 4.2: Maintain Healthy Riparian Zones***
3. *See **Section 4.1: Timing and Location of Project Activities***

4.9.9 Resource Extraction, Renewable Energy, and Other Projects

Potential Project Impacts	Potential Beneficial Management Practices
Mining, oil and gas, solar and wind farm, or hydroelectric project activities, may lead to loss or alteration of amphibian habitat. Polluted surface water can result from spills or leaks of lubricants, and other potentially toxic substances. Amphibians with access to tailings ponds may be exposed to toxic substances. Project activities may reduce numbers of burrowing animals or cause burrows to collapse, leading to a loss of refuge or overwintering habitat.	Avoid project activities in areas of amphibian habitat by adhering to setback distances, if possible.[1] Maintain healthy riparian zones.[2] Quickly contain any spills and follow spill response plan. Time project activities for when amphibians are not present or least likely to be encountered, if possible.[3] Construct barrier fencing around projects to prevent amphibians from colonizing project areas.[4]
Hydroelectric projects may lead to changes in surface and subsurface hydrology, causing erosion and release of sediment into waterbodies, or flooding or draining of amphibian habitat.	Avoid construction of hydroelectric projects in areas of amphibian habitat by adhering to setback distances, if possible.[1]

	Maintain natural surface water pathways and flow rates to avoid causing erosion and release of sediment into waterbodies and to maintain natural hydroperiod.
Project equipment or vehicles may accidentally injure or kill amphibians.	Time project activities for when amphibians are not present or least likely to be encountered.[3] Install barrier fences or crossing structures to prevent amphibians being injured or killed by project equipment (Pilliod and Wind 2008).
Vehicles and other equipment can spread invasive plant or animal species, or diseases. This can lead to loss or alteration of amphibian habitat, increased predation or competition, negative effects on other species, or disease outbreaks.	Avoid transporting invasive species or spreading disease.[5]
Solar, windfarm, oil and gas, and other projects can result in the removal of vegetation, leading to drier conditions and loss of amphibian movement corridors.	Avoid project activities or removing vegetation in areas of amphibian habitat by adhering to setback distances, if possible.[1]
Solar panels may attract aquatic insects and be mistaken for bodies of water (Horváth et al. 2010). This can lead to altered prey abundance for amphibians.	Avoid project activities in areas of amphibian habitat by adhering to setback distances, if possible.[1] Consider using solar cells with non-polarizing white borders and white grates (Horváth et al. 2010).
Constructing roads for resource extraction, renewable energy, and other projects may cause injury, death, loss or alteration of habitat, exposure to chemicals, interfere with daily or seasonal amphibian movement, or cause changes to behaviour.[5]	Avoid constructing roads in areas of amphibian habitat or follow the beneficial management practices in ***Section 4.9.1: Roads***.[6]
Excavations or trenches for resource extraction, renewable energy, and other projects may cause injury, death, loss or alteration of habitat, exposure to chemicals, changes to behaviours, and may interfere	Avoid excavations or trenches in areas of amphibian habitat or follow the beneficial management practices in ***Section 4.9.3: Excavations and Trenches***.[7]

with daily or seasonal amphibian movement.[6]	
Ditches, dams, dugouts, storm water, or other holding ponds can cause loss or alteration of habitat, attract amphibians to sink habitat, and may trap or otherwise interfere with daily or seasonal amphibian movements.[7]	Avoid creating waterbodies that are sink habitat that may inadvertently attract amphibians, or follow the beneficial management practices in ***Section 4.9.4: Holding Ponds and Other Created Waterbodies***.[8]
Draining waterbodies can cause loss or alteration of habitat, injure or kill amphibians, or interfere with daily or seasonal movements.[8]	Avoid draining waterbodies or follow the beneficial management practices in ***Section 4.9.5: Waterbody Drainage***.[9]
Construction or maintenance of culverts or bridges may lead to erosion and sedimentation, chemical exposure, or interfere with daily or seasonal movements.[9]	Avoid constructing culverts or bridges in areas of amphibian habitat or follow the beneficial management practices in ***Section 4.9.2: Culverts or Bridges***.[10]

1. *See **Section 4.3: Observe Setback Distances***
2. *See **Section 4.2: Maintain Healthy Riparian Zones***
3. *See **Section 4.1: Timing and Location of Project Activities***
4. *See **Appendix 5: Barrier Fences***
5. *See **Appendix 4: Disinfecting Equipment and Hygiene***
6. *See **Section 4.9.1: Roads***
7. *See **Section 4.9.3: Excavations and Trenches***
8. *See **Section 4.9.4: Holding Ponds and Other Constructed Waterbodies***
9. *See **Section 4.9.5: Waterbody Drainage***
10. *See **Section 4.9.2: Culverts or Bridges***

4.10 Holding and Release

If the disturbance is less than five days and the habitat remains suitable after the disturbance, it may be possible to avoid translocation by temporarily holding and releasing amphibians into the same area once project activities are complete.

Due to concerns about feeding and maintaining appropriate holding conditions, do not hold captive animals for periods longer than five days, unless cared for in a licensed facility, such as a wildlife rehabilitation facility, university-run Canadian Council on Animal Care (CCAC)-approved animal care facility, or a zoo accredited by the Canadian Association of Zoos and Aquariums (CAZA). Check with your provincial regulator for approved facilities.

*See **Appendix 8: Transporting and Holding Amphibians.***

5 Mitigation Translocation Risks and Challenges

Mitigation translocation is not without risk—the practice can result in injury, death, stress, and exposure to pathogens for the translocated animals or for other animals at release locations. Once released, amphibians may disperse from the release site or return to the project area, or may face increased competition, predation, or genetic incompatibility with naturally occurring conspecific or sympatric species at the site. Released amphibians could also die if the habitat at the release site is unsuitable or disconnected from other required habitats.

5.1 Risks to Individuals

Animal Welfare

Stress can reduce the fitness of translocated individuals by interfering with reproduction, increasing disease susceptibility and risk of predation, increasing risk of starvation and dispersal from the release site (Teixeira et al. 2007, Dickens et al. 2010).

Improper capture, containment, transportation, or release methods may also result in injury or death of amphibians. (*See* ***Section 9: Mitigation Translocation Procedures*** *for information on appropriate capture methods*).

Examples of risks to individuals:

- Aquatic amphibians and life stages may be sensitive to differences in water temperature, pH, dissolved oxygen, and salinity between source and release sites. Sudden changes in temperature can result in death.
- Terrestrial life-stages are at risk of desiccation and death if not transported with water or kept moist.
- Larvae have delicate bodies that are susceptible to injury during capture and handling.
- Individuals of different sizes or different species may injure or kill each other if transported or held in the same container.
- Newly released individuals may experience higher rates of predation or exposure due to unfamiliarity with the release location (Fischer and Lindenmayer 2000).

Exposure to Novel Pathogens or Parasites

Amphibians at the source or release site may carry novel diseases or parasites that could pose significant risks to translocated or resident amphibians, or other susceptible species that have little resistance to novel pathogens. The presence of a pathogen or parasite may not affect the translocation decision if the same strain of pathogen or species of parasite is present at both the source and release site.

See ***Section 9.1: Preventing Disease Transmission****, for examples of amphibian diseases.*

Reusing or improperly disinfecting equipment, transporting multiple animals together, and releasing water used in translocations can spread disease among individuals and between locations. Stress caused by translocation can also increase the risk of disease transmission and the severity of infection (Teixeira et al. 2007, Sainsbury and Vaughan-Higgins 2012).

*See **Appendix 4: Disinfecting Equipment and Hygiene** and **Section 9.3: Handling and Hygiene** for more information on prevention of disease transmission**.***

Unsuitable Habitat or Lack of Habitat Connectivity

Many amphibian translocations fail because the release site lacks suitable quality, quantity or connectivity of habitat to meet the needs of all life stages (Germano and Bishop 2009).

- **HABITAT:** If the waterbody lacks appropriate food or the water temperature is too cold, larval development may slow and metamorphosis may be delayed, which can reduce survival (Álvarez and Nicieza 2002, Altwegg and Reyer 2003). Many amphibian species require a diversity of habitats to meet their life-history requirements. Release sites that lack habitat for all-life stages are unsuitable.
- **HYDROPERIOD, WATER DEPTH AND FLOODING:** Amphibian species have different hydroperiod requirements—the number of days a pond is flooded annually (Paton and Crouch 2002). If a waterbody's hydroperiod is too short, eggs or larvae may become stranded and die before reaching hatching or metamorphosis. If water depth is insufficient, overwintering aquatic amphibians may freeze or water may become anoxic and amphibians may die of a lack of oxygen. Waterbodies that are prone to flooding can wash eggs and larvae away or force them into deeper, cooler water, slowing their development and making them more susceptible to predators.
- **INCOMPATIBLE LAND USES:** Amphibians can be sensitive to environmental contaminants from incompatible land uses which could pose risks to individuals and populations. Land uses such as agriculture and other types of development can degrade habitat and reduce habitat connectivity. For example, biocides or nitrogen pollution from agricultural runoff, and effluent from industrial wastes can have lethal and sub-lethal effects on amphibians (Rouse et al. 1999). Release sites should be distant from areas with incompatible land uses or areas of unsuitable habitat which could be sink habitat (i.e. not within the dispersal distance for the species) or should be inaccessible to amphibians.
- **METAPOPULATIONS**: Many amphibian populations are thought to function as metapopulations, in which isolated subpopulations are connected by occasionally dispersing individuals (Smith and Green 2005). Each subpopulation has a likelihood of extinction, but because of connectivity among subpopulations through dispersal and migration, subpopulations may persist at the regional level of the metapopulation. For this reason, activities that lead to habitat fragmentation or disrupt movement corridors can interfere with dispersal, and negatively affect populations.

Inopportune Timing or Conditions

- **TEMPERATURE:** Amphibians are ectothermic, meaning that they cannot internally regulate their body temperature. Amphibians may be lethargic and unable to escape from predators or seek cover or die if temperatures are outside their seasonal thermal tolerance.

- **DESICCATION:** The skin of most amphibians is thin and moist, and permeable to water and respiratory gases (Hillman et al. 2009). Although toads have slightly thicker skin and are better able to conserve water than frogs and salamanders, amphibian skin is prone to desiccation, which may also interfere with an individual's ability to disperse or seek cover, if exposed to conditions that are dry and windy (Russell and Bauer 2000). Aquatic species or life stages are more vulnerable than terrestrial species to desiccation and may be unable to breathe if dry.
- **SEASON**: Moving amphibians during the breeding season may disrupt breeding behaviour, and could result in reduced recruitment for that year. Amphibians that require very specific overwintering habitats may be unable to locate suitable overwintering habitat if moved late in the fall. *See* ***Section 8.1.1: Timing of Translocation and Amphibian Life Stage and Section 9.7: Winter Translocation.***

Homing and Dispersal

In a review of amphibian translocation projects, homing and dispersal from the release site was identified as one of the major causes of translocation failure (Germano and Bishop 2009). Many species of amphibians demonstrate high site-fidelity to breeding and overwintering sites and may attempt to return to their capture location if displaced (Dole 1968, Sinsch 1990). Amphibians that manage to return to the project area may be at risk from project activities. Amphibians may also die attempting to return to the project area if the intervening habitat matrix is inhospitable or the distance is too great. Alternately, animals may become disoriented and disperse to unsuitable habitat if released at an unfamiliar site.

5.2 Risks to Populations

Genetic Risks

Translocation may lead to inbreeding if the founder population is small and the release site is unoccupied and geographically isolated from other source populations, resulting in loss of genetic variation (Simberloff 1988, Dodd and Seigel 1991). Populations separated by geographic distance or barriers to dispersal or those adapted to local environments may be genetically differentiated. Breeding between genetically differentiated populations may result in reduced fitness of offspring and possible population extinction (Simberloff 1988). There has been little research into the genetic structuring of amphibian populations in the Prairie Provinces, but a study of northern leopard frogs (*Lithobates pipiens*) suggests that there was no significant relationship between geographic and genetic distance for populations of this species (Wilson et al. 2008). Even with sufficient genetic diversity, translocations that involve small numbers of individuals are more likely to fail to establish new populations (Germano and Bishop 2009).

It has been suggested that amphibian populations that are separated by distances less than 10 kilometres are unlikely to be genetically differentiated (Gibbs and Reed 2008). Because mitigation translocations are generally short distance (less than 10 kilometres), genetic risks are not likely to be a major concern.

Negative Interactions among Populations or Species

Competition for limited habitat or food can lead to the failure of translocation projects (Germano and Bishop 2009). Translocated individuals may be in direct competition with resident conspecifics, leading to a net loss of individuals or populations if the source habitat is destroyed. Translocation can also accidentally introduce invasive plant or animal species to new locations, which may negatively affect populations or species at the release site.

Social Feasibility

Although releasing amphibians within their natural range is unlikely to have a direct negative impact on people or their livelihoods, there are potential legal implications of moving at-risk species (Government of Canada 2013). If amphibians are released in locations not owned by the proponents or where they were not previously found, stakeholder and adjacent landowners should be supportive and permissions obtained (IUCN/SSC 2013). It is advisable to have agreements or conservation easements in place so that incompatible land uses will not negatively affect the release site. Social feasibility is not likely to be a concern if the translocation is short-distance and the proponent owns the property.

5.3 Low Success Rates

Although the objectives of human-mediated movements of amphibians for conservation and mitigation purposes are often different, challenges to their successful outcomes are often similar. The most commonly cited causes of failure for amphibian conservation translocations are inadequate habitat at the release site and failure of relocated amphibians to stay at the release site after translocation (Rathbun and Schneider 2001, Germano and Bishop 2009).

Translocation outcomes are rarely adequately assessed and, where evaluated, failure rates are high. Fewer than 40% of conservation translocations of amphibians that have been reported in the literature are considered successful (i.e., a self-sustaining population has been established) (Dodd and Seigel 1991, Seigel and Dodd 2002, Germano and Bishop 2009).

Success rates for mitigation translocations may be low compared to conservation translocations because the latter are typically conducted by well-organized and well-funded recovery programs that follow standard translocation guidelines (e.g. IUCN/SSC 2013), and usually involve the movement of larger numbers of animals over multiple years (Sullivan et al. 2015). However, the goals of mitigation translocations may be different from conservation translocations if the purpose is to prevent individual mortality rather than to establish a new population. A well-designed plan for follow-up monitoring and reporting is essential to understand the reasons for failure and to improve future translocation success. *See* ***Section 10: Post-Release Monitoring and Reporting***.

6 Select Potential Release Sites

Locating appropriate habitat for amphibians in new areas can be challenging, and requires important consideration in the early planning stages of any translocation. The release site should consist of a matrix of suitable habitats that meet the needs of all life stages of the target species translocated.

It is important to ensure that suitable quantity, quality, and connectivity of habitats is available to meet all life-history requirements. Seasonal habitats should be as proximate as possible, or at least within the natural seasonal migration distance for the species. *See* ***Appendix 3: Amphibian habitat and dispersal.***

6.1 Location of release sites

Release sites should be (in order of preference):

- Located in the nearest available suitable habitat outside the area impacted by the project. Source and release sites should be less than 350 m apart to reduce risk of transmitting disease among sites (Gray et al. 2017).
- Located within the seasonal migration distance of the source site so that local population dispersal, colonization and recolonization patterns are preserved as much as possible. If species-specific seasonal migration distances are unknown, seasonal migrations are generally not greater than 500 metres for salamanders or 1,500 metres for most frogs and toads (Sinsch 1990, Russell et al. 2005).
- If habitat is unavailable within the seasonal migration distance, move individuals only as far as their maximum dispersal distance (*see* ***Appendix 3: Amphibian habitat and dispersal***).
- Located within the same drainage or habitat corridor and within 10 km of source sites to maintain genetic boundaries and reduce disease risk (Gibbs and Reed 2008). Some species may be moved further if it is known that populations are genetically compatible, and habitat, and disease concerns have been addressed.

Contact government regulators to discuss the location of release sites. If the release site is located beyond the seasonal migration or dispersal distance of the species, genetics may need to be considered and disease testing conducted. If there are no release sites that meet the above criteria, there may be an opportunity to collaborate with recovery teams to move species-at-risk for use in conservation-oriented reinforcements or reintroductions.

Release sites must be located within the historic range of the species (IUCN/SSC 2013).

6.2 Food Sources

Food availability at the release site is important, but difficult to assess because amphibian diets vary by species, size of individual, and life stage.

Larval amphibian diets are highly variable, depending on the species—many are herbivores, eating bacteria and algae, but some are omnivorous, carnivorous or exhibit opportunistic cannibalism (McWilliams 2008). Small-bodied (and mouthed) sub-adult and adult amphibians tend to eat small insects and other invertebrates, whereas larger amphibians eat larger invertebrates or even small vertebrates (Pough 2001).

In the absence of good information regarding food availability, it is reasonable to assume that if the release site possesses adequate and pesticide and herbicide-free habitat for amphibians, it also possesses adequate habitat for their food sources.

6.3 Waterbody Complexes

Waterbody complexes are preferable to isolated ponds as release sites because they are more likely to provide reliable habitat during dry years because some waterbodies in the complex may still have water to support the entire life cycle of the species (Petranka et al. 2007). Release sites should have other suitable waterbodies nearby with adequate connectivity to support metapopulations (Smith and Green 2005, Petranka and Holbrook 2006).

If habitat is of uncertain quality and multiple sites are available for translocation, one approach may be to distribute translocated animals in various locations within a waterbody or in multiple waterbodies. This strategy may also reduce intraspecific competition for food and other resources and concerns that waterbodies may dry while aquatic species or life-stages are present.

6.4 Other considerations

- Release sites should be distant from areas of sink habitat (i.e. not within the dispersal distance for the species) or sink habitat should be inaccessible to amphibians.
- Current and future land use activities adjacent to the release site should be compatible with amphibian survival.
- Some translocated individuals may disperse or return to the project area upon release (homing). Repeated translocations may be avoided by selecting a release site with natural habitat barriers such as cliffs or a large river, or installing barrier fencing to prevent return. *See **Appendix 5: Barrier Fences***.
- The hydroperiod at the release site should be of sufficient length to meet the species life-history requirements (i.e., long enough for larval amphibians to reach metamorphosis, or permanent hydroperiod for fully aquatic species, aquatic hibernators, or those that take more than one year to reach maturity).
- Release sites should not be prone to sudden fluctuations in water level from flooding, water diversion, drawdown, or drying.
- Stakeholders at or near the release site should support the translocation.
- Ideally, the release site should lack predatory fish and if other amphibians are present should be below full capacity to reduce the risk of predation, inter- and intra-specific competition. *See **Section 6.4.1: Occupied vs. Unoccupied sites**.*

- Amphibians should be released in areas with good quality habitat. Given that the source site has good quality habitat, release sites should be chosen that have similar environmental characteristics as the source site. Translocated individuals should be released in environments with similar elevation, latitude, waterbody class, flow, vegetation height/structure or density of plants, water chemistry and temperature, and soil type etc. from which they came because they may possess genetic adaptation to those environments. *See* ***Section 5: Mitigation Translocation Risks and Challenges****.*

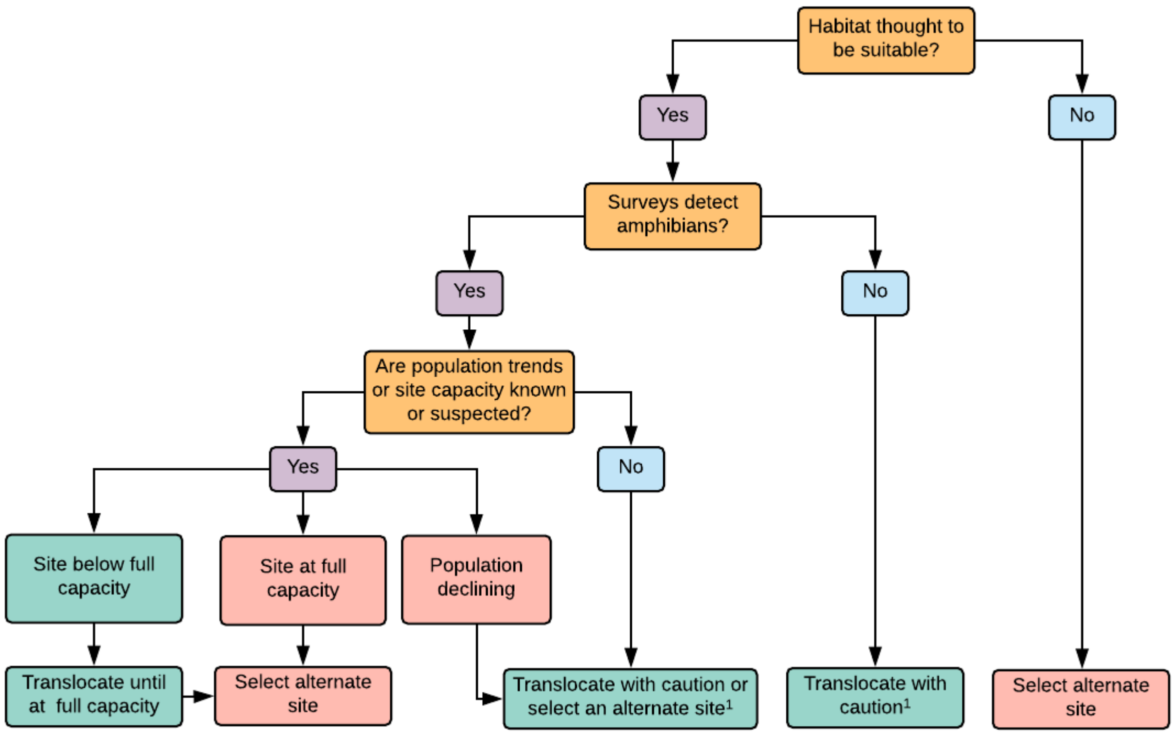
6.4.1 Occupied vs. Unoccupied sites

Amphibians should only be released at sites with suitable habitat. If the site is unoccupied, exercise caution—lack of occupancy may indicate unsuitable habitat. Declining population trends may indicate that habitat is no longer suitable; however, if a site is below full capacity or declining, translocation may help reinforce the population at the release site.

Extensive surveys or data collection are required to ensure that a site is unoccupied, populations are declining, or site is below capacity. This may not always be feasible, so assessment should be based on the best available knowledge.

Select an alternate release site for translocation of any surplus animals once site capacity is reached. If the release site is at full capacity, select an alternate release site because moving additional amphibians may result in competition with resident conspecifics and lead to a net loss of individuals and will not achieve the objectives of the translocation. For widespread species that potentially already occupy all available suitable habitat, the ideal would be to aim for release sites that have been newly created or restored.

If habitat quality at the release site is uncertain, population trends are declining, or the site capacity is unknown, exercise caution when translocating: translocate fewer individuals, translocate to multiple sites, or select alternate sites. Give priority to sites with suitable habitat that are below capacity, or restored or newly created sites, followed by unoccupied sites, or occupied sites with declining population trends or unknown capacity. *See* ***Figure 1: Site Selection Decision Tree.***



[1.] Translocate fewer individiduals, or translocate to multiple sites to reduce risk of competition or unsuitable habitat

Figure 1: Site Selection Decision Tree

7 Mitigation Translocation Decision

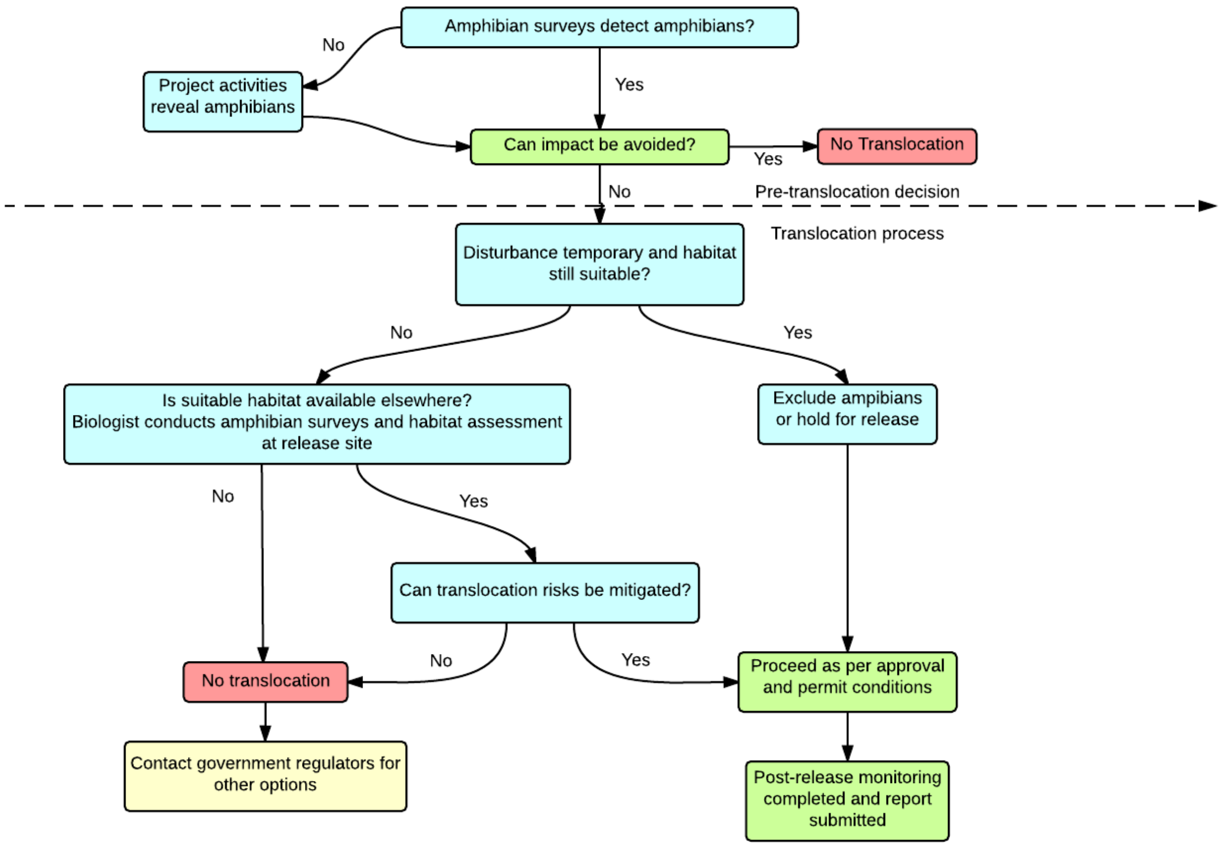


Figure 2: Mitigation Translocation Decision Tree

8 Mitigation Translocation Plan

In most cases, the goal of translocation should be to preserve all life stages of amphibians present but especially breeding adults which are important for maintaining populations. A translocation plan should maximize the likelihood of a successful translocation while minimizing the risks to individuals and amphibian populations.

Translocations should only occur when all other alternatives to avoid and minimize project impacts on amphibians are exhausted. Translocation risks must be addressed and consideration given to the timing and methods of translocation. If risks cannot be mitigated, translocation is not advised (Cunningham 1996, Letty et al. 2007, Dickens et al. 2010, Sainsbury and Vaughan-Higgins 2012). *See* ***Section 7- Figure 2: Mitigation Translocation Decision Tree***.

Not all translocations go according to plan, so a predetermined back-up strategy may be necessary. For example, alternate release sites can be selected in advance in case the habitat proves unsuitable at the time of release (IUCN/SSC 2013).

8.1 Translocation Considerations

8.1.1 Timing of Translocation and Amphibian Life Stage

In general, the timing of translocation should maximize the likelihood of capture and survival, or minimize the number of individuals that need to be translocated, or the likelihood of dispersal at the release site.

Decisions regarding the timing of the translocation and the choice of life stages to translocate are interrelated. If translocations occur late in the spring it may be necessary to translocate multiple life-stages, whereas fewer life-stages may be available for translocation if translocation occur late in the fall. Similarly, if the translocation plan targets moving larvae, then by necessity the translocation would happen in the spring for most amphibian species.

Usually the goal of translocation is to prevent injury or death of individual amphibians rather than to start a new breeding population. In these situations, the objective of translocation should be to move all affected individuals. However, if this is not feasible, then it is more important to preserve breeding-age adults than earlier life stages. If the individuals have already bred in a pond, mitigation options may include translocation of all life stages, or waiting until individuals have reached metamorphosis and have naturally dispersed before continuing project activities.

If project activities are likely to destroy a breeding pond, the goal of translocation should be to relocate the breeding population. Although all life stages present should be translocated and the welfare of breeding adults should be of primary concern, translocations of eggs or larvae are actually more likely to establish a population because they can more readily adapt to local environmental conditions and exhibit site fidelity to the release site (Bloxam and Tonge 1995, Marsh and Trenham 2001, Trenham and Marsh 2002). Eggs should be targeted for translocation over larvae because it is easier to move large numbers of eggs, and collection methods for larvae are typically inefficient and may result in injury (Kendell and Prescott 2007). Eggs may also be at reduced risk of transmitting *Batrachochytrium dendrobatidis* (Bd), the causative agent of chytridiomycosis, than other life stages. *See* ***Section 9.1: Preventing Disease Transmission***.

Depending on the circumstances, it may be appropriate to time translocation for when amphibians are easy to capture, such as when adults congregate at spring breeding ponds, at metamorphosis, or in the fall at overwintering habitats, as long as conditions are suitable and there is sufficient time for amphibians to locate alternate habitat at the release site. Amphibians may be easier to locate when they are more active but may also be more difficult to capture using some methods. *See* ***Section 4.1.1: High Amphibian Activity***.

Amphibians should not be moved when conditions are unsuitable, such as when it is too hot and dry, or too cold. Translocations are generally not recommended during the winter or at sub-zero temperatures, except in emergencies, for example when amphibians are encountered unexpectedly during winter project activities. Translocations have been successfully used to move northern leopard frogs in the Upper Qu'Appelle River in Saskatchewan out of harm's way of dredging activities into September (Corie White, personal communication, March 1, 2018). Translocations are usually acceptable from early spring into the fall period (September through October), if the weather is favourable for amphibian activity.

If possible, time translocations of adult amphibians so that they occur outside the breeding season. Moving amphibians during the breeding season may disrupt breeding behaviour, and could result in reduced recruitment for that year. However, disrupting breeding is better than allowing reproductive adults to be injured or killed.

Amphibians that require very specific overwintering habitats, such as animal burrows or deep water, should be released near overwintering habitat and when there is still sufficient time to locate suitable overwintering habitat. This is critical because of the shortened time available for amphibians to locate hibernation sites before the onset of freezing temperatures, and because amphibians may have reduced mobility when cold.

See ***Section 9.6: Emergency Translocation*** *and* ***Section 9.7 Winter Translocation****. See* ***also Appendix 3: Amphibian habitat and dispersal***.

If amphibians unexpectedly colonize a project area, and there is adequate time for individuals to locate alternate breeding, foraging, or overwintering habitats at a release site, it is usually best to translocate amphibians as soon as they are discovered.

8.1.2 Preventing Return to the Project Area

Given that most translocations occur within the natural dispersal distance for the species, and that many species of amphibians demonstrate high site-fidelity, it is likely that translocated individuals will attempt to return to their capture location if displaced. Therefore, it may be necessary to prevent recolonization of the project area using barrier fences or by releasing amphibians in areas with natural barriers to dispersal, or by releasing aquatic species or life stages in unconnected waterbodies outside the project area. If this is not possible, ongoing translocation may be necessary to ensure that amphibians are not impacted by project activities. *See **Appendix 5: Barrier Fences***.

8.2 Permits, Permissions and Approvals

Ensure that all necessary permits, permissions, and approvals are obtained from the appropriate municipal, provincial and federal authorities. Conduct all stages of translocation according to the permit conditions, protocols and laws of the relevant jurisdiction.

The following provincial permits are currently required for amphibian translocation, but are subject to change. Additional permits may be required if project activities occur in municipal areas, provincial or national parks, or for species listed under the federal Species at Risk Act.

Alberta:
In Alberta, a Research and Collection Permit is required to conduct activities related to translocation of amphibians, such as capture, handling, transportation and release.

Saskatchewan:
In Saskatchewan, a Research Permit is required for Species Detection Surveys. A permit may be required for capture, holding and translocating amphibians.

Manitoba:
In Manitoba, an Environment Act Licence is required to conduct project activities, and conditions specific to amphibian translocation may be included. If any of these conditions cannot be followed, a Wild Animal Capture Permit may be required.

*See **Appendix 2: Additional Resources** for more information on permits and conditions.*

9 Mitigation Translocation Procedures

A proper translocation plan should follow appropriate capture, handling, holding, and release procedures to reduce risks of disease, injury and death. Only experienced personnel familiar with capture and handling methods should conduct translocations.

9.1 Preventing Disease Transmission

Transmission of amphibian pathogens and parasites between source and release sites can occur through infected amphibians, water, organic debris, mud, vegetation, or by contact with contaminated fieldworkers, their clothing or equipment (Ballou et al. 1993). The greatest risk of disease transmission among individual amphibians occurs when they are in close contact with each other—in the same container or when gloves, containers or equipment are re-used without being disinfected or disposed of between amphibians (Speare et al. 2004, Gray et al. 2018). Animals should be considered exposed to all infectious agents present at the site (Ballou et al. 1993).

*See **Section 9.3: Handling and Hygiene** and **Appendix 4: Disinfecting Equipment and Hygiene** for information on disease prevention.*

Examples of amphibian diseases

Many bacteria, viruses, fungi, and parasites can cause amphibian diseases. Some diseases cause readily observable symptoms in affected individuals:

- **CHYTRIDIOMYCOSIS**: *Batrachochytrium dendrobatidis* (Bd), the causative agent of chytridiomycosis, is most prevalent among adult and sub-adult anurans. Eggs are less likely to be infected (Richardson et al. 2014). Prevalence of Bd is greatest in early spring and declines throughout the summer (Voordouw et al. 2010). Therefore, moving eggs may be less risky in terms of Bd transmission than moving other life-stages, and moving terrestrial age classes may be less risky late in the season. It is possible to test water samples and to swab individuals to determine the presence of Bd and other diseases, but this information may be of limited value given the prevalence of some pathogens in the environment, and especially if amphibians are being moved within the same watershed (Chestnut et al. 2014). Resistance to diseases such as chytridiomycosis tends to vary geographically by species, and both within and among populations of amphibians (Kriger and Hero 2007, Woodhams et al. 2007, Tobler and Schmidt 2010, Voordouw et al. 2010).

  Indications: Excessive shedding skin, red skin, skin lesions, convulsions, lack of the righting reflex, posture changes, thinness and lethargy (Parker et al. 2002, CWHC 2017a).

- **BATRACHOCHYTRIUM SALAMANDRIVORANS** (Bsal), a pathogen related to Bd that mainly affects salamanders, has yet to be detected in North America but it is predicted to be a future threat to salamander populations (Yap et al. 2015).

Indications: Redness and ulceration of skin, thinness and lethargy (CWHC 2017c).

RANAVIRUS: An infectious disease that causes between 90 and 100% mortality in affected individuals (CWHC 2017b). The virus can be transmitted by ingestion, direct contact, or exposure to infected soil or water. Ranavirus is most commonly observed in the spring and summer because it more severely affects larval amphibians.

Indications: Skin lesions, swelling and redness of the body, weight loss and lethargy (Greer et al. 2005), buoyancy problems, gasping for air, and fluid accumulation under the skin (CWHC 2017b).

- **RED LEG SYNDROME**: A systemic bacterial infection causing hemorrhage often caused by the bacterium *Aeromonas* (Densmore and Green 2007).

  Indications: Weight loss and lethargy, edema, and hemorrhaging on the underside of belly and legs, sloughing, or necrosis (Densmore and Green 2007).bac

- **SAPROLEGNIA**: An infectious disease caused by several species of water molds that are commonly found in the aquatic environment (Densmore and Green 2007). They commonly affect amphibian eggs but can also be primary skin and oral pathogens of larval amphibians.

  Indications: A mold with a fluffy or cotton-like appearance that can infect eggs or larval amphibians. Remove affected eggs by hand, or with tweezers or a pipette (Kendell and Prescott 2007, Fernández-Benéitez et al. 2008).

To reduce disease risk to translocated amphibians and populations:

- Move animals within the natural dispersal distance for the species and within the same drainage.
- Target life stages or times of year with lower risk of disease (Nelson 2002).
- Reduce stress during handling and transport by careful handling, reduced transport time, and maintaining appropriate temperature, etc. *See **Section 9.3: Handling and Hygiene***.
- Transport and hold amphibians individually in single-use or decontaminated containers.
- Clean all containers and equipment in contact with amphibians or waterbodies. *See **Appendix 4: Disinfecting Equipment and Hygiene***.
- To reduce the risk of spreading disease between individuals or sites, only outwardly healthy amphibians should be translocated.

Some common signs of illness in amphibians:

- Lethargic
- Emaciated
- Cloudy eyes
- Loss of the righting reflex
- Abnormal posture (slightly splayed legs, or rigid body with outstretched back legs)
- Discoloured skin (red blotches on skin, caused by hemorrhaging, or white fuzzy blotches, caused by fungi)
- Swelling from fluid accumulation in the body tissues (edema)

Contact the Canadian Wildlife Health Cooperative (CWHC) and government regulators after finding outwardly sick or recently dead amphibians to get advice on appropriate methods of preserving and submitting samples for analysis.

9.2 Capture

The goal of a mitigation translocation should be to capture and move all individuals that could be negatively affected by project activities. To achieve this, capture may need to begin well in advance of project activities and may need to be ongoing for the duration of the project. Capturing and moving adult or larval amphibians at small waterbodies (less than 100 square metres) or in terrestrial habitat should begin at least two weeks before project activities begin (Skelly and Richardson 2010, Ministry of Forest 2016). In some cases, it may be necessary to begin translocations a season before project activities begin.

It may be necessary to conduct visual searches and trapping several times a day to ensure that linear project areas such as roads, pipeline right of way, etc. remain clear of amphibians. If captured, release non-target species unharmed, in an appropriate location. *See* ***Section 9.5: Release****.*

Various methods can be used to capture amphibians, depending on the habitat, species and life stages targeted for translocation. Use seine, dip nets, or aquatic funnel traps to capture amphibians in waterbodies. In terrestrial habitat, visual searches combined with hand or capture with nets, pit or funnel traps, or searches under cover objects are often effective. To increase the likelihood of capturing amphibians, select times when amphibians are most active. *See* ***Section 4.1.1: High Amphibian Activity****.*

All stages of capture must use clean equipment and proper hygiene. *See* ***Appendix 4: Disinfecting Equipment and Hygiene****.*

9.2.1 Nets and Hand Collection

Monorail and other styles of nets can be effective for capturing terrestrial amphibians and dip or seine nets can be effective for capturing aquatic species or life stages of amphibians. Dip nets (*see* ***Figure 3: Collecting Larva With a Dip Net***) are especially effective for capturing aquatic amphibians when combined with draining waterbodies (Graeter et al. 2013). *See* ***Appendix 6: Waterbody Drainage***.

Figure 3: Collecting Larva with a Dip Net
(Photo by Andrew Didiuk)

Seine netting (or drag netting) is a method useful for capturing aquatic amphibians and amphibian larvae (*see* ***Figure 4: Seine Net Fence with Aquatic Funnel Traps***). The technique uses a net that hangs vertically in the water, with its bottom edge held down by weights and its top edge buoyed by floats. The net is typically anchored on shore and pulled in an arc through the water by several people. The process corrals amphibians near the shore where they can be more easily dip netted and removed from the wetland.

The efficacy of the seine net is reduced in areas with submerged debris, large boulders, logs, and irregular bottom features that cause the bottom edge of the net to lift off the bottom of the wetland, allowing amphibians to escape or the net to become snagged. Take precautions to prevent plant material, sediment and other debris from accumulating in the net which can potentially injure amphibians as the net is pulled through the water.

Figure 4: Seine Net Fence with Aquatic Funnel Traps
(Photo by Lea Randall)

The mesh size of nets should be smaller than the targeted life stages and species. Refer to amphibian guidebooks for more information on amphibian species and size of life stages.

Searching by hand through ground litter or under cover objects like logs, stumps or loose rocks, may reveal hidden animals (Graeter et al. 2013). Gently placing a cupped hand over adult and sub-adult amphibians may also be an effective way to capture individuals, but beware as they can be easily injured and most amphibians are slippery and can fit through small holes between fingers.

Basking individuals may be collected with a net along the edge of waterbodies when conditions are hot and sunny. Individuals of some species may be brazen while they are in breeding aggregations, making them easier to capture. Use a spotlight at night to locate breeding individuals by their eyeshine and capture with a net. This method tends to be more effective for species with larger eyes such as ranid frogs and does not work as well with small or medium sided individuals (Corben and Fellers 2001). Breeding salamanders in shallow water and terrestrial salamanders can also be detected using this method (Corben and Fellers 2001).

9.2.2 Traps

There are many types and variations of amphibian traps, but most are variations of either the funnel trap (***Figure 5: Homemade Funnel Trap and Drift Fence in a Terrestrial Setting***) or pitfall trap (***Figure 6: Pitfall Trap with Plastic Cover and Stakes)*** (Willson and Gibbons 2010b). Funnel traps consist of a tapered funnel-shaped entrance that guides animals into a holding chamber, where they are unable to find their way back out through the small entrance hole. Pitfall traps work on a similar principle—a container is placed in the ground and animals that fall in are unable to climb out.

*See **Appendix 7: Funnel and Pitfall Traps** for detailed information*.

Figure 5: Homemade Funnel Trap and Drift Fence in a Terrestrial Setting
(Photo by Kris Kendell)

9.2.3 Drift Fences

Drift fences are barrier fences set perpendicular to the direction of amphibian movement that intercept animals moving between habitats like a breeding pond to foraging or overwintering habitat (Willson and Gibbons 2010a). Drift fences can be used to improve trapping success by guiding amphibians into traps or to crossing structures. Barrier fences can be used to exclude amphibians from project area.

*See **Appendix 5: Barrier Fences** for detailed information**.***

Figure 6: Pitfall Trap with Plastic Cover and Stakes
(Photo by Murdoch Taylor, Golder Associates Ltd.)

9.2.4 Stopping point

It can be difficult to determine when a translocation is complete. It may not be feasible to ensure that all amphibians have been moved if they are difficult to locate or trap. In some cases, regulators may require that a specified period has passed without an observation of an amphibian before commencing project activities, or in other cases, translocations may need to be on-going for the duration of the project. Although mostly used in fisheries, catch per unit effort (CPUE) can be calculated to determine when most individuals have been captured and removed from the project area. To calculate CPUE, divide the number of individuals caught during each capture session by the capture effort, which can be quantified as number of traps set, number of trap days or time spent searching or area searched.

Catch per unit effort should decrease as animals are captured and removed from the project area, assuming animals cannot recolonize the project area. Although targets may vary, one may be confident that most animals have been captured if CPUE has decreased to less than 10% of the peak CPUE (Jamie Sparrow, pers. comm. March 30, 2015).

Challenges of this approach are that capture probabilities may vary with weather conditions, observer, time of day, etc., so declining captures may reflect declining capture probability rather than indicating that most of the population has been removed (Matechou et al. 2016).

9.3 Handling and Hygiene

Amphibians are sensitive to heat, cold, desiccation, and chemicals on hands and on equipment used for capturing, handling and holding specimens. Amphibians may become heat stressed if conditions are warm and if handled extensively (CCAC 2004). To reduce stress, decrease handling time and keep amphibians cool and moist, especially during hot or dry weather and during the breeding season. Once captured, immediately transfer animals to a transport or holding container, and place in an area out of the sun.

Amphibians may struggle and can be slippery. Vigorous kicking with their hind limbs or whip-like thrashing movements can cause joint dislocations or back injuries. Use handling bags and nets to reduce risk of injury to amphibians. Contact with the abrasive edges of vegetation, like cattails, can easily damage delicate amphibian skin. For salamanders, inappropriate handling can result in tail loss or damage to delicate external gills.

Handling amphibians can also pose risks to human health. For example, amphibians may have bacteria in their intestines and feces that are human pathogens such as *Salmonella* and *Leptospira*. The parotid gland of toads can secrete a toxin that causes irritation to the eyes and mouth, or illness, if ingested.

Always handle amphibians gently with moist hands or gloves, and equipment that is free of chemicals, to reduce stress and risk of injury. Use single use containers, gloves, and equipment or disinfect between handling individual animals to reduce the risk of disease transmission. *See* ***Appendix 4: Disinfecting Equipment and Hygiene*** *for more information.*

Handling Different Amphibian Species and Life Stages

- **EGGS, LARVAE, MUDPUPPIES, AND NEOTENIC SALAMANDERS** should not be handled out of water and should only be handled using nets. Never grasp larval and neotenic salamanders by the tail, or around the head or neck.

- **SMALL JUVENILE OR ADULT FROGS AND TOADS** may be held between gently cupped hands or in a gently closed fist (Graeter et al. 2013) or carefully held by the hind legs. To prevent kicking, animals held by the hind legs should not be allowed to bend (flex) their hip and knee joints.
- **MEDIUM AND LARGE FROGS AND TOADS** should be grasped around the waist with the hind limbs fully extended, the front legs should be supported with the other hand (Ontario Environment and Energy).
- **ADULT SALAMANDERS** should be grasped around the middle of the body, between the fore and hind limbs, or held in the whole hand and gripped with the thumb and fingers just behind the head (Graeter et al. 2013). Do not grasp or pick up salamanders by the tail.

Direct handing can be avoided by using a net or hands to guide amphibians to a holding container. If amphibians have suffered superficial skin abrasions, treat by applying Bactine® to prevent skin infections.

9.4 Containment and Transportation

Amphibians are sensitive to various environmental conditions when contained and transported. For example, too high of air and water temperatures can lead to overheating, low relative humidity can lead to desiccation, and degradation of water quality can be harmful to amphibians by reducing their overall fitness. Therefore, amphibians should be transported and held in containers of suitable size and at an appropriate density, depending on their life stage, size, and species requirements. To ensure appropriate conditions are met, careful monitoring is required.

*See **Appendix 8: Transporting and Holding Amphibians.***

9.5 Release

Select a release site that meet the needs of all life stages of the target species. Release amphibians in a safe location, in similar habitat to the collection site. If habitat is of uncertain quality and multiple sites are available for translocation, one approach may be to distribute translocated animals in various locations within a waterbody or in multiple waterbodies. *See **Section 6: Select Potential Release Sites.***

Amphibians may be sensitive to abrupt changes in temperature or water chemistry and are vulnerable to predation when released in an unfamiliar location or when inactive. Take care to prevent transporting and releasing invasive species or disease to the release site.

Aquatic amphibians should be slowly acclimated to the temperature and water chemistry at the release site. Aquatic amphibians that are transported in containers can undergo serial water changes on land or transferred to bags. Aquarium bags can be floated directly in the water while undergoing serial water changes. *See **Section 9.4: Containment and Transportation and Appendix 8: Transporting and Holding Amphibians** for more information**.***

- Release larvae in small numbers throughout different areas of the waterbody (or in several waterbodies) where there is little chance of becoming stranded if water levels drop before metamorphosis. A wire-mesh strainer can be used to count and release larvae (*see* ***Figure 7: Counting and Releasing Tadpoles***). Be careful not to step on larvae or stir up sediment during this process. During acclimation, replace no more than 25% of the water at a time ensuring no rapid changes to temperature (no greater than 1°C/hour) or water chemistry (NRC 1974).
- Ensure that no water or vegetation from the source site enters the waterbody. Water must be disposed of on land at a distance greater than 50 metres from the shore, reducing the likelihood of accidentally transmitting disease or introducing invasive species to the release site. Vegetation should not be transported to the release site.

Figure 7: Counting and Releasing Tadpoles
(Photos by Audrey Gagné-Delorme and Lea Randall)

- Release amphibians in habitat similar to where captured, or along the edge of waterbodies in places with emergent vegetation to provide adequate cover from predators.
- Release amphibians when they are active so that they can evade predators. *See* ***Section 4.1.1: High Amphibian Activity.***

9.6 Emergency Translocation

Emergency translocation can often be avoided by conducting rigorous amphibian surveys to detect amphibians in advance of project activities (*see* ***Section 3: Amphibian Detection Surveys***) and by adhering to beneficial management practices outlined in ***Section 4: Translocation Avoidance and Beneficial Management Practices***).

Emergency translocations are prompted by situations, including:

- Unexpected damage to habitat resulting from events such as a chemical spill, sudden changes in water level, etc.
- Sudden dispersal or migration into the project area during seasonal movements of amphibians.
- Failure of barriers designed to exclude amphibians from the project area.

- When amphibians are in immediate, unavoidable danger, for example, if amphibians are at risk of being crushed by vehicles, unexpectedly uncovered during excavation or draining wetlands.

If project activities occur in quality amphibian habitat, a translocation plan should be in place even if surveys do not detect amphibians. *See* ***Section 8: Mitigation Translocation Plan***. Emergency translocations require the same rigour and considerations as planned mitigation translocations. Project activities may need to be suspended or delayed until adequate planning, action, and monitoring is considered and committed to.

9.6.1 Moving Out of Harm's Way (Distance less than 25 meters)

If an amphibian is in imminent danger of injury or death, it should first be encouraged to move on its own. Walk towards the amphibian in the direction you want it to move. If the amphibian does not move on its own or moves in the wrong direction, it should be picked up and moved to a safe location nearby (i.e., less than 25 m) (Ontario Environment and Energy). It is usually best to move amphibians in the direction that they appeared to be heading, unless that direction is unsafe. If it is unclear which direction they were moving, move them to the nearest suitable habitat out of harm's way. *See* ***Section 9.6.1: Handling and Hygiene***.

All stages of capture and moving must use clean equipment and proper hygiene. *See* ***Appendix 4: Disinfecting Equipment and Hygiene***.

9.6.2 Wildlife Rehabilitation Facilities or Zoos

Wildlife rehabilitation facilities or zoos may accept animals in cases of injury or when short-term holding or translocation is not an immediate option but may be possible in the long term.

See ***Section 9.7: Winter Translocation*** *and* ***Section 9.8: Injury, Death and Euthanasia.***

Amphibians held in wildlife rehabilitation facilities or zoos with the intention of being released back into the wild:

- must be maintained in quarantine to reduce disease concerns;
- must be submitted to the rehabilitation facility with the coordinates and description of the site and habitat from which they were collected;
- should be maintained in a state of hibernation until spring if rescued during the winter, to promote breeding and reduce care requirements, and;
- should be released to another location according to the protocols outlined in this document if the source site is no longer suitable for release.

It is the responsibility of each jurisdiction to decide if temporary holding at a rehabilitation facility or zoo is an acceptable option, and this must be formalized in the terms and conditions of the translocation permit.

Under these circumstances, the licensed wildlife rehabilitation facilities listed below may be able to take small numbers of amphibians. Please contact the facility beforehand to see if they are willing to accept the amphibian(s). Most are not-for-profit organizations with limited budgets, and charitable donations are needed for operation.

Please check with your provincial regulator for a current list of accredited rehabilitation facilities and zoos.

Alberta:

- The Wildlife Rehabilitation Society of Edmonton (Edmonton) 780-914-4118
- Medicine River Wildlife Centre (Spruce View) 403-728-3467
- Calgary Wildlife Rehab Society (Calgary) 403-266-2282
- Alberta Institute for Wildlife Conservation (Madden) 403-946-2361
- The Cochrane Ecological Institute (Cochrane) 403-932-5632

Saskatchewan:

- Wildlife Rehabilitation Society of Saskatchewan (Saskatoon) 306-242-7177
- Salthaven West (Regina) 639-999-4957
- Living Sky Wildlife Rehabilitation (Saskatoon) 306-652-5975

Manitoba:

- Wildlife Haven Rehabilitation Centre (Winnipeg) 204-878-3740
- Prairie Wildlife Rehabilitation Centre (Winnipeg) 204-510-1855

9.7 Winter Translocation

Winter translocation (from mid-October to before spring breeding) is typically not advisable for most amphibian species because it is cold and dry, and because overwintering habitat may be difficult to locate. However, because overwintering amphibians can be difficult to detect, project activities may already be underway before amphibians are discovered. If winter habitat for amphibians is suspected in the project area, proponents should have a translocation plan in place.

See ***Section 4.1.2: Low Amphibian Activity***.

Winter translocation may be permitted when activities are restricted at other times of year due to concerns for other wildlife or for amphibian species that are active during the winter. (*See* ***Section 9.7.2: Freeze-Intolerant Aquatic Hibernators***.) The survivorship of these types of translocations is unreported.

Typically, hibernating individuals should remain in a hibernating state in the dark at appropriate temperature and humidity depending on their hibernation strategy. Use coolers or refrigerators for this purpose.

For more information on amphibian winter habitat requirements see ***Appendix 3: Amphibian habitat and dispersal***).

All stages of capture and transportation must use clean equipment and proper hygiene. *See **Appendix 4: Disinfecting Equipment and Hygiene**.*

9.7.1 Freeze-Tolerant Hibernators

To transport freeze-tolerant species:

- Maintain temperatures just below freezing (e.g., -1 to -2°C).
- Transport hibernating individuals in single-use or disinfected containers with disposable moist substrate such as moss, damp sponge or unbleached paper towel.
- Relocate hibernating individuals into a habitat similar to where they were captured.
- Ensure the release site has suitable soil, substrate temperature and moisture conditions for hibernation.
- Alternately, transport the individual to a qualified and willing wildlife rehabilitation facility or zoo. *See **Section 9.6.2: Wildlife Rehabilitation Facilities or Zoos***.

9.7.2 Freeze-Intolerant Aquatic Hibernators

To transport freeze-intolerant species:

- Ensure that amphibians do not freeze while being moved and that transport containers are maintained between 2 to 4°C.
- Transport aquatic individuals submerged in cold water in dark containers (NRC 1974). Some aquatic hibernators can withstand brief periods of sub-optimal conditions (e.g., below zero or low dissolved oxygen) (Fisher 1999).
- Release animals into nearby habitat in the same waterbody, but outside the area of project disturbance with sufficient dissolved oxygen. If that is not feasible, release animals into another nearby waterbody occupied by the same species, or choose a release site that is unlikely to freeze to the bottom, and which has similar temperature, water chemistry, and dissolved oxygen content as the source site. Drill a sufficiently wide hole in the ice (if necessary) to permit safe release. The success of these types of translocations are unknown.
- Alternately, transport the individual to a qualified and willing wildlife rehabilitation facility or zoo. *See **Section 9.6.2: Wildlife Rehabilitation Facilities or Zoos***.

9.7.3 Freeze-Intolerant Terrestrial Hibernators

The chance of successfully translocating terrestrial freeze-intolerant individuals in winter is probably very low, as they are likely to be injured or freeze in the process of being uncovered (or recovered). In these situations, possible courses of action include:

- Document and continue work (resulting in death of amphibian).
- Stop work, carefully recover the amphibian and avoid the area until spring (unlikely to be successful).
- Transport the individual to a qualified and willing wildlife rehabilitation facility or zoo. *See **Section 9.6.2: Wildlife Rehabilitation Facilities or Zoos***.
- Euthanasia by a qualified individual. ***See Section 9.8: Injury, Death and Euthanasia.***

If transporting freeze-intolerant terrestrial amphibians:

- Ensure that amphibians do not freeze and that transport containers are maintained between 2 and 4°C.
- Transport in single-use or disinfected containers with disposable a moist substrate such as moss, a damp sponge or unbleached paper towel.

9.7.4 Other Considerations for Overwintering Individuals

- ***Returning to hibernation***: Animals roused from hibernation between October and March can be returned to hibernation through a series of small temperature changes (NRC 1974). As a rule of thumb, do not expose amphibians to temperature changes greater than about 1°C per hour. Temperatures can be lowered incrementally by 3 to 5°C every 9 to 12 hours, and should be maintained around 2 to 3°C for freeze intolerant amphibians, and -1 to -2°C for freeze tolerant amphibians (NRC 1974). It is a best practice not to rouse amphibians if intending to overwinter.
- ***Feeding and watering:*** Hibernating individuals do not need to be fed or have water changes unless roused for greater than 5 days (NRC 1974). Amphibians that are going to be returned to a hibernating state should either not be fed or should be deprived of food for at least 7 days before returning to hibernating state.
- Aquatic hibernators can be held in amphibian-safe plastic container at 2 to 4°C filled with 10 to 12 centimetres of water, ensuring that the animal is covered in water. For enclosures suitable for larger numbers of animals, please see *Amphibians: Guidelines for the breeding, care, and management of laboratory animals* (NRC 1974).
- Coolers or refrigerators can be used to maintain appropriate temperatures during transportation or holding.

9.8 Injury, Death and Euthanasia

Consult with regulatory authorities if amphibians are injured or killed during translocation. Euthanasia by a qualified person such as a veterinarian, animal health technician, or biologist trained in the procedure, may be a reasonable option if amphibians are injured or diseased, or if translocation or temporary holding is not an option and development activities are likely to result in suffering and death.

Specimens should be submitted, as per permit conditions, to the Canadian Wildlife Health Cooperative, Fish and Wildlife offices, university collections, museums or tissue banks. These organizations should be contacted in advance to ensure that specimens are collected and preserved in an appropriate manner. These specimens could be used to assess the genetic structure of amphibian populations or used for other applications to help inform future translocation decisions.

10 Post-Release Monitoring and Reporting

A well-designed plan for post-release monitoring and reporting is essential to understanding why translocations may not be successful. One of the major challenges in assessing the efficacy of amphibian translocation is that post-release monitoring is infrequent, and results are rarely reported. Post-release monitoring may also identify whether further intervention is required to protect the translocated amphibians if land-use activities at the translocation site threaten amphibians or if habitat becomes unsuitable.

Specific projects and jurisdictions have permit terms and conditions for monitoring and reporting. Please refer to the processes in your area.

10.1 Goals and Measures of Translocation Success

The goals and measures of success should be clearly laid out before beginning any translocation (IUCN/SSC 2013), including mitigation translocations.

For example, if the goal of the translocation is to prevent injury or death of amphibians in the project area, measures of success could include no observations of amphibians in the project area after translocation, and no injury or mortality of amphibians in the project area while activities are occurring. Other measures of success could include that individuals remain at the release site for period of time, or do not experience high levels of mortality upon release. Long-term measures of success could be that amphibians still occupy the translocation area in subsequent seasons or years.

If the goal of translocation is to establish a new population at a previously unoccupied release site, measures of success could be that amphibians successfully overwinter and breed at the release site, and that the site remains occupied in future years. Long-term goals could include that successive generations are observed.

The measures of success, and duration and intensity of monitoring required to assess success, will depend on permit conditions. Discuss endpoint goals with local regulators.

10.2 Post-Release Monitoring

Mitigation translocations should include monitoring using presence/absence, dispersal, relative abundance, or estimates of overall population size for some period after the translocation event to assess the success of the translocation against the objectives. Replicated surveys are needed to estimate detectability using occupancy modelling for presence-absence, N-mixture models for abundance, and CMR models for population size. These methods are increasingly being applied to amphibian populations.

The goals of the translocation and conditions at the release site will determine which survey methods and level of precision are most appropriate to assess success. Presence/absence surveys, for example, are only useful for determining if translocated individuals remain at a release site if they were absent before. Whereas, presence/absence surveys may be adequate if the goal of the translocation is to ensure that the site remains occupied in subsequent seasons or years.

Relative abundance methods use some of the same techniques as presence/absence surveys (e.g., visual, auditory, or trapping surveys), but include measurements of sampling effort. Measures of sampling effort may include area surveyed, number of traps used, or number of observers, and duration of sampling. These methods usually require little additional effort and cost, yet greatly improve population assessments by allowing for a relative measure of population size.

Monitoring population size, mortality of translocated individuals, or monitoring movement often requires mark-recapture methods because unless individuals are marked before release, it is impossible to say if observed individuals were translocated, resident individuals, or animals that naturally immigrated. Some mark-recapture methods such as toe-clipping, marking with elastomere, pit-tagging, and radio-telemetry, may be damaging to the animal (see CCAC 2004 for more information on marking). Only professionals experienced in these techniques and authorized by the provincial regulators should use these methods.

For amphibian species with unique pigmentation patterns, such as northern leopard frogs (*Lithobates pipiens*) or long toed salamanders (*Ambystoma macrodactylum*), it is possible to visually identify individuals from photographs without using invasive marking methods. This approach is only be feasible for small numbers of animals (Caorsi et al. 2012). An understanding of mark-recapture data analysis is also required when using these methods to ensure appropriate interpretations of the data.

See ***Appendix 2: Additional Resources*** *for information on Monitoring Techniques, and Species Identification and Species Biology.*

Appendix 1: Status of Amphibian Species

Provincial Conservation Data Centre S-Rank and Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status (as of January 2017) of amphibian species in Alberta (AB), Saskatchewan (SK) and Manitoba (MB).

Table 1: Status of Amphibian Species in Alberta, Saskatchewan and Manitoba

Species	Province			COSEWIC[4]
	AB[1]	SK[2]	MB[3]	
Boreal Chorus Frog (*Pseudacris maculata*)	S5	S5	S5	N/A[low]
Spring Peeper (*Pseudacris crucifer*)	-	-	S5	N/A[low]
Columbia Spotted Frog (*Rana luteiventris*)	S3	-	-	N/A[mid] (NAR)
Northern Leopard Frog (*Lithobates pipiens*)	S2	S3	S4	Special Concern
Wood Frog (*Lithobates sylvaticus*)	S5	S4	S5	N/A[low]
Green Frog (*Lithobates clamitans*)	-	-	S1, S2	N/A[low]
Mink Frog (*Lithobates septentrionalis*)	-	-	S3	N/A[mid]
Gray Treefrog (*Hyla versicolor*)	-	SNR	S4, S5	N/A[low]
Canadian Toad (*Anaxyrus hemiophrys*)	S3	S4	S4	N/A[high] (NAR)
Great Plains Toad (*Anaxyrus cognatus*)	S2	S3	S2	Special Concern
Plains Spadefoot (*Spea bombifrons*)	S3	S3	S2, S3	N/A[mid] (NAR)
Western (Boreal) Toad (*Anaxyrus boreas)*	S3	-	-	Special Concern
American Toad (*Anaxyrus americanus*)	-	-	S4, S5	N/A[low]
Long-toed Salamander (*Ambystoma macrodactylum*)	S3	-	-	N/A[low] (NAR)
Eastern Tiger Salamander (*Ambystoma tigrinum*)	-	-	S2	Endangered
Western Tiger Salamander (*Ambystoma mavortium*)	S4	S5	S4, S5	Special Concern
Blue-spotted Salamander (*Ambystoma laterale*)	-	-	S3, S4	N/A[low]
Common Mudpuppy (*Necturus maculosus*)	-	-	S3, S4	N/A[high] (NAR)

S1 - Very rare throughout its range or in the province (5 or fewer occurrences, or very few remaining individuals). May be especially vulnerable to extirpation
S2 - Rare throughout its range or in the province (6 to 20 occurrences). May be vulnerable to extirpation
S3 - Uncommon throughout its range or in the province (21 to 100 occurrences)
S4 - Widespread, abundant, and apparently secure throughout its range or in the province, with many occurrences, but the element is of long-term concern (> 100 occurrences)
S5 - Demonstrably widespread, abundant, and secure throughout its range or in the province, and essentially impossible to eradicate under present conditions
SNR - Status Not Ranked
N/A - Candidate wildlife species. Many species in Canada have not yet been assessed by COSEWIC, but are suspected of being at some risk of extinction or extirpation. High, mid, and low refers to their priority for assessment
NAR - Not at Risk. Candidates may also include wildlife species already assessed by COSEWIC as Not at Risk
Special Concern - A wildlife species that may become Threatened or Endangered because of a combination of biological characteristics and identified threats
Endangered - A wildlife species facing imminent extirpation or extinction

[1]http://www.albertaparks.ca/albertaparksca/management-land-use/alberta-conservation-information-management-system-(acims).aspx. Accessed 15 Feb 2015
[2]http://www.biodiversity.sk.ca/SppList.htm. Accessed 10 Jan 2017
[3] http://www.gov.mb.ca/sd/cdc/pdf/animal_ranks.pdf. Accessed 10 Jan 2017
[4] http://www.cosewic.gc.ca/eng/sct3/sct3_2_e.cfm. Accessed 10 Jan 2017

Appendix 2: Additional Resources

Beneficial Management Practices and Mitigation

Amphibians on my Land
http://www.ab-conservation.com/avamp/publications

Beneficial management practices- Environmental manual for crop producers in Alberta-water
Agriculture Alberta, food, and rural development. 2004. Edmonton, AB

Beneficial management practices- Environmental manual for cow/calf producers
Agriculture Alberta, food, and rural development. 2004. Edmonton, AB

Beneficial management practices- Environmental manual for Alberta farmsteads
Agriculture Alberta, food, and rural development, 2006. Edmonton, AB

Best Management Practices for Amphibians and Reptiles in Urban and Rural Environments in British Columbia
https://www2.gov.bc.ca

Road crossing structures for amphibians and reptiles: informing design through behavioral analysis.
Woltz, H. W., Gibbs, J. P., & Ducey, P. K. 2008. *Biological Conservation*, *141*(11), 2745-2750.

Best Management Practices for Mitigating the Effects of Roads on Amphibian and Reptile Species at Risk in Ontario
https://www.ontario.ca/environment-and-energy/species-risk-guides-and-resources

Emergency Preparedness and Response Requirements for the Petroleum Industry
https://www.aer.ca

Environmental Guide for Wildlife Mitigation
http://www.mto.gov.on.ca

Petroleum Industry Activity Guidelines for Wildlife Species at Risk in the Prairie and Northern Region
https://www.canada.ca

Quality farm dugouts
http://www.agriculture.alberta.ca

Caring for the Green Zone: Riparian Areas and Grazing Management
http://cowsandfish.org

Stepping Back From the Water: A Beneficial Management Practices Guide for New Development near Water Bodies in Alberta's Settled Region

https://www.alberta.ca

The stockman's guide to range livestock watering from surface water sources
Prairie agricultural machinery institute, Portage la Prairie, Manitoba.

Conservation Status of Amphibians

Alberta Conservation Information Management Centre
https://www.albertaparks.ca

Amphibians Species at Risk Resources
https://www.alberta.ca

Reports on the General Status of Wildlife Species
http://www.registrelep-sararegistry.gc.ca

Manitoba Conservation Data Centre
http://www.manitoba.ca

Saskatchewan Conservation Data Centre
http://www.biodiversity.sk.ca

Disinfection and Preventing the Spread of Invasive Species and Disease

Alberta Invasive Species Council
https://www.abinvasives.ca

Best Management Practices for Boat, Gear and Equipment Decontamination
http://www.wisconsin.gov

Decontamination Protocol for Field Work with Amphibians and Reptiles in Canada.
http://www.cwhc-rcsf.ca

Decontamination Methods for Sampling Activities and Fieldwork
https://invasivemusselcollaborative.net/prevention/researchers-managers-prevention

Disease Strategy: Chytridiomycosis (Infection with Batrachochytrium dendrobatidis)
http://www.environment.gov.au

Interim Hygiene Protocols for Amphibian field staff and researchers
https://www.viu.ca

Interim Hygiene Protocol for Handling Amphibians: Department of Environment and Heritage Protection
https://www.ehp.qld.gov.au

Invasive Species Council of Manitoba
http://invasivespeciesmanitoba.com

Minimizing Exposure of Amphibians to Pathogens during Field Studies
Phillott, A. D., Speare, R., Hines, H. B., Skerratt, L. F., Meyer, E., McDonald, K. R., ... & Berger, L. 2010. *Diseases of Aquatic Organisms*, *92*(2-3), 175-185.

Preventing spread of aquatic invasive organisms common to the intermountain region
https://www.fs.usda.gov

Rocky Mountain National Park Aquatic Disinfection Guidelines
https://www.nps.gov

Saskatchewan Invasive Species
http://www.saskatchewan.ca

Stop the Spread
https://www.alberta.ca

Monitoring Techniques

Amphibian Ecology and Conservation: A Handbook of Techniques
Dodd, C. K. 2010. Amphibian ecology and conservation: a handbook of techniques. Oxford Biology, New York, New York

Inventory Methods for Painted Turtle and Pond Breeding Amphibians in British Columbia
https://www2.gov.bc.ca

Inventory and Monitoring: Recommended Techniques for Reptiles and Amphibians.
Graeter, G.J., Buhlmann, K.A., Wilkinson, L.R. & Gibbons, J.W. (Eds) 2013. Partners in Amphibian and Reptile Conservation Technical Publication IM-1, Birmingham, Alabama.

Saskatchewan Amphibian Auditory Survey Protocol
http://www.saskatchewan.ca

Saskatchewan Amphibian Visual Survey Protocol
http:// www.saskatchewan.ca

Techniques for Marking Amphibians
Donnelly M.A., Guyer C., Juterbock J.E. & Alford R.A. 1994. In: Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians (eds. W.R. Heyer, M.A. Donnelly, R.W. McDiarmid, L.C. Hayek & M.S. Foster), pp. 277-284. Washington DC: Smithsonian Institution Press

Permits and Conditions

Alberta Wildlife Animal Care Committee Class Protocol Amphibian Class Protocol 003

www.alberta.ca

Manitoba Environment Act Proposal Form
http://www.manitoba.ca

Manitoba Application for Wild Animal Capture Permit
http://www.manitoba.ca

Saskatchewan Research Permit
https://www.saskatchewan.ca

Wildlife Research and Collection License
https://www.alberta.ca

Setback Distances

Master Schedule of Standards and Conditions
http://www.alberta.ca

Petroleum Industry Activity Guidelines for Wildlife Species at Risk in the Prairie and Northern Region
https://www.canada.ca

Planner's Guide to Wetland Buffers for Local Governments
https://www.eli.org

Recommended Land Use Guidelines for Protection of Selected Wildlife Species and Habitat within Grassland and Parkland Natural Regions of Alberta
https://www.alberta.ca

Saskatchewan Activity Restriction Guidelines for Sensitive Species
https://www.saskatchewan.ca

**Setback distances are not available for Manitoba*

Species Identification and Species Biology

A Peterson Field Guide to Western Reptiles and Amphibians.
Stebbins R.C. and R.T. Peterson. 2003. Houghton Mifflin Harcourt, New York, New York. 650 pp.

Alberta Conservation Information Management System
https://www.albertaparks.ca

Amphibians and Reptiles
http://cwf-fcf.org

Amphibiaweb
http://www.amphibiaweb.org

ARKIVE Wildscreen Website
https://www.arkive.org

Frogs and Toads of North America
Elliott, L., C. Gerhardt and C. Davidson. 2009. The frogs and toads of North America: A comprehensive guide to their identification, behaviour and calls. Houghton Mifflin Co. New York. 343 pp.

Inventory and Monitoring
http://parcplace.org

Identifying Frogs
https://www.naturewatch.ca/frogwatch

Online Identification Guides
http://eol.org

Manitoba Conservation Data Centre (CDC)
http://www.manitoba.ca

Reptiles and Amphibians of Canada
Fisher, C.A. Joynt and R.J. Brooks. 2007. Reptiles and amphibians of Canada. Lone Pine Publishing. Edmonton, AB. 208 pp.

Salamanders of the United States and Canada
Petranka, J.W. 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington, DC, 576 pp.

Species information- Amphibians and Reptiles of Canada
http://canadianherpetology.ca

The Amphibians and Reptiles of Alberta: A Field Guide and Primer of Boreal Herpetology
Russell, A. P. and A. M. Bauer. 2000. 2nd edition. University of Calgary Press, Calgary, Alberta. 279 pp.

USGS Tadpoles of the United States and Canada: A Tutorial and Key
http://www.pwrc.usgs.gov/tadpole

Translocation Procedures

Alberta Wildlife Animal Care Committee Class Protocol 003
https://www.alberta.ca

Amphibian Husbandry Documents

http://www.amphibianark.org

AVMA Guidelines on Euthanasia
https://www.avma.org

Amphibians: Guidelines for the Breeding, Care, and Management of Laboratory Animals
http://www.ncbi.nlm.nih.gov

Best Management Practices for Amphibian and Reptile Salvages in British Columbia
https://www2.gov.bc.ca

Capture – Amphibians (Pitfall traps, Funnel Traps, and Drift Fence/Trap Arrays)
https://www2.gov.bc.ca

CCAC Species-Specific Recommendations on Amphibians and Reptiles
http://www.ccac.ca/Documents/Standards/Guidelines/Add_PDFs/Wildlife_Amphibians_Reptiles.pdf

Chiricahua Leopard Frog Recovery Plan
https://www.fws.gov

Drift fences, coverboards, and other traps. In Amphibian ecology and conservation: a handbook of techniques.
Willson, J.D., and Gibbons, J.W. 2010. Edited by C.K. Dodd. Oxford University Press, Oxford. pp. 229-245.

Herpetological Monitoring Using a Pitfall Trapping Design in Southern California
https://pubs.usgs.gov

Inventory and Monitoring: Recommended Techniques for Reptiles and Amphibians.
http://www.nwparc.org/products

Live Animal Capture and Handling Guidelines for Wild Mammals, Birds, Amphibians & Reptiles
https://www2.gov.bc.ca

Restraint and Handling of Live Amphibians
https://www.nwhc.usgs.gov

Waterbody Restoration and Habitat Management

A Guide to Creating Vernal Ponds
Biebighauser, T.R. 2002. *A Guide to Creating Vernal Ponds: All the Information You Need to Build and Maintain an Ephemeral Wetland*. USDA Forest Service.

A Handbook of Constructed Wetlands
http://water.epa.gov

Habitat Management Guidelines for Amphibians and Reptiles of the Northwestern United States and Western Canada
http://www.nwparc.org/products

Waterbody Drainage, Restoration, and Repair
Biebighauser, T.R. 2007. Waterbody drainage, restoration, and repair. University Press of Kentucky. 242 pp.

Waterbody Restoration and Construction: A Technical Guide
Biebighauser, T.R. 2011. Waterbody Restoration and Construction: A Technical Guide. Upper Susquehanna Coalition New York. 186 pp.

Appendix 3: Amphibian habitat and dispersal

Amphibian species in the Prairie Provinces can occupy various terrestrial and aquatic habitats, and these habitats can vary by species, season and by life-stage. Refer to amphibian guidebooks for species-specific habitat requirements, Table 2. and ***Appendix 2: Additional Resources** for information on species biology*.

Breeding Habitat

Breeding habitat is typically located in warm, shallow water in temporary, seasonal, permanent or artificial waterbodies. Areas of emergent vegetation are also important for many amphibian species because they provide important protection from predators. Some species will also attach eggs to vegetation to prevent eggs from drifting into cold, deeper water that may slow development or where predators may lurk, or to prevent eggs from washing up on shore in wind and waves.

Foraging Habitat

Foraging habitat varies depending on the life-stage, species, and season. For example, Boreal Chorus Frog (*Pseudacris maculate*) larvae are herbivorous, eating algae at or near the water surface (Dodd 2013). During the breeding season, adults often forage in leaf-litter adjacent to wetland breeding sites. During the non-breeding season, adult Boreal Chorus Frogs also forage in moist forested areas, upland grasslands, or old fields.

Overwintering Habitat

Overwintering habitat varies depending on the overwintering strategy employed by the species.

Freeze-tolerant amphibian species typically overwinter on land near breeding ponds, and under various objects such as leaf and plant litter, fallen logs, tree roots, and other woody debris, flat rocks, or construction materials (Storey 1990). Areas with plant litter, high groundwater levels and snow accumulation may also be essential for the winter survival of some amphibian species.

Freeze-intolerant species may occupy terrestrial or aquatic habitat during the winter. Terrestrial freeze-intolerant species burrow below frost depth to survive freezing temperatures. This makes them difficult to detect. They may be found around the roots of trees and bushes that have become hollowed from decay, in the burrows and middens of small mammals, such as red squirrels (*Tamiasciurus hudsonicus*), pocket gopher excavations (*Thomomys talpoides*) or ground squirrel colonies (e.g. *Spermophilus richardsonii*), or in areas where soil conditions are loose and crumbly, making them suitable for burrowing.

Aquatic hibernators overwinter in water with sufficient dissolved oxygen and sufficient depth or flow to prevent freezing such as rivers, streams, lakes, or waterbodies with springs. Some aquatic species or life stages, such as neotenic salamanders and mudpuppies, may be active year-round in waterbodies.

Table 2: Seasonal Habitat Characteristics and Maximum Dispersal Distances of Amphibians in Alberta, Saskatchewan and Manitoba

	Breeding Habitat				Summer Habitat				Winter Habitat			Maximum known dispersal distance (m)
Species	Temporary [a]	Seasonal [b]	Permanent [c]	Artificial [d]	Distant from Waterbody	Near Waterbody	Primary terrestrial vegetation	Primarily Aquatic or Terrestrial	Terrestrial freeze-tolerant [e]	Terrestrial not freeze-tolerant [f]	Aquatic [g]	
Boreal Chorus Frog		X	X	X		X	Grassland, Woodland	Terrestrial	X			685[i]
Spring Peeper		X	X	X		X	Woodland	Terrestrial	X (limited)			300[j]
Columbia Spotted Frog*		X	X	X		X	Grassland, Woodland	Aquatic			X[h]	<5,000[k]
Northern Leopard Frog*		X	X	X	X	X	Grassland	Terrestrial			X	8,000[i]
Wood Frog		X	X	X	X	X	Woodland	Terrestrial	X			2,530[i]
Green Frog		X	X	X		X	Grassland, Woodland	Aquatic			X	4,800[i]
Mink Frog		X	X	X		X	Grassland, Woodland	Aquatic			X	unknown
Gray Tree Frog		X	X	X		X	Woodland	Terrestrial	X (limited)			125[i]
Canadian Toad		X	X	X	X	X	Grassland, Woodland	Terrestrial		X		1,836[l]
Great Plains Toad*		X	X	X	X	X	Grassland	Terrestrial		X		1,300[k]
Plains Spadefoot	X	X	X	X	X	X	Grassland	Terrestrial		X		unknown
Western (Boreal) Toad		X	X	X	X	X	Grassland, Woodland	Terrestrial		X		6,000[i]

	Breeding Habitat				Summer Habitat				Winter Habitat			Maximum known dispersal distance (m)
American Toad		X	X	X	X	X	Grassland, Woodland	Terrestrial		X		6,437[i]
Long-toed Salamander		X	X	X	X	X	Grassland, Woodland	Terrestrial		X	X[h]	1,170[i]
Tiger Salamander*		X	X	X	X	X	Grassland, Woodland	Aquatic, Terrestrial		X	X[h]	600[i]
Blue-spotted Salamander		X	X	X	X	X	Woodland	Terrestrial		X		405[i]
Mudpuppy			X			In waterbody	-	Aquatic			X	256[i]

* Species with COSEWIC status reports, see status reports and ***Appendix 2: Additional Resources***

[a] Shallow water from spring run-off, or shallow water from heavy rains in late spring to early summer; usually applicable to dry grassland regions south of parkland

[b] Water in basin usually present until mid-July

[c] Water in basin usually present all year except during extreme drought periods

[d] Includes dugouts, borrow pits, stock dams, reservoirs, sewage lagoons and ditches providing suitable shoreline vegetation is present

[e] Overwinter near surface in leaf litter and upper soil horizon

[f] Overwinter below frost limit

[g] Require water bodies with sufficient oxygen; can include permanent ponds, lakes, streams and rivers, spring, seepage flows and artificial waterbodies

[h] Larvae may overwinter at the bottom of well-oxygenated water bodies that do not entirely freeze

[i] (Smith and Green 2005)

[j] (Dodd 2013)

[k] (Lannoo 2005)

[l] (Constible et al. 2010)

Appendix 4: Disinfecting Equipment and Hygiene

Translocation can accidentally introduce disease or invasive species through the movement of water with translocated animals, vehicles or other equipment, or moving animals between source and release sites. This can lead to loss or alteration of amphibian habitat, increased predation or competition, disease outbreaks, or negative effects on other species.

Dispose of, or clean and disinfect, all collection and transportation equipment, such as nets, buckets, traps, holding containers, waders and footwear, etc. used at sites before use at another site greater than 350 m away (Gray et al. 2017). Similarly, clean and disinfect any equipment that has come into direct contact with an amphibian before use on another individual.

- **STEP 1:** Remove mud and organic matter from equipment with a nylon bristle scrub brush and rinsing with water; continue scrubbing until equipment appears clean (*see **Figure 7: Removing Mud From Waders Before Disinfection***).
- **STEP 2**: Apply an appropriate disinfectant to all surfaces for the recommended contact duration (*see **Table 3: Disinfectant Concentrations, Exposure Times and Target Pathogens***)
- **STEP 3**: Rinse with clean municipal water, if required.
- **STEP 4**: Dispose of disinfectants following manufacturer's instructions.

Note: Dispose of water from serial water changes in upland areas at least 50 metres from waterbodies, or dispose of wastewater using municipal sewage treatment facilities. Ensure that not transferring invasive species.

When applying disinfectants, refer to SDS sheets and product instructions for information on proper handling and application, required concentration and contact time, and appropriate disposal.

Most disinfectants lose potency with time, or exposure to light or air, and should be discarded and replaced frequently (refer to SDS sheets or instructions on container). Bleach rapidly dissipates when exposed to air. Sunlight inactivates ethanol and ethanol evaporates quickly when exposed to air. Test strips are available to test the viability of many disinfectants, including bleach, Virkon™, and quaternary ammonia compounds.

Figure 8: Removing Mud From Waders Before Disinfection
(Photo by Lea Randall)

Although there are many types of disinfectants available, some may only be appropriate for use on specific materials or target specific pathogens *see* ***Table 3: Disinfectant Concentrations, Exposure Times and Target Pathogens.***

Safety and ease of use is another important consideration when choosing a disinfectant. Although household bleach is easy to obtain and very effective against multiple pathogens, it is damaging to equipment, the environment, and toxic to aquatic life. Virkon™, by comparison, is non-toxic to amphibians, humans, and less damaging to the environment once in solution.

Soaking for at least the minimum contact time is recommended for most equipment, but spray sensitive items or equipment that cannot be submersed with a disinfection solution and maintain a wet surface for the appropriate contact time (Bureau of Water Quality 2016). We do not recommend using wading boots with felt soles in wetlands, as they can be difficult to clean and disinfect. Whenever possible, allow equipment to dry completely before entering another waterbody.

Invasive Species

Invasive plants and seeds may also be introduced to new areas on vehicles and equipment. Avoid areas of infestation and wash vehicles and equipment before moving to a new area (Alberta Agriculture and Forestry 2014). Ensure waste wash is contained and does not run off into waterbodies. Monitor areas for invasive plants, and undertake control measures as necessary.

Additional precautions may be necessary to prevent the transmission of aquatic invasive species during translocation, for example, *Didymosphenia geminata (*also known as didymo), Zebra mussel (*Dreissena polymorpha*) or Quagga mussel (*Dreissena bugensis*), or parasites such as *Myxobolus cerebralis* which cause whirling disease are found in areas of the Prairie Provinces. Some information is provided in ***Table 3: Disinfectant Concentrations, Exposure Times and Target Pathogens,*** but also see ***Appendix 2: Additional Resources*** for more information on disinfection and preventing the spread of invasive species and disease.

Table 3: Disinfectant Concentrations, Exposure Times and Target Pathogens

Summary of disinfectant concentrations and exposure times effective against select pathogens and invasive species. Information adapted from Gray et al. (2017), Van Rooij et al. (2017), Murray et al. (2011), Phillott et al. (2010), Webb et al. (2007), Speare et al. (2004) and Johnson et al. (2003).

Disinfectant	Concentration	Contact Time	Target Pathogen
Disinfecting surgical equipment, scales, countertops			
Ethanol	70%	1 minute	Bd, Bsal, Ranaviruses
Virkon™	1 mg/mL	1 minute	Bd, Bsal, Ranaviruses
Benzalkonium chloride (e.g. Lysol®)	2 mg/mL	1 minute	Bd
Disinfecting collection equipment, containers, footwear, waders, boats, nets etc.			
Sodium hypochlorite (household bleach usually between 4% to 6% sodium hyporchorite)	Active ingredient 1% sodium hypochlorite (a 17% solution of 6% household bleach)	1 minute	Bd
	Active ingredient 4% sodium hypochlorite (a 67% solution of a 6% household bleach)	1 minute	Bsal
	Active ingredient 4% sodium hypochlorite (a 67% solution of a 6% household bleach)	15 minutes	Ranaviruses
	Active ingredient 0.6% sodium hypochlorite (a 10% solution of 6% household bleach)	Soak for 10 minutes, freeze overnight, dry (ideally in sun at temp 29°C or hotter)	Whirling disease, Bd, New Zealand mudsnails, the alga *Didymosphenia geminata* ("Didymo"), or Zebra and Quagga mussels[2]
	Active ingredient 3% sodium hypochlorite (a 50% solution of 6% household bleach)	Spray[1] 10 minutes, freeze overnight, dry (ideally in in sun at temp 29°C or hotter)	Whirling disease, Bd, New Zealand mudsnails, the alga *Didymosphenia geminata* ("Didymo"), or Zebra and Quagga mussels[2]
Quaternary ammonium compounds	400 ppm	10+ minutes	Bd
	1500 ppm	Soak 10 minutes	Whirling disease[3]
	3000 ppm	Spray[1] 10 minutes	Whirling disease[3]
Virkon™	1 mg/mL	1 – 5 minutes	Bd

	2 g/Litre	1 minute	Ranaviruses
F10® Super Concentrate Disinfectant	0.7 mL/Litre	1 minute	Bd
Potassium permanganate	2%	10 minutes	Bd
Nolvasan	0.75%	1 minute	Ranaviruses
Hot wash (for cloth bags and clothing)	60°C or greater	30 minutes	Bd, Ranaviruses
Heat	60°C	15 minutes	Bd
	60°C	30 minutes	Ranaviruses
	37°C	8 hours	Bd only
Complete drying footwear	NA	≥ 3 hours	Bd
Sterilising UV light (1000 mW m-2, wavelength 254 nm)	NA	1 minute	Ranaviruses

1. Only for sensitive equipment that cannot be soaked
2. Rocky Mountain National Park Aquatic Disinfection Guidelines (www.nps.gov)
3. Decontamination Protocol for Watercraft and Equipment (www.alberta.ca)

Hand Hygiene and Using Gloves

- When handling amphibians, hands and gloves must be free of lotion, sunscreen, insect repellent, hand sanitizer or other substances that amphibians can absorb through their skin.
- Keep hands or gloves moist when handling amphibians.
- Minimize handling time as oils produced by human skin may clog pores, leading to suffocation in some amphibian species (Ontario Environment and Energy).
- Use non-powdered (talc-free) single use gloves*, and rinse with dechlorinated tap water, distilled water, or site water before handling animals to reduce potential toxicity (Greer et al. 2009).
- Handling uninfected individuals with gloves that have been used to handle diseased individuals can increase the risk of disease transmission and mortality by up to 30 times (Gray et al. 2018). Change and dispose of gloves between handling separate individuals to reduce the likelihood of disease transmission.
- To reduce using gloves, some biologists handle an amphibian with a single gloved hand, or dip gloved hands into disinfectant between animals, allowing sufficient contact time of the disinfectant, and rinse gloves with clean water (Gray et al. 2017). Some biologists will forego the use of gloves if hands are clean and damp, and only a single animal is handled or hands can be properly washed between individuals (Phillott et al. 2010).

**There is debate over the best types of gloves. Latex, nitrile and vinyl gloves have all been implicated in the deaths of individuals of some species of larvae (Cashins et al. 2008). Other* *studies found no effect on mortality of amphibians and concluded that this should not be used as a reason not to wear gloves (Greer et al. 2009).*

Appendix 5: Barrier Fences

Barrier fences can temporarily or permanently keep amphibians away from project areas or sink habitats. Erecting barrier fences before amphibians begin seasonal migrations into the project area can prevent unnecessary translocations later in the year. Barrier fences can also be used as drift fences to guide amphibians into traps. ***(See Section 9.2.3 Drift Fences).***

Figure 9: Barrier Fence Constructed of Geotextile Fabric
(Photo by Jamie Sparrow, Golder Associates Ltd.)

Construct terrestrial barrier fencing along linear disturbances, or along or around waterbodies. Install water-permeable barrier fences such as geotextile fabric or silt fencing, to prevent amphibians from entering the project area (See ***Figure 9: Barrier Fence Constructed of Geotextile Fabric***).

The type and proximity of the disturbance, and intended fence longevity, influence which type of fence is most appropriate (OMNR 2013, Ministry of Transportation 2015).

Barrier Fence Considerations

- For short-term activities (less than 6 months), light-duty geotextile (e.g., silt fence) or pre-fab drift fence with the material already attached to the stakes may be appropriate. Heavy-duty geotextile fencing (e.g., double-row or trenched fencing), durable plastic, or hardware cloth fences (bird screen or galvanized mesh) are more appropriate for activities lasting 2 to 3 years.
- For long-term activities (greater than 3 years), concrete or vinyl wall fences are more durable and require less maintenance.
- Aluminum flashing should not be used as fencing material because it may become hot in the sun, which could result in injury to amphibians or personnel, or be a potential fire hazard.
- Fence material should not permit individuals to pass underneath or between openings (e.g., 0.5 centimetres hardware mesh). However, deliberate gaps in barrier fencing may allow one-way amphibian movement (e.g., one-way gates, chutes and jump-offs) to facilitate movement out of a project area.
- Fence material should not pose a risk of entanglement; avoid using geotextile fencing with nylon mesh lining as snakes can become trapped in the mesh.
- Remove vegetation, or trim on the side where amphibians frequent, to prevent climbing over the fence.

- An overhang or lip on the side frequented by amphibians can help prevent amphibians from climbing or jumping the fence.
- Avoid folds in fencing that may trap amphibians.
- Small animals may chew holes or fencing may be knocked down by larger animals. Fences should be inspected regularly for damage and repaired as required.
- Electric fencing is effective for excluding cattle and other large animals from amphibian habitat.

An Example of How to Construct a Barrier Fence

- **STEP 1:** Dig a trench (10 to 20 cm deep) to create a boundary for the exclusion or capture area (***Figure 10: Using a Self-Propelled Trencher to Install a Barrier Fence***).
- **STEP 2:** Cut fencing material (e.g., sheet metal, window screen, hardware cloth, polyethylene, shade cloth, geotextile fabric, silt fencing, etc.) to appropriate length.
- **STEP 3:** Drive fence supports (wooden, plastic, or metal) to a depth of 30 cm. Fabric is typically attached to stakes spaced 2-3 m apart, on the side opposite where amphibians travel to prevent them from climbing the fence. Pre-fab barrier fence is also available with the fence supports already attached.

Figure 10: Using a Self-Propelled Trencher to Install a Barrier Fence

- **STEP 4:** Bury the fencing 10 to 20 cm deep within the trench. The fence should be about 50 cm tall. If the substrate prohibits burial, it may be possible to backfill or weigh down the fence with heavy items such as sand bags.
- **STEP 5:** Backfill the trench and compact soil on both sides of the fence.

Appendix 6: Waterbody Drainage

Aquatic species or life stages may be encountered while draining waterbodies. Injury or death may result if aquatic amphibians are left stranded as water is removed, or when amphibians are crushed or sucked into pumps.

To avoid injuring or killing aquatic amphibians during waterbody drainage:

- Be sure to cover the opening to the intake hose with a mesh screen to prevent crushing or sucking aquatic species or life stages into pumps.
- Ensure that the screen is far enough from the intake to reduce suction.
- Place the pump inside a sump container.
- Use active net sweeps to remove amphibians before they reach the sump.
- Monitor pumps regularly to ensure that amphibians do not become trapped on the screen.

Appendix 7: Funnel and Pitfall Traps

A wide variety of passive amphibian traps have been developed by researchers over the years. Most amphibian traps are of two trap types, funnel traps or pitfall traps.

Regardless of trap type, traps must be checked frequently—at least once early in the day, and more frequently if weather conditions threaten the survival of trapped animals—to minimize the amount of time animals spend in traps, and to reduce the risk of desiccation, predation and disease transmission (CCAC 2004).

All traps must be covered, closed, or removed when not in use to prevent accidental captures. Terrestrial traps should be shaded, or positioned to avoid exposure to direct sunlight.

Funnel Traps

At their most basic, funnel traps consist of a wide, funnel-shaped tube located at one or both ends of the trap, that becomes progressively narrower and guide animals to a central holding chamber (Willson and Gibbons 2010a, Graeter et al. 2013). Once in the holding chamber, animals are unable to find there way back out through the small entrance hole. Funnel traps can be used in aquatic or terrestrial environments. There are many types of homemade and commercial funnel traps. They can be constructed of many materials, such as, nylon mesh, PVC pipe, hardware cloth, plastic bottles, etc. *See* ***Appendix 2: Additional Resources.***

An Example of How to Construct a Funnel Trap

- **STEP 1:** Cut a piece of screen to 50 centimetres wide by 100 centimetres long (length can range from 50 to 100 centimetres). Roll the long side into a tube and staple the ends together (the tube should be 25 centimetres in diameter). This tube forms the body of the trap.
- **STEP 2:** Using screen, make two funnels that are also 25 centimetres in diameter by rolling and stapling a square piece of screen into a cone shape.
- **STEP 3:** Insert one funnel into each end of the tube (flared outwards). Attach one of the funnels using staples. Attach the other funnel temporarily (e.g., with clips), to allowing access to trapped animals.

Using Terrestrial Funnel Traps

Ensure that the funnel trap abuts the drift fencing (*see* ***Figure 5: Homemade Funnel Trap and Drift Fence in a Terrestrial Setting)*** because gaps may allow amphibians to slip past the trap. Terrestrial funnel traps can be used in places where the ground is unsuitable for digging pitfall traps. Place a damp cloth, piece of moss or a sponge in trap to prevent desiccation.

Using Aquatic Funnel Traps

Aquatic species or life-stages can be captured using aquatic funnel traps such as box traps, steel or plastic minnow traps, or collapsible nylon traps (Willson and Gibbons 2010a). Aquatic funnel traps are typically cylindrical or rectangular (*see **Figure 4: Seine Net Fence with Aquatic Funnel Traps***); commercial minnow traps can be purchased in many stores that carry fishing supplies. Plastic bottles can also be used and are cheap, effective and easy to obtain.Ensure the mesh size is small enough to prevent entrapping amphibians. Sheathing an aquatic funnel trap in pantyhose makes it possible to capture even small larvae (Brian Eaton, pers. comm. October 21, 2015).

Aquatic traps should be partially submerged, but provide an airspace for adult frogs and salamanders to breathe and prevent drowning. Place a float (e.g., a piece of pool noodle) within or attached to the minnow traps to prevent the trap from becoming submerged.

Derelict or lost traps can continue to capture animals, resulting in significant loss of life, so fix traps in place to prevent drifting and attach labeled buoys to traps to help locate them. Check aquatic traps frequently for predatory macroinvertebrates such as dytiscid diving beetles, which can kill or injure small amphibians. Use seine nets or drift fence to guide amphibians into aquatic funnel traps (*see **Figure 4: Seine Net Fence with Aquatic Funnel Traps***).

Pitfall Traps

Pitfall traps work on a similar principal as funnel traps. Pitfall traps are typically sunk into that ground and animals that fall into the trap are unable to climb out. *See **Figure 11: Diagram of a Pitfall Trap***.

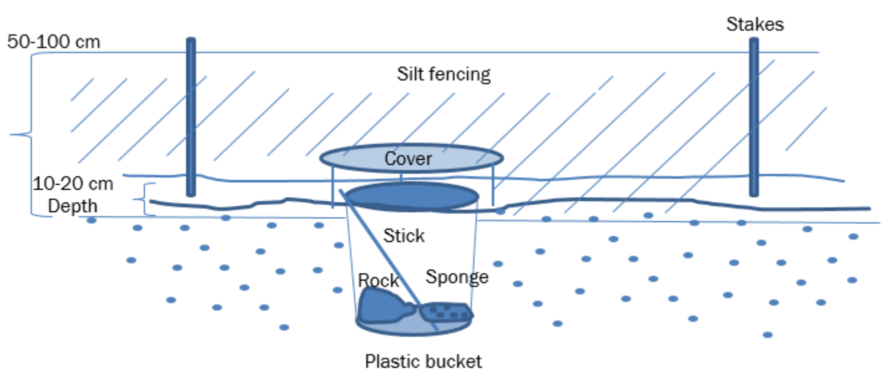


Figure 11: Diagram of a Pitfall Trap
(Adapted from Willson and Gibbons 2010)

The tops of traps should be flush to the ground, deep enough and have a lip or a funnel to prevent amphibians from climbing or jumping out (Graeter et al. 2013). Pitfall traps are usually made from a metal or plastic container (e.g., bucket or flower pots). They can range in size depending on the target species, but are usually around 5 to 10 litres (Steinhilber et al. unpublished). Larger buckets are necessary to capture large numbers or bigger amphibians; deeper buckets or buckets with a lip should be used for those species that are good at jumping or climbing (Willson and Gibbons 2010a). Check pitfall traps more often in extreme hot, dry or cold weather conditions.

Pitfall Trap Considerations

- **PREVENTING ESCAPE**: Create a lip around the edge of the container with plastic sheeting or lengths of pipe insulation zip-tied inside the trap, to prevent escape (Brian Eaton, pers. comm. October 21, 2015).

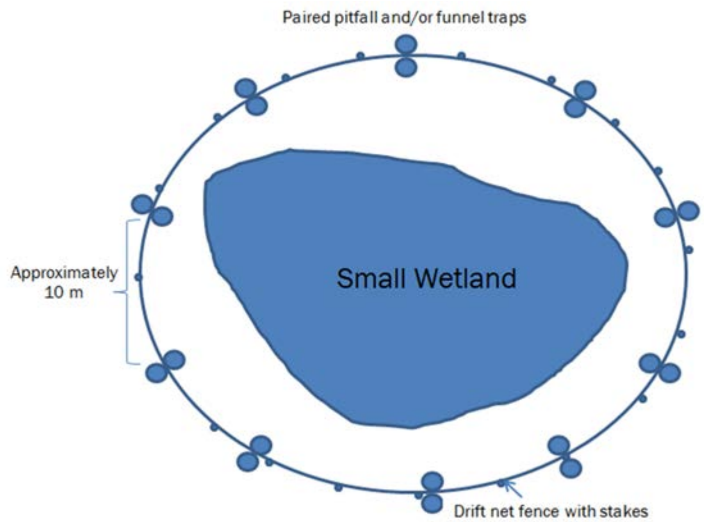


Figure 12: Diagram of Pitfall or Funnel Traps Encircling Small Waterbody
Adapted from Willson and Gibbons. (2010a)

- **FLUCTUATING WATER LEVELS:** If pitfall traps are installed in areas prone to flooding, fluctuating water levels may dislodge traps rendering them ineffective and some species may drown. Pre-drilled holes (~2 centimetres from the bottom) permit drainage and prevent the pressure of rising groundwater from forcing buckets out of the ground (Enge 1997). Small floating rafts such as pieces of Styrofoam or synthetic sponges, or objects like rocks, may prevent individuals from drowning if flooding occurs. Prevent traps from dislodging by staking down the trap (*see **Figure 6: Pitfall Trap with Plastic Cover and Stakes***).
- **COVER**: A raised plastic cover supported by stakes can exclude predators, provide protection from the sun, and keep water from accumulating in the trap during heavy rains (CCAC 2004, Ferguson and Forstner 2006). (***Figure 5: Homemade Funnel Trap and Drift Fence in a Terrestrial Setting***).
- **PREDATORS AND SMALL MAMMALS**: Place a long stick in the trap, or a knotted piece of rope or twine leading out of the trap, to allow small mammals and predators to escape.
- **MAINTAINING HUMIDITY**: If conditions are hot or dry, use a sponge or piece of moss soaked in pond water (and rehydrated as necessary) to prevent desiccation.
- **CLEANING**: Discard or clean traps and materials in traps between captures. *See **Appendix 4: Disinfecting Equipment and Hygiene.***

Trap arrays

Trap arrays can increase the likelihood of capturing amphibians. Arrays are often set to intersect known movement corridors with drift fencing between traps to direct amphibians into the trap (Willson and Gibbons 2010a). They can also be situated near waterbodies, burrows, fallen logs, or snags.

A small waterbody can be encircled by barrier fence (*see* ***Figure 12: Diagram of Pitfall or Funnel Traps Encircling Small Waterbody***). Traps can be placed at 10 m intervals along one or both sides of the fence to capture individuals travelling to or from the waterbody (Pretzlaw et al. 2002). If work is being conducted within the fenced area it may only be necessary to place traps on the inside of the fence to capture and translocate animals in the work area.

Trap arrays can have various configurations, depending on the structure of the habitat and number of traps (e.g., X, Y or 3- or 4-fence; *see* ***Figure 13: Different Configurations of Barrier Fences and Trap Arrays Constructed of Galvanized Mesh with Snake Funnel Traps***). Traps are usually placed at the ends of the fence without a gap, or at shorter intervals if fences are longer than 10 metres.

Figure 13: Different Configurations of Barrier Fences and Trap Arrays Constructed of Galvanized Mesh with Snake Funnel Traps
(Photos by Andrew Didiuk)

When not in use, close or remove traps and fences, or leave a segment of the fence open to allow passage (Steinhilber et al. unpublished). *See* ***Appendix 2: Additional Resources.***

Appendix 8: Transporting and Holding Amphibians

Amphibians should be transported and held in containers of suitable size and at an appropriate density, depending on their life stage, size, and species requirements. Holding involves temporarily containing amphibians and releasing them at the capture site once the project has been completed.

Captive animals must not be held for periods longer than five days, unless cared for in a licensed facility, such as a wildlife rehabilitation facility, university-run CCAC approved animal care facility, or a CAZA-accredited zoo (check with your provincial regulator for approved facilities).

Transporting or holding diseased animals with uninfected individuals for even short periods of time (e.g., 15 minutes) or reusing contaminated gloves can raise the risk of disease transmission (Gray et al. 2018). All stages of capture and holding must use clean equipment and proper hygiene. *See **Appendix 4: Disinfecting Equipment and Hygiene.***

Aquatic Species and Life-stages

In general, aquatic species or life-stages should be transported and held in a similar manner to live fish. The recommendations in the following bullets are adapted from Sredl and Jennings (2007), IATA (2001), (CCAC 2004), IATA (2017).

- Bags and containers should be single-use or containers should be disinfected between uses (*see **Appendix 4: Disinfecting Equipment and Hygiene).***
- Aquatic species or life-stages may be transported in breather bags, aquarium bags, or a food-grade plastic container with a secure fitting lid.
- We recommend using breather bags to transport aquatic species or life-stages. Breather bags can be filled to the top with water to prevent sloshing and facilitate air exchange (https://aquaticarts.com/products/breather-bags-10).
- Aquarium bag should be at least 0.03 mm thick and can be filled with 80% source water and 20% well-pressurized air to facilitate gas exchange.
- Use double bags and seal each bag independently. Fasten bags by twisting the top and folding over on itself so that it can be sealed with an elastic band, or plastic or metal clips to prevent leaks. Turn the inner bag upside-down within the outer bag to prevent creating corners that could trap or crush larvae or use round-cornered bags.
- Bags should be transported in a sturdy outer container with no sharp edges or staples that could puncture the bag.
- Carry extra water during transport in case containers or bags leak.
- Aquatic species and life-stages can be held in food-grade plastic containers, aquaria, kiddy pools, cattle troughs, and aquaculture tubs are good for holding. Metal containers can be used if lined with a “fish safe” PVC or plastic pond liner.
- Do NOT use cardboard boxes as transport or holding vessels because they degrade when wet.

- If not using breathing bags for transporting aquatic species or life-stages, periodically open the transport container or aquarium bag and conduct water changes during transport to maintain dissolved oxygen and prevent the accumulation of metabolic waste products (NRC 1974). Water can also be oxygenated with oxygen from a medical cylinder prior to transport, if available.
- Aquatic amphibians should be transferred from bags to containers if necessary to facilitate ventilation, water changes, or feeding (if required) while holding. Transfer aquatic species or life-stages to holding container with greater surface area and volume to help maintain water quality and dissolved oxygen at required levels. Dissolved oxygen can be increased by gently aerating using an airstone and aquarium pump.
- Dead larvae, eggs covered in fungus, or uneaten food must be removed to prevent ammonia levels from rising and to reduce risk of disease transmission.
- Water depth should be greater than 10 centimetres for fully aquatic species or life stages and less than 10 centimetres for metamorphosing larvae. Metamorphosing larvae should be provided with dry areas or containers should be placed on an angle so that they do not drown (CCAC 2004).
- Ensure that there are no loose objects in containers that could move and crush amphibians during transport or holding.

Using mesh enclosures for holding eggs and larvae

Use mesh enclosures to anchor eggs or larvae near the surface in warm water, to ensure rapid development and to help protect them from predators such as dragonfly larvae or leeches, fish, or birds. Various designs and materials can be used to construct enclosures (see ***Figure 14: Enclosures Used for Northern Leopard Frog Eggs or Tadpoles***), but typically, a fine mesh bag is suspended within a support structure.

Figure 14: Enclosures Used for Northern Leopard Frog Eggs or Tadpoles
(Photos by Parks Canada and Calgary Zoo)

- Construct mesh enclosures so that larvae are unlikely to become entrapped in mesh or in seams or folds.

- Ensure the mesh bag is shallow enough to keep eggs or larvae near the water surface. If eggs are attached to vegetation, use clips to attach the vegetation to the side of the enclosure.
- Attach a cover to the top of the enclosure to prevent predation from above, and to prevent accidental release of eggs if tipped or submerged.
- Place enclosures in shallow, warm water that will not dry before hatching, and tether enclosures in place to prevent them from drifting into deep water or being washed ashore.
- Place enclosures in a location where they are unlikely to be trampled by cattle or other wildlife, and monitor them frequently to ensure that water levels do not drop and so that larvae are not held longer than necessary.
- If water levels may change suddenly, attach the enclosures to a float and tether them in place so they can rise or fall with changing water levels.
- Monitor eggs in enclosures every two days, and release larvae once they are free-swimming (great than Gosner stage 26).

Serial Water Changes

Maintaining water quality is the biggest challenge for transporting and holding aquatic species and life-stages. Water quality can decline as metabolic wastes and food waste accumulate in the water or as dissolved oxygen is used. For more information on water quality parameters, see Sredl and Jennings (2007) and NRC (1974). Maintain water quality and dissolved oxygen during transport or holding using serial water changes:

- Use water from the source or release site, or use tap water treated with a chemical conditioner to remove chorine and chloramine for water changes. Do no use deionized or distilled water.
- Eggs or larvae should have daily water changes. If the container is aerated, perform 10% water changes daily, if there is no aeration, perform 50% water changes daily. Aquatic sub-adult and adult amphibians should have 100% water changes every 2 days. These recommendations assume that suggested stocking density is followed. More frequent water changes may be required if animals are held at higher stocking density or if water quality deteriorates.
- Water from source site should be disposed of in upland areas that are at least 50 metres from waterbodies at release site or in disposed of using municipal wastewater facilities.

Terrestrial Species and Life-stages

The recommendations in the following bullets are adapted from Sredl and Jennings (2007), IATA (2001), (CCAC 2004), IATA (2017).

- Containers should be single-use or containers should be disinfected between uses (*see* ***Appendix 4: Disinfecting Equipment and Hygiene).***

- Transport and hold terrestrial amphibians in food-grade plastic storage containers with moist substrate and a secure fitting lid to prevent escape.
- Substrate should not be abrasive or toxic such as moss, damp sponge or unbleached paper towel. Substrate should not be too wet as the weight could smother a small amphibian.
- Dispose of substrate if soiled and replace between uses to minimize risk of disease transmission and to maintain hygienic conditions.
- Limit container height and width for terrestrial anurans to prevent injury caused by jumping inside the container. Anurans less than 15 centimetres long should have a maximum of 2 centimetres of clearance above their head, and larger individuals should have a maximum of 2.5 centimetres.
- Pack containers lying flat.
- Containers must have adequate ventilation.
- Prior to placing amphibians in the container, make ventilation holes (approximately 0.5 centimetres) in the tops and sides of containers. Create holes from the inside out to avoid forming sharp edges which may injure animals. Drill or melt holes in plastic containers using a tool such as a soldering iron in a well-ventilated area.
- Ensure that ventilation holes are not blocked if stacking containers.
- Ensure that there are no loose objects in containers that could move and crush amphibians during transport or holding.

Feeding

- Eggs and recently hatched larvae (less than Gosner stage 26 or not free-swimming) do not require feeding.
- If larvae greater than Gosner stage 26, or free-swimming, are held longer than a day they will need to be fed. Fish flakes, lightly boiled greens (e.g., romaine lettuce, kale, chard, spinach) or ground rabbit pellets work well for feeding most anuran tadpoles; larval salamanders and Plains Spadefoot are carnivorous and will eat brine shrimp or blood worms (CCAC 1984).
- Sub-adult and adult amphibians in good condition should be able to tolerate brief periods (5 days or fewer) without food.

Maximum Stocking Density

Avoid overcrowding while transporting and holding amphibians to reduce physiological stress, accumulation of waste materials, and the risk of disease transmission (Denver and Crespi 2006).

Individuals from different sites, of different size classes or species, salamanders and spadefoot larvae, should be transported and held in separate containers to reduce predation, cannibalism, and disease transmission (CCAC 1984).

The following stocking densities are recommended but may be unnecessary if travel time is short (i.e., less than 6 hours) and appropriate conditions are maintained. However, if transporting at higher density, or for longer duration, it will be necessary to conduct more frequent water changes. This maximum recommended stocking density assumes that water quality is monitored and maintained.

The following are the maximum recommended stocking densities for transporting (CCAC 2004, Sredl and Jennings 2007):

- Containers for transporting amphibians may vary in size depending on the size of the individual(s) being transported. As a guide, containers must be large enough to allow the entire ventral surface of every animal to contact the bottom of the container.
- 1 egg mass per 4 litre bag or container.
- Up to 25 larvae under 1.25 centimetres (total length) per 4 litre bag or container.
- Up to 15 larvae 2.5 to 3.8 centimetres (total length) per 4 litre bag or container.
- 1 large anuran with snout-vent length over 15 centimetres or salamanders over 30 centimetres long can be housed per container. Transport container should be 5 liters or larger.
- Up to 20 medium anurans with snout-vent length of 6 to 15 centimetres or salamanders 15 to 30 centimetres long can be housed per container.
- Up to 40 small anurans with snout-vent length of 3 to 6 centimetres or salamanders 6 to 15 centimetres long can be housed per container.
- Up to 50 very small anurans with snout-vent length less than 3 centimetres or salamanders less than 6 centimetres long can be housed per container.

Maximum stocking density should be less for holding than for transporting amphibians. As a general recommendation, amphibians should be held at a density less than 1/3 the recommended transport density but personal judgment will be required if this does not seem like enough room.

Two-gallon (approximately 7-litre) cooler containers (*see* ***Figure 15: Two-Gallon Cooler***) filled two-thirds full of water have been used to safely transport up to 300 recently-hatched, free-swimming northern leopard frog tadpoles for up to five hours (Barb Houston, pers. comm. June 23, 2015). Recently hatched, free-swimming tadpoles (approximately Gosner Stage 26) of northern leopard frogs have also been safely transported for up to six hours at densities of about 200 tadpoles in three-gallon (approximately 11-litre) aquarium bags (***Figure 16: Transporting Tadpoles in Aquarium Bags in a Styrofoam Cooler***) without water changes (Lea Randall, personal observation). Bags were opened periodically to monitor dissolved oxygen and to release carbon dioxide.

Figure 15: Two-Gallon Cooler
Used for transporting up to 300 recently-hatched northern leopard frog tadpoles (Photo by Lea Randall).

Temperature

Temperature should be maintained during transport within the range of temperatures occurring at the time of collection (Wind and Team 2002) or slightly cooler to reduce activity and risk of injury to amphibians.

Except during hibernation, optimal temperature for holding eggs, anuran larvae, and adult salamanders is 18 to 20°C, 10 to 12°C for larval salamanders, and between 22 and 25°C for sub-adult or adult anurans (NRC 1974, CCAC 1984). During hibernation, freeze-intolerant amphibians should be held between 2 to 4°C, and freeze tolerant amphibians between -1 to -2°C. Amphibians should not be exposed to temperature changes greater than 1°C/hour (NRC 1974). A temperature probe with an external readout can be used to monitor the temperature in the transport container.

Figure 16: Transporting Tadpoles in Aquarium Bags in a Styrofoam Cooler
Dissolved oxygen and temperature is monitored (Photo by Lea Randall)

Transport amphibians inside a climate-controlled vehicle, but if not possible:

- **Cool amphibians in hot conditions** by placing ice packs or several inches of ice at the bottom of a cooler with a false bottom or a Styrofoam sheet between the ice and the amphibians (Sredl and Jennings 2007).
- **Warm amphibians in cold conditions** by placing a hot water bottle under Styrofoam or wrapped in insulating layers of towels to maintain temperatures in the container.
- **To maintain temperature conditions**, amphibians may be stored in coolers or in insulated foam shipping containers, or placed in water where they cannot become completely submerged or float away, as appropriate.

Reduce Stress

Transport stress increases with journey time and rough handling and water movement (Phillott et al. 2010).

- Reduce movement during transportation by cushioning empty spaces between containers using towels, blankets, newspapers etc. and restraining containers.
- Select a route or type of vehicle that lowers both the risk of injury from bumpy roads and the time or distance travelled.
- Keep containers in a cool, shaded, or dark area with minimal disturbance from movement or noise.
- Perches and hiding places above and below the water surface in holding containers (e.g., rocks, PVC tubes, ceramic flower pots, etc.) or floating vegetation may help reduce stress and prevent drowning in some species.

Appendix 9: References

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