BEST MANAGEMENT PRACTICES FOR AMPHIBIAN AND REPTILE SALVAGES IN BRITISH COLUMBIA

Version 1.0

Ministry of Forest, Lands and
Natural Resource Operations

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DISCLAIMER

This document summarizes the most current information available regarding best management practices for amphibian and reptile salvages in B.C. Updated editions of this document will be published as our scientific understanding of this subject increases, and as methodologies are improved and refined. Following the guidance in this document does not remove the obligation of due diligence by qualified professionals, who at all times retain their responsibility to follow all applicable laws and regulations, as well as the code of ethics of their professional associations.

SUGGESTED CITATION

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1 BACKGROUND

1.1 Introduction

Amphibians and reptiles ("herpetofauna") occur in all 9 regions of British Columbia (B.C.), the majority of which are classified as Species at Risk (CDC 2014, Appendices 1, 2A, & 2B; Figure 8). Herpetofauna in B.C. frequently are in conflict with industrial development activities, as their occupied habitats often overlap with those that are also favorable for human use. Many of the life history and physiological characteristics of herpetofauna cause them to be particularly susceptible to human disturbance, including habitat site fidelity, dependence on both aquatic and terrestrial habitats, and vulnerability during periods of dormancy.

All native amphibians and reptiles are designated as “Wildlife” in B.C., giving them full protection under the *Wildlife Act* (Section 2.1). As such, any development project located in or near habitats occupied by these wildlife must take measures to avoid killing or injuring these animals. Avoiding the impact should always be the first option considered (Section 1.2). If the impact cannot be avoided, a permit must be obtained to capture, hold, and relocate these wildlife to a safe location (summarized as a "salvage operation").

Amphibian and reptile salvages have become more common in recent years, due to increased conservation concern for this group, combined with increased efforts by the provincial government to ensure regulatory compliance with the *Wildlife Act*. Unfortunately, the same characteristics that make herpetofauna vulnerable to development also causes them to be susceptible to salvage operations. As such, standardized best practices for amphibian and reptile salvages have been widely recognized as an urgent need by resource professionals, government and the private sector in B.C. The objectives of this document are to:

1) Provide guidance for the avoidance of salvage operations;
2) Provide guidance for the safe and efficient capture, handling, translocation and release of herpetofauna that minimizes impacts to both translocated and recipient populations;
3) Facilitate an effective and efficient permitting process by clarifying expectations and supporting consistent salvage implementation, and
4) Ensure that the activities associated with development projects do not violate the *Wildlife Act.*

1.2 Avoidance

Avoidance of salvage operations is the only way to eliminate any possibility of project-specific impacts to wildlife. Salvages are conducted to avoid injury, morbidity or mortality to wildlife caused by development activities, in order to ensure compliance with the *Wildlife Act*. However, given that salvage operations may themselves lead to injury and reduced survival of animals (Section 1.3), capture and translocation should be considered as a last resort only. **Before a decision is made to undertake a salvage operation, the site should be carefully evaluated for the presence of wildlife, and if present, all options to avoid the impact should be considered first.**

The preferred avoidance scenario is to redesign development activities so that they exclude the exposure of amphibian and reptiles to impacts (e.g. use of exclusion fencing prior to expected arrival of amphibians at a breeding site; see Table 1), or to relocate the project away from occupied habitats, thereby eliminating the need for a salvage. Avoidance can be the most cost-effective development option, but it requires prior planning well before the start of construction (Section 4). Avoidance can also avoid project delays associated with unanticipated permit requirements that can arise in later phases of project development.

While salvage operations are considered an (imperfect) measure to mitigate wildlife mortality, **salvages should not be considered as mitigation for habitat loss or degradation**. Salvages themselves do not act to protect or enhance habitat, and projects that require wildlife salvage typically result in habitat loss and degradation, leading to a net reduction in habitat availability within the landscape in which the project occurs. Mitigation options, including habitat restoration and offsetting, should be considered separately, as per the Environmental Mitigation Policy (MOE 2014)[1].

1.3 Potential impacts of Salvage

While there has not been an abundance of research assessing the effectiveness of herpetofauna salvages, evidence suggests that success is poor, or uncertain at best. In a review of amphibian and reptile translocations, the survival of released animals was poor for those motivated by human-wildlife conflict (Germano and Bishop 2008). This is exemplified by a mitigation effectiveness study on the Sea to Sky Highway (Malt 2012). In an impacted wetland where 332 Red-legged Frogs were salvaged and relocated pre-construction, Malt (2012) estimated an 87% population reduction 3 years post-construction. Even under ideal conditions with application of appropriate methodologies, the capture, handling, transport and release of herpetofauna can cause negative impacts to both salvaged and recipient populations.

Potential impacts on salvaged animals include: 1) injury, morbidity or mortality due to stress, cannibalism, desiccation or temperature extremes experienced during capture and holding or after relocation; 2) reduced survival at relocation release sites due to competition with existing host populations; or 3) increased mortality while crossing roads and other modified landscapes while attempting to return to capture sites.

Potential impacts of salvages on recipient populations include: 1) genetic impacts such as disruption of local adaptation, reduction of evolutionary potential, and outbreeding depression when salvaged animals are transported large distances (Gibbs and Reed 2007); 2) spread of diseases and/or invasive organisms such as chytridiomycosis (*Batrachochytrium dendrobatidis*), Ranavirus, Saprolegnia, as well as invasive wetland plant species such as Eurasian watermilfoil (*Myriophyllum spicatum*) and purple loosestrife (*Lythrum salicaria*); 3) changes to food web dynamics (Wyman 1998, Smith et al. 1999); or 4) reduced survival and population growth due to increased competition for limited resources after the release of new animals ("density dependence").

[1] Available at: http://www.env.gov.bc.ca/emop/

Review on Translocation: Based on an assessment of 85 amphibian and reptile translocation studies, Germano and Bishop (2008) found that the survival of released animals was poor for translocations motivated by human–wildlife conflict [i.e., salvages]. "Translocations are not an easy solution to these problems and should not be suggested as a first step in dealing with the conflicts between people and animals. Problem animals and animals whose habitats are to be developed for human use need to be dealt with either through preventative measures or by holding the organizations moving the animals accountable for the results. If animals must be moved for development mitigation, it is essential to consider the strong homing instincts of herpetofauna and the need for appropriate release habitat both in size and quality."

1.4 Types of Amphibian and Reptile Salvages

1.4.1 Capture and Release

This type of salvage involves capturing wildlife prior to the onset of construction activities and holding the individuals under suitable conditions during project works, followed by the release of the animals into the same habitat post-disturbance. In theory, this type of salvage may have the least spatial and temporal impacts on local species, populations, and habitats. This type of salvage is most appropriate where the holding period is of relatively short duration, and where the habitat suitability of the salvaged site is being maintained or improved for the target species.

1.4.2 Capture and Relocate (within project area)

In this type of salvage individuals are moved outside of the area of impact to a nearby site within the same general habitat or in relatively close proximity to the salvage site (e.g., within daily or season movement distances). Often, temporary exclusion fencing is installed to prevent the salvaged individuals from returning to the work area during construction. Upon completion of the project work, the fencing is removed and the habitat is again made accessible to the amphibian and reptile species. This type of salvage is expected to have limited spatial scope of impact or risk to the target species, population, or habitat.

1.4.3 Capture and Relocate (outside of project area)

In this type of salvage individuals are moved outside of the area of impact, often a relatively large distance away from the salvage site. This type of salvage is usually conducted where the physical scope of the project is large and will result in the permanent loss of habitat for the target species (i.e., for the life of the project). These types of projects usually involve the destruction of native habitat (e.g., the infilling of wetlands, etc.), and will have permanent spatial impact to the target species, population, and habitat.

1.4.4 Incidental Salvage

These salvages occur when pre-surveys have indicated species presence but there are no habitat features (e.g., wetlands or dens) or concentrated areas of project construction or activity that coincide with high densities of animals. In this case the Quaified Environmental Professional (QEP; see Section 2.3) obtains a Wildlife Handling and Transport Permit to enable them to move incidentally encountered animals out of the direct path of mortality.

1.4.5 Emergency Salvage Operations

Due diligence by QEPs requires that appropriate inventory and planning is conducted prior to development activities in order to avoid harm to wildlife, and that the required permits are obtained should a salvage be deemed necessary. However, in rare circumstances an "emergency salvage" is required due to an unexpected event, in which case a Regional Wildlife Officer must be contacted for permission *in lieu* of an official permit. If permission is granted, the qualified professional must still apply for a permit under the standard process, even if this is received after the salvage is complete. It may be necessary to capture and temporarily hold animals before being relocated and released (e.g., while appropriate release sites are identified; see Section 7.1). **Proper planning and inventory should be conducted to limit the need for emergency salvages to the greatest extent possible.**

Emergency Salvage Scenarios

Newly metamorphosed Western Toads (*Anaxyrus boreas*) disperse en masse in mid to late summer as they leave their natal wetlands for upland habitats. Unexpected toadlet migrations have been observed suddenly arriving at construction sites or across newly-built roads. Inconspicuous habitat features can also be missed in the assessment stage, and may not be discovered until the onset of construction (e.g., a snake den along the side of a road or in the rip-rap boulders of a dike).

2 REGULATORY FRAMEWORK

2.1 BC Wildlife Act

All native animal species in the province, excluding invertebrates and fish, as well as several non-native species, have been designated as wildlife, giving them full protection under provisions of the *Wildlife Act*, RSBC 1996, Chapter 488 (Province of BC, 2014). Unless authorized by the province, **it is an offence to hunt, trap, wound, or kill wildlife at a time not within the open season** (Section 26(1c). For species without an open season, such as amphibians and reptiles, these activities are therefore prohibited without a permit. It is also an offense to capture, possess, or transport wildlife without authorization (Sections 29, 33, and 37). Under the *Wildlife Act* Permit Regulation, a regional manager may issue a permit authorizing QEPs to conduct these activities for certain purposes [Section 2c]. Permits to conduct salvage activities fall within "scientific purposes" [Section 2c(i)]. Most non-native amphibians and reptiles are exempted from the above protections and are categorized as Schedule C wildlife as per the Designation and Exemption Regulation. Humane euthanization of these animals is required in most cases (See Section 8.2).

2.2 BC Water Act

Salvage operations that require the alteration of water levels or flows (i.e., dewatering of a pond or stream that is to be in-filled) will require authorization or notification under Section 9 of the BC *Water Act* [2].

2.3 Professional Reliance

A wildlife salvage operation must be conducted by a QEP. A QEP is defined as "an applied scientist or technologist... [who is] registered in British Columbia with their appropriate professional organization, and acting under that association's Code of Ethics and subject to disciplinary action by that association, and...who, through demonstrated suitable education, experience and accreditation and knowledge relevant to the particular matter, may be reasonably relied on to provide advice within their area of expertise" (BC MOE 2009).

The BC College of Applied Biology Code of Ethics includes the obligation to "*undertake assignments...only in areas in which they are competent*", and to "*ensure they meet a professional standard of care by practicing applied biology with.... due diligence*" (CAB 2014[3]). In this case, it is expected that the qualified professionals will have expertise in the ecology, physiology, and conservation of herpetofauna, and experience in their inventory and impact assessment, planning of wildlife salvages, and the capture, handling, transport, and release of these animals. Applying the principles and best practices in this document, in combination with their professional judgment, will help to ensure that professionals meet standards of care and ensures due diligence, which includes expending the appropriate level of effort and consulting with experts. Professionals which do not meet the standard of care are subject to complaints filed by other members of the College, and the possibility of disciplinary action by the College if these complaints are found to have merit.

If the project lead has insufficient qualifications to provide a professional standard of care, they may need to retain the services of a QEP with demonstrated competence in herpetology, including specific knowledge of, and experience with, the affected species.

[2] More information, including application details and best practices, can be found at: http://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-licensing-rights/working-around-water

[3] Available at: https://www.cab-bc.org/file-download/code-ethics

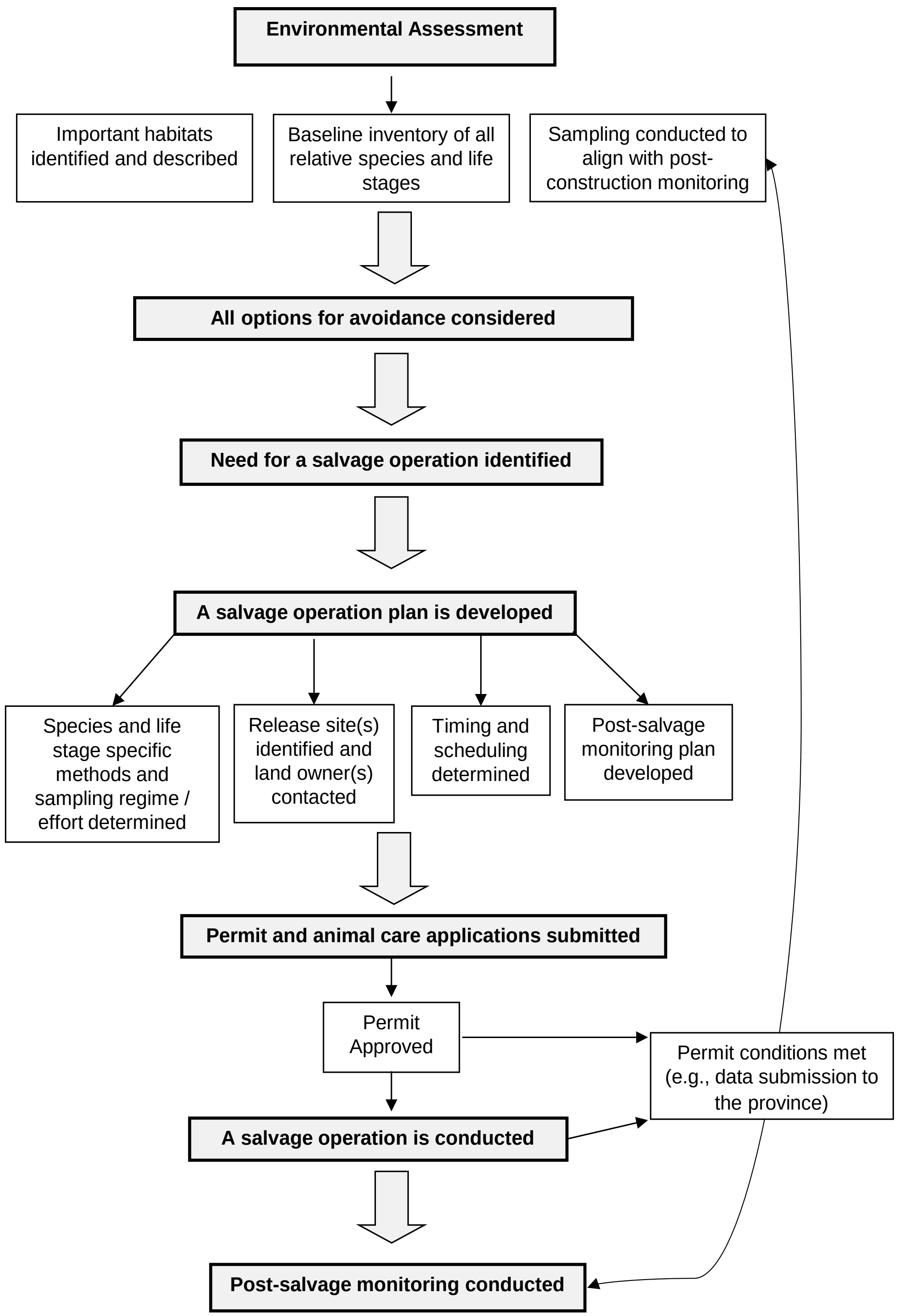

Figure 1. Flowchart illustrating the processes involved in a salvage operation.

2.4 Federal Species at Risk Act

Permits are required by those persons conducting activities on federal lands that may affect species listed as extirpated, endangered, or threatened on Schedule 1 of the federal *Species at Risk Act*, and which contravene the Act's general or critical habitat prohibitions. For more information regarding federal permits, refer to: http://www.sararegistry.gc.ca/sar/permit/permits_e.cfm.

3 PERMITTING PROCESS

Applicants must submit the following to Front Counter British Columbia (FCBC) via mail, or in person, or online at http://www.frontcounterbc.gov.bc.ca/Start/fish-wildlife/, in order to receive an authorization permit under the *Wildlife Act*:

- *General Permit Application* – this application requires information such as project location, permit status, proposed activity, and permit type required.
- *Detailed project proposal* – this should be attached as an Appendix to the General Permit Application, and include a detailed description of proposed activities, parameters that indicate when a salvage effort is considered complete (e.g. when to stop looking for animals), as well as a site map specifying locations of salvage operations, release site(s), and the project footprint (see checklist below).
- *BC Animal Care Form* – this form requires additional information regarding: Canadian Council on Animal Care invasiveness category; expected species and estimated number of animals captured/handled; details of capture and release (including locations), handling and surgical procedures and final disposition; contingency plans (mandatory as accidents can happen at any time), rehabilitation, treatment and field euthanasia protocols as required in contingency plans, and information regarding potentially controversial procedures. The Animal Care Application should be a stand-alone document with all the necessary information integrated within the form (as specified by the checklist below). The ACA is reviewed separately from the General Permit by the provincial Animal Care Committee.

Salvage Permit Information Checklist – this provides explicit guidance regarding required items to be included in the forms above. Key sections that are often inadequately addressed are highlighted to ensure the application is complete before submission, in order to avoid delays associated with government requests for more information in order for regional provincial and regional biologists to complete a thorough review.

These materials can be found at:
http://www.frontcounterbc.gov.bc.ca/guides/fish-wildlife/general-permit/overview/

FCBC contact information can be found a:
http://www.frontcounterbc.gov.bc.ca/locations/index.html

Applicants must include payment of the application fee when applying for a permit. The General Permit Application and the Animal Care Application are reviewed separately. The information provided in the Salvage Permit Information Checklist must be provided in both applications. It takes approximately six weeks to process an application, but the process may take longer if additional information or clarification is needed during the review process. *Permits can be expedited under urgent circumstances for an additional fee.*

In most cases, a single permit will authorize a single salvage project, and **applications for permits that cover multiple different projects (or across multiple regions) are discouraged**. However, a single permit for multiple salvages may be appropriate for large projects where the methods and circumstances of each salvage are similar (e.g. highway construction or hydro right-of-ways). Nonetheless, these applications must still include the details for every site where salvage will occur (as per information checklist noted above). Permits for multiple sites may also be issued when the project primarily involves incidental salvage (Section 1.4.4), or when the level of impact to wildlife is expected to be low. Low-impact projects include those that do not include habitat loss or degradation, where no species of conservation concern are present, and where the number of impacted animals is expected to be low.

Permit holders are strongly advised to carefully read the terms and conditions specified within their salvage permits. These include the use of standard methods, submission of data to the provincial government, and application of proper hygiene, capture, and handling protocols. Failure to adhere to permit conditions is a violation under the *Wildlife Act* and may hinder authorization of future permit applications.

4 PLANNING FOR A SALVAGE OPERATION

4.1 Baseline Inventory and Assessment

Targeted inventory surveys for amphibian and reptile species, with the appropriate level of effort and timing, is the foundation of planning a effective salvage operation. Typically, inventory will already be part of the environmental assessment (EA) conducted by development proponents to support permit applications, whether part of a formal application for an Environmental Assessment Certificate, or as baseline studies for smaller projects (Figure 1). While this document is not intended to provide guidance on how to conduct EAs, inventory and assessment considerations that directly apply to salvage operations are highlighted below.

The following are key inventory considerations that will help to facilitate the permitting process and maximize the effectiveness of a salvage operation:

- **Determine required level of effort and appropriate survey timing beforehand.** A review of the scientific literature, survey standards (i.e. RISC[4]), occurrence records from the BC Conservation Data Centre and Wildlife Species Inventory databases and consultation with

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[4] Guidelines include inventory methods for: Pond-breeding Amphibians and Painted Turtle, Tailed Frog and Pacific Giant Salamander, Plethodontid Salamanders, and Snakes.
RISC standards can be found at:
http://www.for.gov.bc.ca/hts/risc/pubs/

local species experts will help to determine the appropriate level of effort and timing to maximize detection probability of species that occur within the project area. **As a general "rule of thumb", a minimum of three repeat surveys conducted during the appropriate active season(s) is required before absence is considered probable** (Appendix 4).

- **Conduct surveys using a variety of techniques.** For many species, especially amphibians with biphasic life cycles, the probability of detection increases with the number of survey techniques employed during the appropriate season. Specific species and life stages may only be detectable using certain techniques (see Appendix 5). Inventory effort should be standardized in order to compare across habitats and populations, to estimate the number of animals to be salvaged as per permit application requirements, and to act as a baseline for post-salvage monitoring. Inventory methods should also ensure that specific microhabitats where animals are most likely to be found are sampled (e.g. stratified random sampling). These methods will also help to identify potentially important habitats for amphibians and reptiles in order to avoid those areas during development (e.g., rock outcrops, wetlands, creeks).
- **Place the population of interest into a landscape context.** This will help determine the relative "importance" or "uniqueness" of the local population to be impacted, as well as its' connectivity to surrounding populations.
- **Conduct a comprehensive risk assessment.** This should be conducted in advance of considering a salvage operation (IUCN 2012).

4.2 Salvage Timing and Effort

Salvages should be scheduled for the time of year when the least number of species and life stages will be impacted. The focus should always be to minimize impacts to reproductively mature adults within the population, as impacts to this life stage typically causes the greatest effect at the population level.

As such, there are two main strategies to determining salvage timing[5]:

- **Optimize detectability and capture rate.** This strategy is preferable when salvage is required due to permanent habitat loss. For example, for an amphibian salvage of a pond where individuals will be relocated to a newly-created compensation site, timing operations to coincide wih the presence of egg masses or larvae will help to facilitate imprinting within the new habitat.
- **Minimize number of species and life stages impacted.** Scheduling the salvage for when the fewest number of species and individuals are present may be appropriate when habitat impacts are temporary. For example, for an ephemeral wetland breeding site (e.g., that dries by late summer), scheduling operations for the fall will ensure that works occur when

[5] Appendix 4 outlines the active season for BC's amphibians and reptiles (i.e., when high densities can be observed within suitable habitats). Note that timing of the active season varies by latitude, elevation, and yearly weather variation. The breeding season for some amphibian species can vary by as much as a month from year to year depending on spring air temperatures

the fewest species are present. By this time, larvae will have emerged and dispersed, and few, if any, adults will be present at the site.

Due to the sensitive nature of hibernation, Wildlife Act Permits may not be issued for salvage operations scheduled to take place once amphibians and reptiles have begun to overwinter (e.g. Cariboo Region salvage activities must be completed by September 30th)

To optimize capture rates, trapping should begin well in advance of project works. However, where the ideal timing window is not possible due to safety, environmental conditions or other extenuating circumstances, additional effort or alternative techniques may be required. Deploying 50 aquatic funnel traps instead of 25 may result in fewer trap nights required to capture and remove all amphibian larvae. (That being said, shortening the capture period increases the risk that capture rates will be impacted by unpredictable circumstances such as extreme weather.) Under an emergency salvage scenario where a salvaged must be conducted quickly, as many people, traps, and capture methods should be employed as possible to maximize the number of animals caught and removed. Tables 1 and 2 provide some general guidelines regarding alternate strategies and amount of effort required under various scenarios.

Table 1. Possible salvage strategies in relation to example project works.

Impact	**Project Timing Flexible**	**Project Timing not Flexible**
Road mortality during construction	• Time project works for low activity periods (late fall through late winter).	• Install exclusion fencing and pitfall traps; manually re-locate animals to safety. • Underpasses at road crossing hotspots may be needed in cases of permanent road impacts.
Partial wetland / pond infilling	• Time project works to low activity periods (late summer to fall; or winter if no aquatic overwintering adults). • For permanent water bodies that contain developing young or hibernating individuals, a salvage should be scheduled to take place before animals overwinter (i.e., in late summer).	• Construct exclusion fencing around the wetland prior to construction to minimize number of animals moving into construction zone. • Conduct an extensive salvage operation and move animals to a new site well before overwintering (e.g., in late summer). • Exclusion fencing may be needed to avoid animals moving back into the site before winter.
Impacts to a communal snake den	• If disturbance is temporary, conduct works outside snake migration period (spring/fall).	• In the spring, install barrier fencing around the den so that snakes can be captured and moved to safety when they emerge. • In the fall, install fencing around the construction site to intercept returning snakes and move them into the den.

Table 2. Examples of the amount of effort that may be required for a successful salvage following extensive inventory and planning.

Target Spp. & Life Stage	Salvage Operation Habitat	Technique & Effort
Aquatic breeding amphibians (lentic habitats)	Small wetland habitat (e.g., 50-100 m^2)	• Unbaited aquatic funnel traps - 35-50 traps; trapping begins at least 2 weeks prior to project works. • Additional techniques that may be effective: seine netting, dip netting.
Lotic habitat amphibians (e.g.tailed frog tadpoles)	Stream reach (e.g., 3 m x 50 m long)	• Stream simplification with hand capture using aquarium nets; rolling rocks, hand sweeps along bank edges, through gravel beds, and in and along log jams, visual survey of pools. • Surveys begin at least 3 days prior to project works. • Water-permeable exclusion fencing installed into stream bed at the upper and lower end of the stream reach to avoid re-entry into the salvage zone.
Reptiles (lizards and snakes)	Open and semi-open terrestrial habitat with rock outcrop (e.g., 100 m x 200 m) *Does not include communal snake dens	• Hand capture / visual survey / searches under cover objects. • Surveys begin at least 2 weeks prior to project works. • Additional techniques that may be effective: Pitfall trap arrays – 6 arrays with 4 pitfall & funnel traps and three 25m fencing sections, cover boards.
Terrestrial salamander adults and juveniles	Forested terrestrial habitat (e.g., 100 m x 100 m)	• Remove cover objects. Hand capture / visual surveys; rainy night surface surveys with flashlights); surveys begin at least 2 weeks prior to project works. • Additional techniques that may be effective: Pitfall trap arrays – 3 arrays with 4 pitfall traps and three 25m fencing sections.
Population of Western Painted Turtles (adults and juveniles)	Small lake (e.g., 0.5 ha)	• Baited hoop traps – 5-10 traps; trapping begins at least 3 weeks prior to project works. Exclusion fencing, hand captures, holding and releasing. • Additional techniques that may be effective: seine netting, hand netting, basking traps, snorkeling with hand captures.

4.3 Special Considerations by Habitat Type

Planning of salvage operations, including selecting capture techniques, determining inventory and salvage timing, and allocating capture effort, will vary widely depending on the habitat type where salvage is required. This section provides recommendations and habitat-specific considerations for lentic (still water), lotic (flowing water), and terrestrial sites.

In some cases it is effective to plan a salvage operation based on the habitat of interest, taking a community-level approach, so that the timing of various techniques can be optimally timed and employed.

4.3.1 Lentic Environments

- Some species are aquatic year-round in permanent waterbodies, and will require salvage during all seasons (e.g., spotted frogs, Northwestern Salamander, Blotched Tiger Salamander, Western Painted Turtle; Appendix 4).
- The larvae of aquatic-breeding amphibians are present only from early spring through mid to late summer at ephemeral ponds and wetlands. Project works scheduled during the dry season may not need a salvage operation at these lentic sites[6].
- Techniques that can be applied in Lentic habitats include: visual encounter surveys (VES) with hand capture, aquatic funnel traps, hoop / fyke traps, seine nets, and dewatering with dip-netting (see Appendix 5).
- Pitfall traps with barrier fencing can be employed in the adjacent riparian area to intercept migrating or dispersing individuals (e.g., adult amphibians post breeding, dispersing juveniles).
- Typically several capture techniques, as well as repeat sampling, are necessary to ensure that all amphibians and reptiles are captured at aquatic salvage operation sites.
- Remove all woody debris and refuse to enable effective hand capture and netting.
- Install exclusion fencing around aquatic sites to ensure the salvaged individuals do not return to the site.

4.3.2 Lotic Environment

- Visual Encounter Surveys (VES) or hand collection with aquarium nets is typically used for capturing stream amphibians in lotic environments (i.e., tailed frog species and Coastal Giant Salamander).
- Salvages for stream amphibians should occur during the dry summer months (i.e., August to September) when water levels and flows are lowest and detection rates are highest (e.g. RISC 2000).
- Isolate the stream reach to be salvaged, using exclusion fencing at both upstream and downstream ends, to allow water flow but prevent the movement of amphibians. Fencing

[6] Metamorphosed individuals may still use dried areas for foraging, and as such, these habitats should be assessed during baseline surveys to determine if a salvage is required.

should remain in place until all project works are completed and checked daily by the QEP to ensure its effectiveness and conduct repairs where required.

- Repeat capture surveys should start at the downstream end of the salvage area and move upstream, systematically inspecting and removing all cover objects (i.e., simplifying the channel), searching pools and submerged gravel beds, and surveying stream banks and log jams for newly transformed metamorphs, juveniles, and adults.
- Conduct repeat surveys. In theory, as the stream segment is simplified and re-surveyed it should become more difficult for larvae to hide and make it easier to detect them.
- While complete coverage is essential target suitable microhabitats, including pools, cutbanks, and riffles with cobbles and boulders.

4.3.3 Terrestrial Environment

Amphibians and reptiles occur within terrestrial environments throughout the year. However, they are relatively difficult to locate, as they are dispersed and well-hidden in burrows and crevices, and under coarse woody debris, rock debris, and leaf litter. In general, amphibians are easier to locate when they are gathered at aquatic sites to breed versus dispersed in terrestrial environments.

- There are at least three scenarios when it may be desirable to salvage herpetofauna in a terrestrial environment:
    1) development resulting in permanent loss of terrestrial habitat,
    2) a need for hand-capture of animals to move them away from machinery, and
    3) construction activities that coincide with a migration event (e.g. dispersing toadlets in midsummer or hibernating snakes emerging in spring).
- Capture techniques in terrestrial environments include: barrier fencing with pitfall or funnel traps, VES / hand capture, cover boards, and road surveys.
- In areas that will be permanently altered, conduct cover removal sampling, whereby cover features are dislodged and relocated outside of the project area. This will help to reduce the chance of recolonization.
- Exclude or intercept individuals before they enter the project area using barrier fencing and traps, and ensure they are checked daily for effectivness (Section 5.7.1).

<u>Amphibians</u>

- The best time to salvage amphibians in terrestrial environments is during rainy nights, when they are taking advantage of cool, wet weather to forage and move between habitats.
- Terrestrial salamanders are active under these conditions in the fall, when adults are searching for mates on the forest floor.
- Warm, rainy nights in spring and fall can also result in large movements of amphibians (e.g., moving to and from overwintering or breeding sites). Road surveys can yield large numbers of amphibians under these conditions.
- If a salvage operation occurs during a dry period, where there are no rainy nights, the capture rate will be low to nil, except perhaps for Western Toads, which are active most nights.

Reptiles

- VES / hand captures of reptiles are most effective when conducted in the spring. For instance, snakes and turtles are best encountered as they emerge from hibernacula in the spring
- Snake hibernacula are typically in rock outcrops, but some snakes also hibernate in earthen dens and fill areas.
- Turtles hibernate under water, on the bottom substrate of lakes and wetlands.
- In spring, there is usually a "laying out" period when snakes bask in the sun, or they are under the first layer of cover rocks, making them relatively easy to detect.
- For some species (e.g., Western Rattlesnake), but not all (e.g., Northern Rubber Boa), a basking or "laying out" period may occurin the fall, depending on weather conditions..
- Surveys for reptiles in the heat of the summer are generally ineffective. During these times reptiles may be encountered basking in the morning or found moving in the evening. Because reptiles are mostly sedentary and tend to use security habitat during dry, hot periods detections are usually relatively low.
- Western Skinks, Sharp-tailed Snakes, Northern Rubber Boas, and Desert Nightsnakes are very fossorial (spend time under debris and underground) and are readily overlooked
- Surveys for these species usually involve intense searches under cover objects and result in considerable disturbance to the area.
- Trained and skilled searchers are essential for reptile surveys as most inexperienced surveyors easily overlook them due to their cryptic nature
- Reptile salvages are ineffective unless exclusion fencing is installed around to the project area to keep animals from migrating back; or the salvage is conducted immediately before a short-term disturbance to the habitat.

AVOIDANCE TIP
One way to avoid the accidental harming of reptiles (and some amphibians) by equipment is to remove or disturb cover objects in the workspace well in advance of construction. The removal of cover objects before work begins may exclude animals from entering, and force animals to move away from, the workspace. Small cover objects can be removed by hand and larger ones using light machinery.

5 CAPTURE TECHNIQUES

Once a complete species list by life stage has been identified during inventory (Section 4.1) consult the RISC standards for the most effective method for capturing each life stage for each species. Suitable capture techniques for species where no provincial standards have been developed (e.g., lizards) can be found below and in Appendix 5. In many cases several techniques will be required to effectively detect and capture a species, but these often overlap with techniques used for other species or life stages.

Salvage operation sampling designs may differ somewhat from those developed for species inventories and research studies, which often involve random site selection and a systematic sampling regime (e.g., visual surveys along transect lines). Salvage operation sampling regimes should not be completely random or too restrictive, as the objective is to optimize detections and capture rates in order to remove all individuals from the site. As such, there should be a certain amount of knowledgeable, purposeful bias towards certain habitats and microhabitats during salvage operations (e.g., searching under rocks and woody debris for lizards and salamanders, through shallow, warm water areas of lakes and wetlands for amphibian larvae, and in crevices of rock outcrops for snakes). Keeping track of effort during all surveys conducted as part of environmental assessments and salvage operations will allow for spatial and temporal comparisons. For example, record the amount of time spent searching, area covered, and the number and location of traps. More detailed information can be found in the resources listed in Appendix 5.

The techniques listed below (with the exception of dewatering) are suitable to detect the presence of amphibians and reptiles during environmental assessments, to capture individuals as part of salvage operations, and for surveys conducted as part of post-salvage monitoring (Section 9).

5.1 Visual Encounter Surveys

Visual Encounter Surveys (VES) involve searching visually for animals, and when found, capturing individuals by hand or with nets. Generally, VES is most effective in terrestrial or shallow water habitats; including forest floors (eg. within coarse woody debris, under rocks), ephemeral pools or wetland margins, and in shallow portions of streams. In deep aquatic habitats, VES for amphibians is generally less effective. For salvage operations, in most cases capture rates are improved when VES is combined with other capture techniques (e.g., VES with aquatic funnel traps in lentic sites).

Guidance on VES methods for amphibians is available within RISC Standards. For reptiles, the following are important considerations that are not documented in the RISC standards or described elsewhere.

<u>Turtles</u>
VES can be an effective capture method for turtles. In deeper water, turtles can captured by snorkeling, or by hand or net from a boat. In smaller water bodies such as ditches or creeks, turtles can be captured by hand from shore.

<u>Lizards</u>
VES is the most effective capture technique for lizards (no RISC standards have been developed for lizards in B.C.). Northern Alligator Lizards and Western Skinks are the only two native lizards that occur in B.C., and both are solitary. As such, considerable effort is required to capture them using VES:

- Noose poles can be used to catch lizards, but they tend to be most effective when utilized during the first attempt, and less so subsequently.
- Spring is the best time of year for catching these native lizard species.

- Capture of Northern Alligator Lizards should be done in the morning, when they can typically be found basking. They should be approached slowly, and may have to be excavated if they are startled and escape into their refuge.
- The most reliable method to capture Western Skinks is to carefully overturn cover objects such as flat rocks; under which they spend most of their time. They can quickly be captured by hand, while they are still immobile in the initial phase of startle response.
- Care must be taken when capturing lizards to grasp the body, and not the tail, which can be readily shed in response to attempted capture. While lizards can regenerate their tails, their loss may negatively affect their long-term health and survival.

Figure 2. Examples of Visual Encounter Survey (VES) methods. [Photo credits: E. Wind]

5.2 Aquatic Funnel Traps

Aquatic funnel traps, also known as “Gee” or minnow traps, are effective for many frog and salamander species and life stages. The rectangular or circular shaped traps have an opening at each end of a funnel that guides animals into the trap. Once inside, animals tend to swim along the inner edges of the trap, making it difficult to detect the funnel openings. These traps can be used with or without bait.

- When targeting herbivorous larvae (e.g., Northern Red-legged Frog, Western Toad) do not use bait, as this can attract non-target predators such as fish.
- Use appropriate mesh sizes for the target species you (e.g., small larvae may not be captured in metal Gee traps).
- When trapping larger animals (e.g. neotenic tiger salamanders), the funnel opening may have to be enlarged to provide a sufficiently large opening to allow entry.
- Submerge funnel openings to optimize capture.
- Leave an air space at the top of the trap, either with foam floats or by tying traps to shoreline vegetation, to provide a location for trapped individuals to access oxygen.

- Traps are usually set overnight to maximize capture rates. Note that trap check duration should be not more than 12 hours, and shorter during hot summer conditions.
- An ideal trap location for detecting larvae are shallow, warm water shorelines of lakes and wetlands. In this case, traps should be partially shaded (e.g., against a shrub), or set late in the day to avoid mid day heat.
- Distribute traps to sample all microhabitat types, but with an emphasis on high suitability areas of target species to maximize capture rates.
- Netting can be used as “aquatic directional fencing”, to increase capture rates by guiding animals towards traps (Wilson and Dorcas 2004). Nets are suspended with floats, and staked into the substrate to act as a barrier. This method has been implemented successfully for trapping Oregon Spotted Frogs; increasing annual capture rates of breeding adults from approximately 5 to 200 (Amanda Kissel, unpub. data).

Figure 3. Examples of aquatic traps and netting used as directional fencing. [Photo credits: B. Beasley]

Users of aquatic funnel traps must be aware of issues related to non-target and invasive species that are commonly encountered at lentic and lotic sites (see Section 8.1)

5.3 Dewatering with Dipnetting

This technique is best suited to development projects where in-filling or temporary dewatering of aquatic habitats is required. Prior to dewatering, determine the number of personnel required, which should be a function of the aquatic area to be salvaged. Steps include:

- In advance of dewatering (i.e. before sump and pump installation), capture and remove as many animals as possible using funnel traps, dip nets, and/or seine netting. Continue until capture rates steadily decrease to a few to no individuals.
- Split large aquatic areas into smaller, more manageable, salvage sites.
- Install steel plates or seine nets from bank to bank

- Bury plates or nets deep into the substrate, or secure them with weights to prevent movement out of the salvage area.
  - Prepare for dewatering by digging a hole or "sump" for the pump intake, usually in the deepest location.
  - Determine sump depth according to substrate type; eg. ~ 1 m depth in clay and fine silts, and ~ 0.5 m in gravel and cobbles.
  - Create a sump area (width and length) that is large enough to: 1) accommodate the size of the intake pump and filter cage and, 2) allow for substrate spill, and 3) allow for dipnet immersion to capture species drawn into the sump area.
- If an excavator is used to install the sump, drain excess water from the bucket of substrate it *prior* to depositing the substrate on land.
- Monitor the deposited substrate for animals emerging from the stock pile and salvage as appropriate.
- Secure a filter cage around the intake pump to stop aquatic species from being drawn in.
- Conduct a final full "sweep" using a dipnet until capture rates decline to minimal or no individuals before pumping is initiated.
- Activate the pump at low speeds to start, and adjust as required; according to the efficacy of water volume being pumped and number of organisms to be salvaged.
- Remain on-site throughout the dewatering process to monitor the pump and water levels, and to dipnet individuals. Periodically clean substrate from the filter cage as pump intakes get clogged during the dewatering process.
- Periodically turn the pump off, to allow for rigorous dipnetting, and to reduce stress to animals.
- Plan for intensive salvage activity, including sufficient crew numbers, as water levels decrease to a low level, for at this time a large number of individuals will start to surface.
- Place large, clean buckets of fresh water from unaffected areas (i.e. release sites) within reaching distance of each crew member for temporary holding.
- Frequently relocate salvaged individuals to the release site to avoid stress and mortality, and replenish the fresh water in the holding buckets each time.
- Avoid or minimize water being transferred from source pond to the release pond to reduce the probability of transmission of disease, parasites and introduced species.

Dewatering in aquatic environments with soft substrate: Exercise caution when conducting a dewatering salvage in aquatic environments with soft substrate. People conducting salvages in these conditions may get stuck in the soft substrate or even fall. Ensure your health and safety plan identifies the potential hazards and provides and implements appropriate mitigative measures associated with this type of work. It is recommended that chest waders, long, sturdy rope, and structures such as pallets topped with a slip-free surface to stand on are readily available to those conducting salvages during the dewatering process in this type of environment.

Other important considerations:

- Mesh size should be no larger than ¼" for dipnets to ensure capture of most life stages of aquatic organisms.
- Filter cages are available to rent with water pumps, but in most cases they are not suitable due to mesh size and require additional modifications (see text box below).

Figure 4. Sump creation and/or pump installation [left; photo credit N. Sands], and dipnetting during dewatering [right; photo credit S. Sloboda]

5.4 Seine Net

Seine netting can be used as an effective alternative to dipnetting or trapping, as it can sample a rather large area in a short period of time. This method is not well suited for deep water bodies, aquatic areas with large amounts of woody debris or snags, or sites with dense shoreline and/or aquatic vegetation.

- Use a crew of at least four people to maneuver the relatively large net.
- Suspend the net vertically in the water column, keeping the top above the water surface.

Filter cages for pump intakes: A combination of double-layered ¼"wire mesh / hardware cloth wrapped with burlap and secured with "zap straps" may be used for the filter cage. Other modifications to filter cages around pump intakes include large garbage pails (77-litre) modified with ¼" drilled holes to allow for water flow to the pump intake, with the pump intake encased by ¼" wire mesh / hardware cloth wrapped in burlap. Alternatively, add a 2" layer of gravel at the bottom of the sump, place the pump intake into the sump on top of the gravel layer, and bury the pump intake with crushed gravel (D. Sutherland, pers. comm.). This method does not require a cage as the gravel acts as a natural filter.

- Attach sufficient weights to the bottom of the net to keep it on the bottom substrate in order to limit escapement underneath.
- Once the net is suspended, surveyors at each end of the net should slowly move towards each other in a wide arc to corral animals in the inside area.
- Use a net mesh size suitable to capture the target species and life stages (e.g. small salamander larva body size can be < 0.25 cm in width)

5.5 Hoop Trap

A Hoop (or "Fyke") Trap is a collapsible cylindrical trap with a funnel at one end (Figure 5). Hoop Traps are typically used to capture turtles, but have also been used to target amphibians (e.g., Schmetterling and Young 2008). This technique was not included in the RISC guidelines for pond breeding amphibians and turtles.

- While the trap opening should be submerged, use floats to keep the structure at the surface to provide locations for individuals to breathe.
- Ensure there are no folds in the trap that could entangle and drown individuals.
- For turtles, place Hoop Traps adjacent to areas where basking has been observed, and bait traps with food attractant such as sardines or cat food.

5.6 Basking Trap

Basking traps are akin to "floating pitfall traps'. A log or rounded slab is used as the floating portion of the trap, which lures turtles to use the float to bask. When alarmed, diving turtles are trapped by the basket (Figure 5).

- Before initiation of salvage activities, conduct surveys to determine the approximate number of turtles and location of basking sites, which will help to determine density and location of traps.
- Attach a submerged wire mesh basket to the float at a depth that allows turtles to swim freely on the surface of the water to the float.
- If necessary (e.g. in large water bodies), anchor the float to keep it within high suitability (nearshore) habitats.
- Approach the float carefully in a boat. When alarmed turtles dive and are trapped by the basket, net or hand-capture them from the boat.
- Set traps for a minimum of 10 trapping days (RISC 1998; A. Mitchell, pers. comm.), or longer if known individuals remain uncaptured.

A similar trap is the Sundeck Turtle Trap, which uses a submerged basket with a float around it's rim. The inner edge of the float is designed such that turtles that dive into the middle of the basket cannot get back up on the float. This trap works well where the trap can be left out for long periods of time.

Figure 5. Examples of basking traps. [Photo credits: left E. Wind, right B. Beasley]

5.7 Barrier fencing

Barrier fences are constructed to intercept the natural travel of an amphibian or reptile. This can be done to exclude them from, or confine them to, an area, or to 'drift' them towards a trap. Barrier fences can be constructed of many different types of material, including plywood, sheet metal, building wrap, silt fencing, and hay bales. Typically the use of barrier fences, combined with funnel or pitfall traps, is the most effective method for capturing reptiles.

- Determine the height of and material for barrier fencing according to the burrowing and climbing ability of the target species:
- If non-climbing species are the target, the fence can be relatively low (e.g., 25 cm).
- If large snakes are anticipated then the fence should be at least 100 cm tall.
- Support fencing by stakes to ensure that it stays in place and animals do not use sags or folds to climb over the barrier.
- It will often be necessary to use strapping to attach the material to the stakes. If staples are used, tape should be placed over top to prevent tearing.
- Bury the bottom of flexible fencing material with a lip at the bottom; and/or lay into a backfilled trench 5 to 10 cm deep, which will:
    - prevent burrowing species (e.g., Great Basin Spadefoot, large salamanders and snakes) from passing underneath, and
    - prevent material from being pulled out of the ground when it is pressured (e.g., by large animals or weather conditions).
- Create a lip or angle towards the anticipated incoming direction of travel to further reduce the opportunity to climb the barrier.
- Use knowledge of on-site species distribution and location of travel corridors (gained during project assessment surveys) to determine fencing array locations.
- Consider site topography and movement behaviour when determining orientation of fencing.
- If individuals moving down a gully are targeted, construct a downwards-pointing 'V', with the trap at the bottom where the two sides meet.

- If travel is expected to be in both directions, use a ‘W’ design with traps located at all five points of the ‘W’.

5.7.1 Pitfall Traps & Fencing

The addition of pitfall traps to barrier fences allows for the capture of animals that will be temporarily retained or moved off site. Pitfall traps are installed along a barrier fence so that animals that are being guided by the fence will fall into the trap. Pitfall traps can also be installed underneath a flat-bottomed funnel trap, as the recessed environment will provide protection from extreme weather for captured animals. Pitfall traps work best on toads, salamanders, lizards and small fossorial snakes; but can also be effective for capturing adult frogs. These traps are not effective for large snakes, but have been used to capture post-metamorphic tailed frogs.

- The pitfall trap usually consists of a plastic tub or bucket that is buried flush with the ground.
- Determine the trap diameter and depth according to the target species:
    - Ranid frogs (true frogs) have good jumping abilities, so pitfalls must be deep enough to prevent their escape.
    - Chorus frogs and some terrestrial salamanders (e.g. Wandering Salamander) are strong climbers. Insert a funnel into the top of the trap to improve capture rates of these species.
- Buckets should have perforated bottoms so that they do not fill with water. If ground water enters the bucket, soil or rocks should be added to provide a ‘dry’ surface.
- Add moss, duff, and/or leaves to provide cover and moisture for captured animals.
- Where necessary, install elevated cover boards (e.g., small pieces of plywood propped on stones over the top of the trap), which:
    - prevents frog escapes,
    - provides suitable environmental conditions (e.g., shading) for captured animals, and
    - protects the trap from being stepped on by large mammals.
- Determine frequency of trap “checks” according to the target and non-target species:
    - Where water shrews are anticipated, check traps 3-4 times daily (e.g. every 6-8 hours). If small mammals are expected to be trapped hang a secured string into the trap which they can climb to escape.
    - For most herpetofauna, check traps at least once per day (twice during weather conditions that might stress animal health, such as high heat, cold, potential for flooding etc).

5.7.2 Funnel Traps & Fencing

Funnel traps are very effective for capturing salamanders, snakes and lizards. Often it is necessary to construct funnel traps, as they are not readily available from commercial sources.

- Construct traps with small dimension lumber and ¼” hardware cloth, incorporating other materials such as plywood as needed.
- Single openings are fine to incorporate into most fences. However in situations where the trap is placed along a long fence, an entrance on each side of the trap is required.
- Install additional fencing to form “wings” to help guide animals into traps placed at the end of a fencing.

- Additonal construction and deployment practices that will help to provide appropriate environmental conditions include:
  - placing traps in shaded areas to prevent overheating,
  - providing recessed water dishes (flush with the ground) inside the trap for amphibians,
  - providing cover material, and
  - adding insulation to the exterior of the trap (e.g. Styrofoam) if the trap is deployed during hot or cold weather.
- Determine the frequency of trap "checks" according to the target and non-target species in the area:
  - For most herpetofauna, check traps at least once per day (twice during more extreme weather conditions).
  - Frequent inspections also reduce predation if multiple individuals are captured

Figure 6. Example of a pitfall trap array. [Photo credits: E. Wind]

6 TEMPORARY HOLDING

6.1 General Considerations

Consider the following when temporarily holding herpetofauna:

- As ectotherms, the activity level of amphibians and reptiles is reduced at low temperatures. As such, stress on captive individuals can be reduced by keeping temperatures at the lower end of their natural range. This can be accomplished in part by using light-colored holding containers that do not absorb heat in case they are accidentally exposed to the sun.
- Both diurnal and nocturnal herpetofauna appear to feel more secure in the dark, and perceive movement as a source of potential predation risk. Therefore, holding containers should be opaque to minimize light input and stimulus caused by movement.
- Reptiles are typically held in cloth bags after capture.
- Containers should have soft duff or leaf litter for individuals to hide within.

- Containers housing burrowing amphibians (e.g. Blotched Tiger Salamander, Northwestern Salamander, and Great Basin Spadefoot) should be filled with slightly moist, non-compacted topsoil. In particular, spadefoots will wear their feet raw against a plastic container if there is insufficient soil to burrow in.
- All containers should be well ventilated.

Western Rattlesnakes should only be handled by trained personnel. Previous knowledge of antivenin availability at hospitals is necessary for handler safety. Rattlesnakes are to be picked up using handling tongs, secured in a cloth bag and then placed in a rigid ventilated container with a secure lid. Contained snakes are not to be left unattended and the public must not have access to the containers. If the containers are to be transported by vehicle, the containers must be secured so the lids cannot open in the event of an abrupt stop or accident. Containers should have proper signage indicating they contain venomous snakes.

6.2 Long-term Containment

Long-term containment should be avoided if possible. If required, i.e. due to the immediate lack of a suitable release site, consider the following:

- Depending on the context, it may not be appropriate to hold animals long-term in artificial environments such as plastic tubs. An alternative is to create an enclosure within the natural environment of the captured species, with barriers to prevent both escape of the captured animals and access by outside predators.
- Enclosures should include the availability of cover objects specific to the needs of the species being held.
- Check for gravid females. If present, isolate these individuals in separate containers, in order to provide suitable conditions for survival of young.
- In rare circumstances it may be necessary to overwinter herpetofauna (in which case a separate permit for long-term holding is required). This can be done using a dedicated fridge set to an average temperature of 7°C, and monitored to ensure temperature is maintained between 5°C and 10°C. Animals should not be placed at the bottom of the fridge where it is cooler. Amphibians must be kept moist, while reptiles can remain dry.
- Long-term retention of animals is best done in rehabilitation center certified by the Canadian Aquarium and Zoo Association or the province of B.C. Long-term retention of animals will only be permitted under exceptional circumstances, and should be discussed with the provincial Animal Care Committee.
- In most cases it is best not the feed the animals during captivity to minimize the potential transfer of unknown diseases and parasites from commercial pet store feed suppliers. Many herpetofauna can survive long periods without feeding, but they should have access to clean water at all times.

6.3 Avoiding Interspecific Predation

It is important to consider predator-prey relationships when housing different species:

- Always keep amphibians and reptiles separate.

- Keep invertebrates separate from aquatic tadpoles and larvae (some large invertebrates prey on tadpoles). Larger predaceous invertebrates like the Giant Water Bugs (*Belostomatidae*) can also prey on small frogs such as Pacific Chorus Frog and large salamander larvae.
- Keep anuran (frog and toad) tadpoles separate from everything else (many species and life stages prey on these).

6.4 Containment of Lotic Species

- All stream amphibians should be temporarily held and transported in fresh, clean, cool, stream water.
- Larger Coastal Giant Salamanders captured during the salvage should be kept in separate containers for holding and transport as they will eat smaller amphibians.
- Individual housing for amphibians is preferred to minimize pathogen and parasite transfer among individuals, but sometimes the sheer number of animals captured makes this impossible. As guidance, animals that would not normally come into contact, and predators, should be housed separately. Animals should be housed at as low a density as possible. Stream amphibians must be kept cool (e.g., shaded) and transported and released as soon as possible.

7 RELOCATION

7.1 Site Selection

In cases where the source habitat is lost or rendered unsuitable, it may be necessary to relocate animals to new areas (Section 1.4.3). Proper selection of release sites is essential, as poor or unsuitable release habitat is one of the most common reasons behind failure of salvage projects (Germano and Bishop 2008). Historically-occupied sites may not necessarily be the best habitat for translocated species (IUCN 2012), especially in the face of disease issues related to amphibians and changes in habitat since the site was last occupied. Currently-occupied sites are not necessarily optimal either, as increasing the densities of resident species can have a variety of impacts on the local population and the rest of the ecosystem.

Therefore, because selection of release sites should include attempts to minimize effects on both captured animals and host ecosystems, **it is recommended that compensation sites (e.g., constructed or restored wetlands) be created to serve as potential release sites** over naturally occurring habitat whenever possible (also see text box below). Selection of release sites should consider the following criteria:

- Availability of suitable habitat for multiple life history stages of the target species; including breeding, embryonic and larval development, terrestrial activity, and hibernation.
- Dispersal and movement distances of target species. Release sites should be selected within migration distance of the source site, so that local population dispersal, colonization and recolonization patterns are maintained as much as possible. For most amphibians, lizards and turtles this distance is often less than 5 km. All else being equal, release sites should be selected to be as close to the source site as possible.

- Release sites are of equal or better habitat value relative to salvage sites, based on life history requirements (see above).
- Landscape-level connectivity to capture sites. Avoid selecting release sites on the other side of barriers such as busy roads, as these pose a mortality risk if philopatric individuals attempt to return to capture sites. If this can't be avoided, ensure that barrier fencing and safe crossing structures such as wildlife underpasses are installed to limit mortality.
- If migration hazards are temporary (i.e. associated with project construction only), exclusion fencing may only be required for the duration of project works.
- Knowledge of the presence of disease such as chytrid fungus in both the salvaged and host populations.
- Status and/or ownership of release sites, and permission for access and use.

When selecting release sites in lotic environments, consider the following:

- Release larvae and neonates upstream of the protect area, as close to the salvage site as possible, but beyond where there would be a risk of drift back into the disturbed area (i.e. tailed frog tadpoles are estimated to move ~1 m / day; Wahbe and Bunnell 2001). A rule of thumb is 100 m upstream in a stream with relatively continuous habitat.
- Release site locations and densities should be a function of capture numbers and habitat suitability.
- Where suitable stream amphibian habitat is patchily distributed within the stream channel it may be desirable to select a number of release sites.
- Individuals should be suitably dispersed throughout the channel within the release location to avoid larval densities that could limit resources such as food and cover. As such, higher capture rates should result in a greater number of release sites over a larger area.
- For projects where stream impacts are temporary, all cover objects should be returned to the stream channel upon completion of project activities and related impacts. Accurate photo documentation and marking of cover object locations prior to salvage can help to ensure proper restoration of the in-stream habitat.
- Stream amphibians should be released in microhabitats with relatively calm water. Do not release animals directly into fast-flowing water, as this may cause animals to be inadvertently swept downstream.

Artificial Reptile Dens as Relocation Sites. Lizards and some snake species do not have fidelity to a specific den site and will opportunistically use any feature that allows them to go below the frost line during the winter. As such, it is possible to create artificial dens by excavating a trench in a south-facing slope that is deep enough so that the back is at least three metres deep. The bottom of the trench is backfilled with at least 0.5 m of blast rock, ensuring that some of the rock protrudes beyond the profile of the slope. Avoid the use of round rock as it may create large interstitial spaces that allow predators such as weasels to gain access to hibernating reptiles. Medium-sized fill should be spread over the blast rock to prevent infilling. Cover objects should be scattered near the entrance of the den. Installing enclosure fencing around the den in the fall can ‘force’ salvaged reptiles to use the artificial den. In BC, artificial dens have been created for Western Skink, Racer, Northern Rubber Boa, and Great Basin Gophersnake. (M. Sarell)

7.2 Genetics and Disease

It is often assumed that diseases are present and shared among populations occurring within the natural movement distances of individuals and dispersing juveniles. To minimize the potential effects of salvage operations on local populations, it is assumed that appropriate hygiene precautions and minimizing the distance animals are moved should have the least effect on both genetic fitness and disease transmission.

- It is recommended that suitable release sites are located outside of the project area but as close as possible to the salvage site, ideally within 5-10 km for amphibians and reptiles (Gibbs and Reed 2007).
- If an abnormality is found or a disease is suspected at a site, or dead / dying animals are found, do not move animals off site into new environments. Isolate the abnormal animal(s) from healthy looking ones. Contact the BC Wildlife Health Program or the provincial herpetologist immediately to discuss disease testing, and temporary housing / containment, and mitigation. No release should occur without provincial approval[7].

[7] More information can be found about at:

http://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/wildlife/wildlife-health/wildlife-health-program

8 OTHER CONSIDERATIONS

8.1 Non-target and Incidental Animal Captures

Many of the sampling techniques used for salvage operations could lead to the incidental capture of non-target species, including species at risk and non-native or invasive species.

For example, aquatic capture techniques (Section 5.2) can lead to the capture of fish, water shrews, and invertebrates, while pitfall traps frequently capture small mammals and invertebrates. During EA and salvage planning, a list should be made of non-target species that may be captured incidentally, in order to be prepared for the handling and release of such individuals[8]. In particular, when setting aquatic traps, steps need to be taken to avoid mortality of the at-risk Pacific Water Shrews (*Sorex bendirii*). For a summary of the issue and associated recommendations, refer to *Fish Traps Threaten Pacific Water Shrew Recovery* (Welstead and Vennesland 2006). Other key resources regarding non-target species include *Best Management Practices Guidelines for Pacific Water Shrew in Urban and Rural Areas*, Working Draft (Craig et al. 2009), Fish Collection Methods and Standards (MELP 1997), and Inventory Methods for Small Mammals: Shrews, Voles, Mice & Rats (MELP 1998).

Note: When using aquatic traps it’s important to be aware of the potential to catch other species at risk or non-target species that will need to be temporarily held and released into appropriate habitat(s). For example, fish and water shrews may be captured in funnel, hoop, and Gee traps, and small mammals in pitfall traps. Prior to conducting a salvage, ensure that all necessary permits and release site information are in place for such an event, and take measures to reduce potential impacts to these non-target species. For example, for water shrews, set traps at the surface, install floats inside traps to allow shrews to exit the water if desired to rest, provide a food source, and check and empty traps at least every six hours.

8.2 Non-native and Invasive Species

The main concern regarding non-native and invasive species with respect to salvage operations is the unintentional introduction and spread of these species to new sites. The incidental capture of non-native and invasive vertebrate species is most common adjacent to centres of human population such as aquatic sites in rural and urban areas. Of particular concern is the presence of American Bullfrogs, Green Frogs, European Wall Lizards, sport fish, and slider turtles. The introduction and spread of non-native and invasive plant species, such as Eurasian milfoil, Yellow-flag Iris, and Purple Loosestrife are also problematic throughout BC. Finally, salvage operations can inadvertently lead to the transmission of less-obvious invasive species such as invertebrates, fungi, and viral or bacterial pathogens.

[8] See *Live Animal Capture and Handling Guidelines for Wild Mammals, Birds, Amphibians and Reptiles* (RISC 1998) for information on the handling and care of non-target and incidental wildlife.

- Be aware of invasive species which are known to occur in the project area so that species-specific protocols are in place prior to commencement of operations.
- Follow hygiene protocols (Section 8.3) to reduce the spread of non-visible disease, parasites, and other pathogens.

It is illegal to transport live, non-native and invasive species. As such, they must be euthanized on site. Ensure that the tools and drugs are on hand in accordance with euthanasia guidelines (Leary et al. 2013):

- Adult amphibians and reptiles may be humanely killed through an overdose of anesthetics such as injectable sodium pentobarbital for reptiles or solutions of buffered TMS (MS-222®) for amphibians. Benzocaine hydrochloride may also be used in a bath for amphibians.
- Decapitation does not lead to rapid unconsciousness, and therefore should not be used unless followed by pithing to instantaneously destroy the brain and render the animal insensitive to pain. Propofol and short-acting barbiturates can be used to produce rapid general anesthesia prior to pithing. Cooling or freezing is generally not a recommended method of euthanasia, as formation of ice crystals in the tissues of an animal may cause pain and distress. Quick freezing of deeply anesthetized animals is acceptable
- In cases where large numbers of non-native frogs are captured, methods to enable mass euthanasia may be required. This involves placing tadpoles and frogs into large buckets containing a MS-222 solution. See the Leary et al. (2013) for detailed euthanasia guidelines.

8.3 Avoiding Disease Transmission

Emerging infectious diseases such as the amphibian chytrid fungus (*Batrachochytrium dendrobatidis*) and ranaviruses have been implicated in the decline of amphibian populations from many sites around the world. It is possible that field staff can act as potential vectors of transmission introducing these diseases into new sites and to naïve species. Amphibians also suffer from a variety of other diseases, many of them are secondary infections as a result of poor health, unfavourable environmental conditions or poor husbandry practices (Govindarajulu 2007). Salvage operations can lead to increased stress within the salvaged and host population, making them more vulnerable to disease.

- A standard condition included in all BC Wildlife Act permits that involve handling of amphibians is to incorporate the *Interim Hygiene Protocols for Amphibian Field Staff and Researchers*[9] (B.C. MOE 2008) as Standard Operating Procedure (SOP).
- While concerns regarding infectious diseases have focused on amphibians, these protocols should also be followed when conducting salvages of reptile species, which are known carriers of pathogens such as Salmonella, particularly turtles (BC SPCA 2013).

[9] Protocols can be found at: http://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/wildlife-wildlife-habitat/wildlife-health/wildlife-health-documents/bc_protocol-amphibian_field_researchers.pdf

8.4 Hibernating animals

As a general rule, salvage of animals that have started showing signs of overwintering behaviour is strongly discouraged. However, as discussed in Section 1.4.5, approval to conduct an emergency salvage may be required due to unforeseen circumstances. Given that reptile and amphibian hibernacula / brumation sites can be difficult to locate, there is a possibility that overwintering animals could be excavated during construction, even if there was no previous indication of such.

The following are important to consider if an emergency salvage is required due to discovery of hibernating animals:

- If solitary hibernating reptiles such as snakes are found, contain the individual in a cloth bag and place it in an insulated container (i.e. a cooler) to prevent freezing. Depending on the conditions, a heating source may be required to accomplish the correct temperature.
- If a communal hibernation site is discovered (e.g. snake or toad den), stop work and immediately insulate the site (e.g. cover with tarps) until the animals can be carefully salvaged. If temperatures are close to or below freezing, salvage should be delayed until there is milder weather.

9 POST-SALVAGE MONITORING

As discussed previously, salvage operations are intended to avoid or limit mortality to wildlife, to ensure compliance with the Wildlife Act. However, there is uncertainty regarding the effectiveness of salvages which can themselves negatively impact both salvaged individuals and host populations (Section 1.3). As such, post-salvage monitoring is important to determine the effectiveness of salvage operations in avoiding mortality, and to determine practices that can improve the effectiveness of future salvages.

9.1 BACI Monitoring Designs

Irrespective of the sampling intensity, a Before-After-Control-Impact (BACI) study design is recommended for assessing effectiveness of salvage operations. BACI studies are considered the most well-suited designs for separating human-cased impacts from natural "background" variation (Underwood 1994), as effects are determined by estimating changes to the *difference* between control and impact sites. The goal of post-salvage monitoring should be to assess if there are any impacts of salvage on persistence or survival of herpetofauna species in question. If it has been determined that sample sizes are sufficient to detect an effect (via power analysis), and no effect is detected, then the salvage can reasonably be considered to be successful.

For post-salvage monitoring using a BACI design, impact sites will be the "salvage sites" where development effects occur and animals are removed from, and "relocation sites" where animals are transported to and released (Figure 7). Relocation sites can be either occupied (naturally-occurring) or unoccupied (e.g. a newly-created or restored wetland; Section 7.1). Control sites will be as similar to the salvage site as possible (including similar habitats and species composition), but unaffected by the development impacts and salvage activities. **Note that planning for salvage monitoring should be done prior to baseline inventory**, as data collected during the assessment stage (see Figure 1), if done properly, can also be used as baseline data for post-salvage monitoring. Table 4 demonstrates an example monitoring schedule.

Figure 7. Schematic of different types of sites for sampling under a Before-After-Control-Impact study designed for post-salvage monitoring.

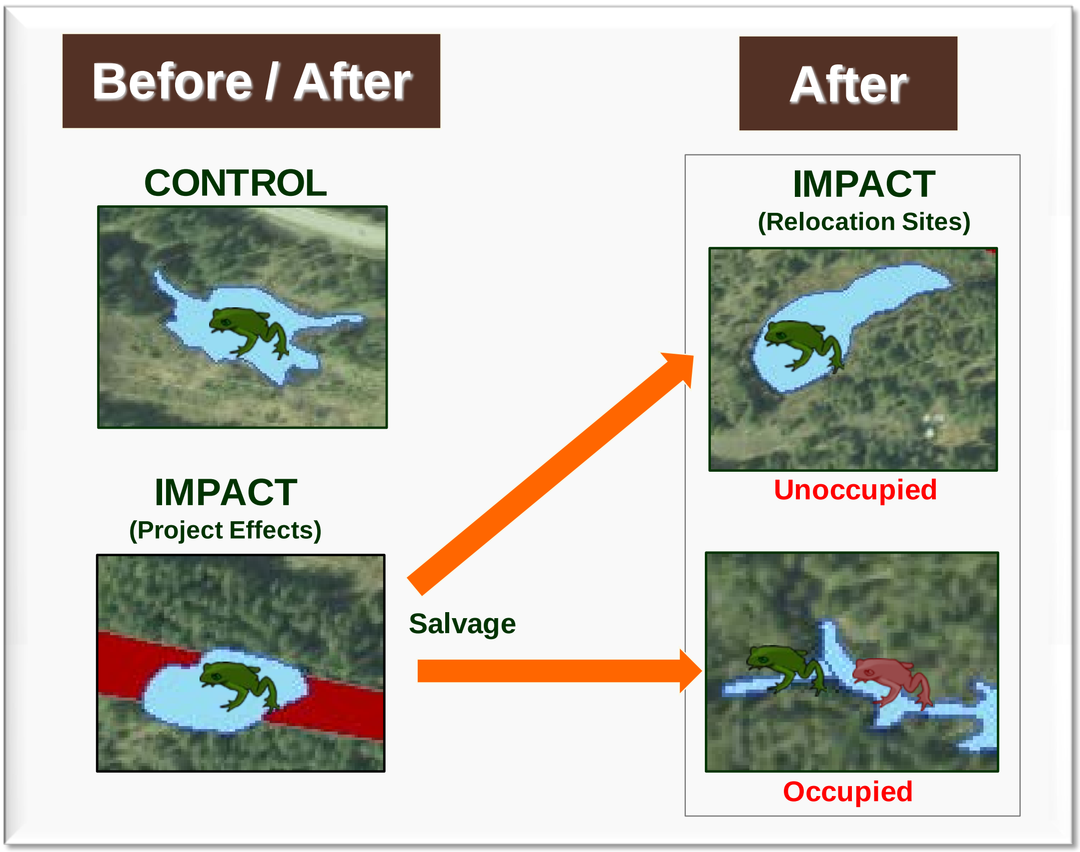

Table 4. Example sampling schedule for post-salvage monitoring using a BACI design.

Site	Site Characteristics	Pre-Salvage		Post-Salvage	
		Yr 1	Yr 2	Yr 1	Yr 2
Control	Similar amphibian community as salvage site	Y	Y	Y	Y
Impact: Salvage[1]	Contains amphibians	Y	Y	Y?	Y?
Impact: Relocation (occupied)	Potential impacts to both salvaged and host populations	Y	Y	Y	Y
Impact: Relocation (unoccupied)	No amphibians occur at this site pre-salvage	N	N	Y	Y

[1]If salvage sites are permanently and completely removed, post-salvage monitoring may not be possible at impact sites, but should still occur at relocation sites. Alternatively, if salvage sites are only temporarily or partially impacted, post-salvage monitoring of impact sites is necessary.

9.2 Assessing Persistence

Depending on the scale of the project and associated permit requirements, the level of effort required for salvage effectiveness monitoring will vary. For small-scale projects, such as instream works on a single watercourse that requires a single Section 9 Water Act permit, monitoring species persistence over time may be sufficient. For larger projects, more effort may be required (see below).

The key question for monitoring species persistence are listed below. Each question assumes that metrics are compared between control and impact sites, before and after salvage:

- Does species presence or breeding success differ between control (undisturbed) and impact (salvage and relocation) sites[10]?
- Does species presence or breeding success differ between occupied and unoccupied relocation sites relative to controls?
- Are the same life stages represented at impact sites before and after salvage?
- At salvage sites where salvage animals are relocated elsewhere, is the site recolonized?

[10] Because animals are not marked when assessing persistence, it is not possible to differentiate between salvaged and host animals at relocation sites, where the long-term goal is to assess whether species composition and life stages are maintained similar to pre-salvage conditions.

Species presence/persistence can be assessed via egg mass surveys in the spring, or aquatic trapping of larvae in the summer (Section 5.2). Breeding success can be determined by sampling metamorphs in late summer/early fall using VES or pitfall trapping with fencing (Section 5.7). Assessing the presence of multiple stages can be determined using a combination of all the above techniques, including VES or pitfall trapping with fencing to sample juveniles and adults (in addition to metamorphs). Recolonization can be assessed by determining whether the same life stages are present post-salvage compared to pre-salvage, using the techniques listed above that are appropriate to the given life-stages.

9.3 Assessing Survival

For projects with a large scope (i.e. “Major Projects” requiring an EA Certificate and many additional permits), a more intensive study investigating long-term effects on survival may be required.

The key question for programs monitoring survival are listed below. As above, each question assumes that metrics are compared between control and impact sites, before and after salvage:

- Does survival differ between salvaged animals (relocation sites) compared to undisturbed animals (control sites)?
- At salvage sites that are only temporarily or partially impacted, does survival differ between salvaged animals and undisturbed animals at control sites?
- For salvaged animals, does survival differ between previously-occupied versus unoccupied relocation sites?
- For host animals, does survival differ between occupied relocation sites relative to control sites?

Assessing survival requires the use of mark-recapture techniques. This involves repeat sampling each season over multiple years. Acceptable marking techniques include the use of VIE elastomer dyes, pit tags, pattern mapping, and scale or scute clips (see RISC standards)[11]. Successfully accomplishing the objectives of such a study requires considerable resources, planning, and expertise. As such, partnerships with academics, government agencies, and non-profit groups should be sought to maximize the potential for success and cost-effectiveness of this type of monitoring program. Planning for a post-salvage monitoring program assessing survival should also include a power analysis to determine number of sites of each treatment, and sampling intensity within them in order to detect statistical differences of a pre-determined effect size. Finally, because estimating survival rates requires marking animals and repeat captures, these studies should be approached with caution. The long-term conservation benefits of such studies should be weighed against the potential shorter-term impacts to populations, particularly when species are highly at risk or very rare.

[11] Toe clipping is not considered an acceptable marking technique, but is still acceptable for genetic sampling as per permit guidelines.

LITERATURE CITED

Balance Ecological. 2010. DRAFT Best Management Practices for Drainage Maintenance Works in Oregon Spotted Frog Habitat. Prepared for BC Ministry of Environment. Victoria, BC.

BC Ministry of Environment (BC MOE), Ecosystems Branch. 2008. Interim Hygiene Protocols for Amphibian field staff and researchers. Standard Operating Procedures: Hygiene Protocols for Amphibian Fieldwork. 8 pp.

BC Ministry of Environment (BC MOE), Water Stewardship Division. 2009. A User's Guide to Working In and Around Water – Understanding the Regulation Under British Columbia's *Water Act*. Originally issued: May 18, 2005. Updated Notifications Step 5, March 12, 2009.

BC Ministry of Environment (BC MOE). 2012. Policy for Mitigating Impacts on Environmental Values (Environmental Mitigation Policy). Final Working Draft. June 11, 2012. BC Ministry of Environment, Ecosystems Protection and Sustainability Branch, Environmental Sustainability and Strategic Policy Division. Victoria, BC. 7 pp.

Cossel, J.O. Jr., Gaige, M.G., and J.D. Sauder. 2012. Electroshocking as a survey technique for stream-dwelling amphibians. Wildlife Society Bulletin 36(2): 358–364.

Craig, Vanessa J., Ross G. Vennesland, and Kym E. Welstead. 2009. Best Management Practices Guidelines for Pacific Water Shrew in Urban and Rural Areas, Working Draft. Version September 2009. Prepared for the Pacific Water Shrew Recovery Team. 41 pp.

Edgar, Paul W., Richard A. Griffiths and Jim P. Foster. 2004. Evaluation of translocation as a tool for mitigating development threats to great crested newts (Triturus cristatus) in England, 1990-2001. Biological Conservation 122 (2005) 45-52. Accessed February 17, 2013. Available at: http://kar.kent.ac.uk/8562/1/Griffiths_%26_Edgar_%26_Foster_TriturusCristatus_March_2005.pdf.

Feral, D., Camann, M.A. and H.H. Welsh Jr. 2005. Dicamptodon tenebrosus larvae within hyporheic zones of intermittent streams in California. Herpetological Review 36(1):26-27.

Germano, Jennifer M. and Phillip J. Bishop. 2008. Suitability of Amphibians and Reptiles for Translocation. Conservation Biology, Volume 23, No.1, 7-15. Dunedin, New Zealand.

Gibbs, J.P. and J.M. Reed. 2007. Population and genetic linkages of vernal pool-associated amphibians. Chapter 8. *In*, Calhoun, A.J.K. and P.G. deMaynadier (Eds.). Science and Conservation of Vernal Pools in Northeastern North America. CRC Press. pp. 149-167.

Govindarajulu, P.P. 2007. Emerging Infectious diseases in British Columbian Amphibians: Literature Review to Assess Risk and Develop Survey Recommendations. Ministry of Environment, Ecosystems Branch, Victoria, BC. 37 pp.

IUCN (International Union for Conservation of Nature). 2012. IUCN Guidelines for Reintroductions and Other Conservation Translocations. Adopted by SSC Steering Committee at Meeting SC 4 6, 5th September 2012. Design: Interim.

Leary, S., Underwood, W., Anthony, R., Cartner, S., Corey, D., Grandin, T., ... & Yanong, R. 2013. AVMA guidelines for the euthanasia of animals: 2013 edition.

Lehtinen, R.M. and S.M. Galathowitsch. 2001. Colonization of Restored Wetlands by Amphibians in Minnesota. American Midland Naturalist 145(2): 388-396.

Malt, Josh. 2012. Assessing the Effectiveness of Amphibian Mitigation on the Sea to Sky Highway: Population-level Effects and Best Management Practices for Minimizing Highway Impacts. Final Report. Ministry of Forests, Lands and Natural Resource Operations, South Coast Region. 33 pp.

Marsh, D. 2008. Metapopulation viability analysis for amphibians. Animal Conservation 11: 463-465.

Marsh, D. M., and P. C. Trenham 2001. Metapopulation dynamics and amphibian conservation. Conservation Biology 15:40–49.

Metro Vancouver. 2011. Regional Parks Plan. Accessed February 19, 2013. Available at: http://www.metrovancouver.org/services/parks_lscr/ParksManagementPlan/Pages/default.aspx.

Ovaska, K., L. Sopuck, C. Engelstoft, L. Matthias, E. Wind and J.Macgarvie. 2003. Best Management Practices for Amphibians and Reptiles in Urban and Rural Environments in British Columbia. http://www.env.gov.bc.ca/wld/documents/bmp/HerptileBMP_complete.pdf.

Resource Inventory Standards Committee (RISC). 1998. Live Animal Capture and Handling Guidelines for Wild Mammals, Birds, Amphibians & Reptiles. Standards for Components of British Columbia's Biodiversity No.3. Ministry of Environment, Lands and Parks, Resource Inventory Branch. Version 2.0.

Resource Inventory Standards Committee (RISC). 1999. Inventory Methods for Plethodontid Salamanders. Standards for Components of British Columbia's Biodiversity No.36. Ministry of Environment, Lands and Parks, Resource Inventory Branch. Version 2.0.

Resource Inventory Standards Committee (RISC). 2000. Inventory Methods for Tailed Frog and Pacific Giant Salamander. Standards for Components of British Columbia's Biodiversity No.39. Ministry of Environment, Lands and Parks, Resource Inventory Branch. Version 2.0.

RSBC. 1996a. *Wildlife Act* [RSBC 1996] Chapter 488. Available at: http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/00_96488_01.

RSBC. 1996b. *Water Act* [RSBC 1996] Chapter 483. Available at: http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/00_96483_01.

RSBC. 1996c. *Local Government Act* [RSBC 1996] Chapter 323, Part 26 – Planning and Land Use Management, Division 2 – Official Community Plans, Section 875(1) Purposes of official community plans. Accessed February 20, 2013. Available at: http://www.bclaws.ca/EPLibraries/bclaws_new/document/LOC/freeside/--%20L%20--/Local%20Government%20Act%20RSBC%201996%20c.%20323/00_Act/96323_30.xml#section875.

Schmetterling, D.A., and M.K. Young. 2008. Summer movements of boreal toads (*Bufo boreas boreas*) in two western Montana basins. Journal of Herpetology 42(1): 111–123.

Seigel, Richard A. and C. Kenneth Dodd Jr. 2002. Translocations of Amphibians: Proven Management Method or Experimental Technique? Conservation Biology, Volume 16, No. 2, April 2002. Pp 552-554.

Semlitsch, R.D. 2008. Differentiating Migration and Dispersal Processes for Pond-Breeding Amphibians. Journal of Wildlife Management 72(1): 260-267.

Smith, G.R., Rettig, J.E., Mittelbach, G.G., Valiulis, J.L., and S.R. Schaack. 1999. The effects of fish on assemblages of amphibians in ponds: a field experiment. Freshwater Biology 41(4): 829–837.

The British Columbia Society for the Prevention of Cruelty to Animals (BC SPCA). 2013. [http://www.spca.bc.ca/welfare/wildlife/exotic/about-exotic-animals.html]. Accessed February 15, 2013.

Titus, V., D.M. Madison, and T.M. Green. *In review*. The potential for relocation, repatriation, and translocation programs for metamorphic tiger salamanders. The Journal of Wildlife Management: 00(0): 000-000, 201X.

Wahbe, T. and F.L. Bunnell. 2001. Preliminary observations on movements of tailed frog tadpoles (Ascaphus truei) in streams through harvested and natural forests. Northwest Science 75(1): 77-83.

Welstead, K. and R. Vennesland. 2006. Fish Traps Threaten Pacific Water Shrew Recovery. Streamline Watershed Management Bulletin. Vol.9/No.2, Spring 2006: 21-24.

Wilson, J.D. and M.E. Dorcas. 2004. A comparison of aquatic drift fences with traditional funnel trapping as a quantitative method for sampling amphibians. Herpetological Review 35(2): 148–150.

Wyman, R.L. 1998. Experimental assessment of salamanders as predators of detrital food webs: effects on invertebrates, decomposition and the carbon cycle. Biodiversity and Conservation 7(5): 641-650.

PERSONAL COMMUNICATIONS

Govindarajulu, Purnima. Ministry of Environment. 2013.

Mitchell, Aimee. 2013.

Pearson, Monica. Balance Ecological. 2013.

Persello, Brent. MOTI. 2013.

Sloboda, Susanne. Environmental Dynamics Inc. (EDI). 2013.

Sutherland, Duncan. Sutherland Environmental Associates. 2013.

Wind, Elke. E. Wind Consulting. 2013

ADDITIONAL RESOURCES

BC Ministry of Environment (BC MOE) 2012. Develop with Care 2012: Environmental Guidelines for Urban and Rural Land Development in British Columbia. Available at: http://www.env.gov.bc.ca/wld/documents/bmp/devwithcare2012/index.html.

BC Ministry of Environment (BC MOE) 2012. Instream Works. Available at: http://www.env.gov.bc.ca/wld/instreamworks/index.htm.

Department of Sustainability and Environment & Biosis Research Pty Ltd. 2011. Salvage & Translocation of Striped Legless Lizard in the Urban Growth Areas of Melbourne: Operational Plan. Victorian Government Department of Sustainability and Environment. Melbourne, March 2011.

(http://www.dse.vic.gov.au/__data/assets/pdf_file/0017/112436/SLL_Salvage_Operational_Plan_March2011.pdf)

English Nature. 2001. Great Crested Newt Mitigation Guidelines. Version: August 2001. (http://publications.naturalengland.org.uk/publication/810429)

Graeter, G.J., K.A. Buhlmann, L.R. Wilkinson, and J.W. Gibbons. (editors). 2010. Inventory and Monitoring: Recommended Techniques for Reptiles and Amphibians, with application to the United States and Canada. PARC Technical Report. Aiken, South Carolina.

Green, D.M. 2005. Biology of Amphibian Declines. In Amphibian Declines: The Conservation Status of United States Species. Edited by Michael Lannoo. University of California Press.

IUCN (World Conservation Union). 1987. IUCN Position statement on the translocation of living organisms: introductions, re-introductions, and re-stocking. IUCN, Gland, Switzerland.

McDiarmid, R.W., M.S. Foster, C. Guyer, J. Whitfield Gibbons and N. Chernoff. 2012. Reptile Biodiversity – Standard Methods for Inventory and Monitoring. University of California Press. Berkeley and Los Angeles, CA. 412 pp.

Northwest Partners in Amphibian and Reptile Conservation Publications (http://www.parcplace.org/publications.html)

Olson, D.H., W.P. Leonard, and R.B. Bury (editors). 1997. Sampling Amphibians in Lentic Habitats. Northwest Fauna No. 4, Society for Northwestern Vertebrate Biology. 134 pp.

Pilliod, D.S., and E. Wind. (editors). 2008. Habitat Management Guidelines for Amphibians and Reptiles of the Northwestern United States and Western Canada. Partners in Amphibian and Reptile Conservation, Technical Publication HMG-4, Birmingham, AL. 130 pp.

Resource Inventory Standards Committee. 1998. Inventory Methods for Pond-breeding Amphibians and Painted Turtle. Standards for Components of British Columbia's Biodiversity No. 37. Ministry of Environment, Lands and Parks, Resource Inventory Branch. Version 2.0.

Resource Inventory Standards Committee. 1998. Inventory Methods for Snakes. Standards for Components of British Columbia's Biodiversity No. 38. Ministry of Environment, Lands and Parks, Resource Inventory Branch. Version 2.0.

Wetland Stewardship Partnership. 2009. Wetland Ways: Interim Guidelines for Wetland Protection and Conservation in British Columbia. Accessed December 14, 2012. Available

at:
http://www.env.gov.bc.ca/wld/documents/bmp/wetlandways2009/Wetland%20Ways%20Ch%201%20Introduction.pdf.

APPENDIX 1A CONSERVATION STATUS OF AMPHIBIANS IN B.C.

Scientific Name	English Name	COSEWIC	BC List	*SARA*
AMPHIBIANS				
Ambystoma gracile	Northwestern Salamander	NAR (May 1999)	Yellow	
Ambystoma macrodactylum	Long-toed Salamander	NAR (Apr 2006)	Yellow	
Ambystoma mavortium	**Blotched Tiger Salamander**	**E (Nov 2012)**	**Red**	**1 (Jun 2003)**
Taricha granulosa	Roughskin Newt		Yellow	
Dicamptodon tenebrosus	**Coastal Giant Salamander**	**T (Nov 2000)**	**Red**	**1-T (Jun 2003)**
Aneides vagrans	**Wandering Salamander**		**Blue**	
Ensatina eschscholtzii	Ensatina	NAR (May 1999)	Yellow	
Plethodon idahoensis	**Coeur d'Alene Salamander**	**SC (Nov 2007)**	**Yellow**	**1-SC (Jun 2003)**
Plethodon vehiculum	Western Red-backed Salamander	NAR (Nov 2001)	Yellow	
Ascaphus truei	**Coastal Tailed Frog**	**SC (Nov 2011)**	**Blue**	**1-SC (Jun 2003)**
Ascaphus montanus	**Rocky Mountain Tailed Frog**	**E (May 2000)**	**Red**	**1-E (Jun 2003)**
Spea intermontana	**Great Basin Spadefoot**	**T (Apr 2007)**	**Blue**	**1-T (Jun 2003)**
Anaxyrus boreas	**Western Toad**	**SC (Nov 2012)**	**Blue**	**1-SC (Jan 2005)**
Pseudacris regilla	Northern Pacific Treefrog		Yellow	
Pseudacris maculata	Boreal Chorus Frog		Yellow	
Rana aurora	**Northern Red-legged Frog**	**SC (Nov 2004)**	**Blue**	**1-SC (Jan 2005)**
Rana luteiventris	Columbia Spotted Frog	NAR (May 2000)	Yellow	
Rana pretiosa	**Oregon Spotted Frog**	**E (May 2011)**	**Red**	**1-E (Jun 2003)**
Lithobates sylvaticus	Wood Frog		Yellow	
Lithobates pipiens	**Northern Leopard Frog**	**E (Apr 2009)**	**Red**	**1-E (Jun 2003)**
Lithobates catesbeianus	American Bullfrog		Exotic	
Lithobates clamitans	Green Frog		Exotic	

Species bolded = Listed Species at Risk
Citation: BC Conservation Data Centre. 2012. BC Species and Ecosystems Explorer. BC Ministry of Environment. Victoria, BC Available: http://a100.gov.bc.ca/pub/eswp/ (accessed Dec 26, 2012).

APPENDIX 1B. CONSERVATION STATUS OF REPTILES IN B.C.

Scientific Name	English Name	COSEWIC	BC List	*SARA*
REPTILES				
Actinemys marmorata	**Western Pond Turtle**	**XT (May 2012)**	**Red**	**1-X (Jan 2005)**
Chrysemys picta	**Painted Turtle**	**E/SC (Apr 2006)**	**No Status**	**1**
Chrysemys picta pop. 1	***Pacific Coast Population***	**E (Apr 2006)**	**Red**	**1-E (Dec 2007)**
Chrysemys picta pop. 2	***Intermountain - Rocky Mountain Population***	**SC (Apr 2006)**	**Blue**	**1-SC (Dec 2007)**
Trachemys scripta	Pond Slider		Exotic	
Phrynosoma douglasii	**Pygmy Short-horned Lizard**	**XT (Apr 2007)**	**Red**	**1-X (Jun 2003)**
Podarcis muralis	Common Wall Lizard		Exotic	
Plestiodon skiltonianus	**Western Skink**	**SC (May 2002)**	**Blue**	**1-SC (Jan 2005)**
Elgaria coerulea	Northern Alligator Lizard	NAR (May 2002)	Yellow	
Charina bottae	**Northern Rubber Boa**	**SC (May 2003)**	**Yellow**	**1-SC (Jan 2005)**
Contia tenuis	**Sharp-tailed Snake**	**E (Nov 2009)**	**Red**	**1-E (Jun 2003)**
Hypsiglena chlorophaea	**Desert Nightsnake**	**E (May 2011)**	**Red**	**1-E (Jun 2003)**
Coluber constrictor	**North American Racer**	**SC (Nov 2004)**	**Blue**	**1-SC (Aug 2006)**
Pituophis catenifer	**Gopher Snake**		**No Status**	**1**
Pituophis catenifer catenifer	***Gopher Snake,* catenifer *subspecies***	**XT (May 2012)**	**Red**	**1-X (Jan 2005)**
Pituophis catenifer deserticola	***Gopher Snake,* deserticola *subspecies***	**T (May 2002)**	**Blue**	**1-T (Jan 2005)**
Thamnophis sirtalis	Common Gartersnake		Yellow	
Thamnophis ordinoides	Northwestern Gartersnake	NAR (May 2003)	Yellow	
Thamnophis elegans	Terrestrial Gartersnake		Yellow	
Crotalus oreganus	**Western Rattlesnake**	**T (May 2004)**	**Blue**	**1-T (Jul 2005)**

Species bolded = Listed Species at Risk
Citation: BC Conservation Data Centre. 2012. BC Species and Ecosystems Explorer. BC Ministry of Environment. Victoria, BC Available: http://a100.gov.bc.ca/pub/eswp/ (accessed Dec 26, 2012).

APPENDIX 2A. AMPHIBIAN OCCURRENCE BY REGION

REGION[1]:	1 V.I.	2 L.M.	3 T-N	4 Ko	5 Car	6 Sk	7 Om	8 Ok	9 Pe
AMPHIBIANS									
Northwestern Salamander	X	X			X	X			
Long-toed Salamander	X	X	X	X	X	X	X	X	X
Blotched Tiger Salamander								**X**	
Roughskin Newt	X	X	X		X	X			
Coastal Giant Salamander		**X**							
Wandering Salamander	**X**								
Ensatina	X	X			X	X			
Coeur d'Alene Salamander				**X**					
Western Red-backed Salamander	X	X							
Coastal Tailed Frog		**X**	**X**		**X**	**X**		**X**	
Rocky Mountain Tailed Frog				**X**					
Great Basin Spadefoot			**X**		**X**			**X**	
Western Toad	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Northern Pacific Treefrog	X	X	X	X	X	X[2]	X	X	
Boreal Chorus Frog							X		X
Northern Red-legged Frog	**X**	**X**				X[2]			
Columbia Spotted Frog		X	X	X	X	X	X	X	X
Oregon Spotted Frog		**X**							
Wood Frog			X	X	X	X	X		X
Northern Leopard Frog	**X**			**X**				**X**	
American Bullfrog	X	X						X	
Green Frog	X	X							
# of amphibian species	13	14	8	8	10	8	6	9	5
# of Prov. &/or Fed listed species	5	5	3	4	3	2	1	5	1

[1] V.I. = Vancouver Island; L.M. = Lower Mainland; T-N = Thompson-Nicola; Ko = Kootenay; Car = Cariboo; Sk = Skeena; Om = Omineca; Ok = Okanagan; Pe = Peace.

[2] Red-legged Frogs and Pacific Chorus Frogs are not native to Haida Gwaii.

APPENDIX 2B. REPTILE OCCURRENCE BY REGION

REGION[1]:	1 V.I.	2 L.M.	3 T-N	4 Ko	5 Car	6 Sk	7 Om	8 Ok	9 Pe
REPTILES									
Western Pond Turtle		**X**							
Painted Turtle	**X**	**X**	**X**	**X**	**X**			**X**	
Pacific Coast Pop.	*X*	*X*							
Intermountain - Rocky Mountain Pop.			*X*	*X*	*X*			*X*	
Pond Slider	X	X							
Pygmy Short-horned Lizard								**X**	
Common Wall Lizard	X								
Western Skink			**X**	**X**				**X**	
Northern Alligator Lizard	X	X	X	X	X			X	
Northern Rubber Boa		**X**	**X**	**X**	**X**			**X**	
Sharp-tailed Snake	**X**	**X**							
Desert Nightsnake								**X**	
North American Racer			**X**	**X**	**X**			**X**	
Gopher Snake	**X**	**X**	**X**	**X**	**X**			**X**	
catenifer *subspecies*	*X*	*X*							
deserticola *subspecies*			*X*	*X*	*X*			*X*	
Common Gartersnake	X	X	X	X	X		X	X	X
Northwestern Gartersnake	X	X	X		X				
Terrestrial Gartersnake	X	X	X	X	X	X	X	X	X
Western Rattlesnake			**X**					**X**	
# of reptile species	9	10	10	8	8	1	2	11	2
# of Prov. &/or Fed. listed species	3	5	6	5	4	0	0	8	0
Total # of amphibian and reptile species	**22**	**24**	**18**	**16**	**18**	**9**	**8**	**20**	**7**
# of Prov. &/or Fed. listed species	**8**	**10**	**9**	**9**	**7**	**2**	**1**	**13**	**1**

[1] V.I. = Vancouver Island; L.M. = Lower Mainland; T-N = Thompson-Nicola; Ko = Kootenay; Car = Cariboo; Sk = Skeena; Om = Omineca; Ok = Okanagan; Pe = Peace.

Figure 8. Regions of B.C. Note that these regions are for reference to provincial-scale amphibian and reptile distributions as per Appendix 2A and 2B, and do not necessarily correspond to all current FLNR administrative names and boundaries. For a current map of provincial regions and district offices, go to https://www.for.gov.bc.ca/mof/maps/regdis/regdismap.pdf

APPENDIX 3A. AMPHIBIAN HABITAT ASSOCIATIONS IN B.C.

GENERAL HABITAT TYPE:	TERRESTRIAL				AQUATIC - LENTIC			AQUATIC - LOTIC	
	Rural / Agricul. / Disturbed	Forest	Sparsely Veget. (shrub, scrub, rock)	Subter-ranean	Lakes	Wetlands / Ponds	Sloughs / ditches / dug outs	Creeks / Streams / Rivers	Springs and Seeps
AMPHIBIANS									
Northwestern Salamander	X	X	X	X	X	X	X	X	
Long-toed Salamander	X	X	X		X	X	X	X	X
Blotched Tiger Salamander	X		X	X	X	X	X	X	
Roughskin Newt	X	X			X	X	X	X	
Coastal Giant Salamander		X	X	X	X			X	X
Wandering Salamander	X	X	X						
Ensatina		X	X			X			
Coeur d'Alene Salamander	X		X	X		X		X	X
Western Red-backed Salamander	X	X	X	X					
Coastal Tailed Frog		X	X			X		X	
Rocky Mountain Tailed Frog		X	X			X		X	
Great Basin Spadefoot	X		X	X	X	X	X	X	X
Western Toad	X	X	X		X	X	X	X	
Northern Pacific Treefrog	X	X	X[a]	X	X	X	X	X	
Boreal Chorus Frog		X			X	X	X	X	
Northern Red-legged Frog	X	X	X		X	X	X	X	
Columbia Spotted Frog	X				X	X	X	X	
Oregon Spotted Frog					X	X		X	
Wood Frog		X			X	X	X	X	
Northern Leopard Frog	X		X		X	X		X	
American Bullfrog	X						X		
Green Frog	X						X		
# amphibian species	15	14	14	7	14	17	13	17	4

APPENDIX 3B. REPTILE HABITAT ASSOCIATIONS IN B.C.

GENERAL HABITAT TYPE:	TERRESTRIAL				AQUATIC - LENTIC			AQUATIC - LOTIC	
	Rural / Agricul. / Disturbed	**Forest**	**Sparsely Veget. (shrub, scrub, rock)**	**Subter-ranean**	**Lakes**	**Wetlands / Ponds**	**Sloughs / ditches / dug outs**	**Creeks / Streams / Rivers**	**Springs and Seeps**
REPTILES									
Western Pond Turtle			X		X	X		X	
Painted Turtle	X				X	X		X	
Pacific Coast Population	*x*				*x*	*x*		*x*	
Intermountain - Rocky Mountain Population	*x*				*x*	*x*		*x*	
Pond Slider					X	X	X		
Pygmy Short-horned Lizard			X						
Common Wall Lizard	X		X						
Western Skink	X	X	X	X		X		X	
Northern Alligator Lizard	X	X	X			X			
Northern Rubber Boa	X	X	X	X					
Sharp-tailed Snake	X	X	X	X					
Desert Nightsnake			X	X				X	
North American Racer	X	X	X	X		X	X		X
Gopher Snake	X	X	X		X	X		X	
catenifer *subspecies*	*x*	*x*	*x*			*x*			
deserticola *subspecies*			*x*		*x*	*x*		*x*	
Common Gartersnake	X	X	X		X	X	X	X	X
Northwestern Gartersnake	X	X	X			X	X	X	X
Terrestrial Gartersnake	X	X	X		X	X	X	X	X
Western Rattlesnake	X	X	X	X		X	X	X	X
# reptile species	12	10	14	6	6	11	6	9	5
Total amphibian and reptile species	**27**	**24**	**28**	**13**	**20**	**28**	**19**	**26**	**9**

Sources: BC Species Explorer; NW PARC HMGs; local / expert knowledge.

APPENDIX 4. APPROXIMATE ACTIVE SEASONS FOR BC HERPETOFAUNA

Month:	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	
SALAMANDERS													**Comments**
Northwestern Salamander	N,L*	N,L,A?	N,L,A,E	**N,L,E**	N,L,E	**N,L**	**N,L**	N,L	N,L	N,L	N,L	N,L	Individuals present year round in aquatic breeding sites
Long-toed Salamander	L?	A?,E?	A,E	**E,L**	L	**L**	**L**	L?	L?,A?	L?,A?	L?	L?	High elevation populations can overwinter as larva
Blotched Tiger Salamander	N,L	N,L	N,L	**N,L,A,E**	N,L,A,E	**N,L**	**N,L,M?**	N,L,M	N,L	N,L	N,L	N,L	Neotenic adults may be present in permanent water
Roughskin Newt			A	E?,L	E?,L	**E?,L**	**L**	**L?**	L?,A	L?,A	A?		Eggs not detectable (laid singly)
Coastal Giant Salamander	N,L	N,L,A?	N,L,A?	N,L,A?	N,L,A?	**N,L**	**N,L**	**N,L**	**N,L**	N,L,A?	N,L,A?	N,L	Terrestrial adults are difficult to detect, but live within 100 m of stream; Fall = fewest number of individuals in the water
Wandering Salamander			A	A	**A**	**A**			**J,A**	**J,A**	J?,A?		Surface disturbances may be best timed when majority of individuals are underground (i.e., dry, hot summer, mid winter)
Ensatina			A	A	**A**	**A**			**J,A**	**J,A**	**J?,A?**		Surface disturbances may be best timed when majority of individuals are underground (i.e., dry, hot summer, mid winter)

LEGEND: [yellow box] **= Main active season or greatest probability of detection**

*Life Stage: A = Adult, J = Juvenile (subadult), E = Egg(s), L = Larva, M = Metamorph, N = Neotenic adult, T = tadpole

APPENDIX 4 (CONT'D): SALAMANDERS

Coeur d'Alene Salamander			A	A	**A**	**A**			**J,A**	**J,A**			Surface disturbances may be best timed when majority of individuals are underground (i.e., dry, hot summer, mid winter)
Western Red-backed Salamander			A	A	**A**	**A**			**J,A**	**J,A**	**J,A**		Surface disturbances may be best timed when majority of individuals are underground (i.e., dry, hot summer, mid winter)

LEGEND: **= Main active season or greatest probability of detection**

*Life Stage: A = Adult, J = Juvenile (subadult), E = Egg(s), L = Larva, M = Metamorph, N = Neotenic adult, T = tadpole

APPENDIX 4 (CONT'D): FROGS

Month:	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
FROGS													**Comments**
Coastal Tailed Frog	T	T	T	T	T	**T**	**T,A?,M?**	**T,A,M**	T,A?	T?	T	T	Fall / winter = fewest number of individuals in the water
Rocky Mountain Tailed Frog	T	T	T	T	T	**T**	**T,A?,M?**	**T,A,M**	T,A?	T?	T	T	Fall / winter = fewest number of individuals in the water
Great Basin Spadefoot			A?,E?	**A,E?**	**T,A?**	**T,M,A?**	**T,M?A?**	T?,M?,A?	T?,M?,A?	A?	A?		Adults and juveniles burrow underground during inactive season
Western Toad			A?,E?	**A,E**	**T**	**T,M?**	**T,M**	T?,M?	T?,M?,A?	A?			May see tadpoles and metamorphs late into the fall at high elevation sites
Northern Pacific Treefrog		A?	A?,E?	**A,E**	**E,T**	**E,T,M?**	**T,M**	T?,M?	T?,M?,A?	A?	A?		
Boreal Chorus Frog			A?	**A,E**	**E,T**	**T,M?**	**T,M**	T?,M?	M?,A?	A?			
Northern Red-legged Frog		A?,E?	A,E	**A,E**	**T**	**T**	**T,M**	T?,M	T?,M?,A?	A?	A?		
Columbia Spotted Frog	A?	A?	A?	**A,E**	**A,T**	**A,T,M?**	**A,T,M**	A,T?,M?	T?,M?,A?	A?	A?	A?	Adults highly aquatic and overwinter in water
Oregon Spotted Frog	A?	A?,E?	A?	**A,E**	**A,T**	**A,T,M?**	**A,T,M**	A,T?,M?	T?,M?,A?	A?	A?	A?	Adults highly aquatic and overwinter in water
Wood Frog			A?	**A,E**	**E,T**	**T,M?**	**T,M**	T?,M?	M?,A?	A?			
Northern Leopard Frog			A?	**A,E**	**T**	**T,M?**	**T,M**	T?,M?	M?,A?	A?			Adults highly aquatic and overwinter in water
American Bullfrog	T?,A?	T?,A?	T?,A?	T?,A?	T,A?	T,A,E?	**T,A,E**	**T,A,M**	T,A,M?	T,A?	T?,A?	T?,A?	Tadpoles and adults present in permanent water year round
Green Frog	T?,A?	T?,A?	T?,A?	T?,A?	T,A?	T,A,E?	**T,A,E**	**T,A,M**	T,A,M?	T,A?	T?,A?	T?,A?	Tadpoles and adults present in permanent water year round

APPENDIX 4 (CONT'D): TURTLES AND LIZARDS

REPTILES													
Western Pond Turtle	A,J	A,J	**A,J**	**A,J**	**A,J**	**A,J**	**A,J**	**A,J**	**A,J**	A,J	A,J	A,J	
Painted Turtle	A,J	A,J	**A,J**	**A,J**	**A,J**	**A,J**	**A,J**	**A,J**	**A,J**	A,J	A,J	A,J	Present in ponds yearround except for upland egg laying and long distance migrations if pond dries
Pond Slider	A,J	A,J	**A,J**	**A,J**	**A,J**	**A,J**	**A,J**	**A,J**	**A,J**	A,J	A,J	A,J	
Pygmy Short-horned Lizard			**A,J**	**A,J**	**A,J**	**A,J**	**A,J**	**A,J**	**A,J**	**A,J**			
Common Wall Lizard			A,J	A,J	**A,J**	**A,J**	**A,J**	A,J	A,J				
Western Skink			**A,J**	**A,J**	**A,J**	A,J	A,J	A,J	A,J				Most evident during the spring
Northern Alligator Lizard				**A,J**	**A,J**	**A,J**	A,J	A,J	**A,J**				

LEGEND: **= Main active season or greatest probability of detection**

*Life Stage: A = Adult, J = Juvenile (subadult), E = Egg(s), L = Larva, M = Metamorph, N = Neotenic adult, T = tadpole

APPENDIX 4 (CONT'D): SNAKES

Month:	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	
REPTILES													
Northern Rubber Boa		A,J	**A,J**	**A,J**	A,J	A,J	A,J	A,J	A,J	A,J			Most evident during spring emergence but can be found travelling during May and Aug. / Sept.
Sharp-tailed Snake			A,J	**A,J**	**A,J**	**A,J**	A,J	A,J	A,J	A,J			
Desert Nightsnake				**A,J**	**A,J**	A,J	A,J	A,J	A,J				
North American Racer			**A,J**	**A,J**	A,J	A,J	A,J	A,J	A,J				Most evident during spring emergence but laying out period is brief
Gopher Snake			A,J	**A,J**	**A,J**	A,J	A,J	A,J	**A,J**	A,J			
Common Gartersnake		A,J	**A,J**	**A,J**	A,J	A,J	A,J	A,J	A,J	A,J			Most evident during spring emergence and subsequent mating
Northwestern Gartersnake		A,J	**A,J**	**A,J**	A,J	A,J	A,J	A,J	A,J	A,J			Most evident during spring emergence and subsequent mating
Terrestrial Gartersnake		A,J	**A,J**	**A,J**	A,J	A,J	A,J	A,J	A,J	A,J			Most evident during spring emergence and subsequent mating
Western Rattlesnake			**A,J**	**A,J**	**A,J**	A,J	A,J	A,J	**A,J**	**A,J**			Evident during laying out periods at dens in both spring and fall; *Note* - pregnant females remain near den throughout summer

LEGEND: [yellow box] **= Main active season or greatest probability of detection**
*Life Stage: A = Adult, J = Juvenile (subadult), E = Egg(s), L = Larva, M = Metamorph, N = Neotenic adult, T = tadpole

APPENDIX 5. INVENTORY AND CAPTURE TECHNIQUES

Detection / Capture Technique:	**Detection & Capture Techniques**									**Detection Techniques**	
Habitat:	*Terr. & Aquatic*	*Aquatic*					*Terrestrial*			*Terrestrial*	*Aquatic*
Technique:	**VES / Hand Capture**	**Aquatic funnel / Gee trap**	**Dewatering with Dip Netting**	**Seine net**	**Hoop / Fyke trap (and basking trap)**	**Electro-shocking**	**Pitfall trap with fencing**	**Terrestrial funnel trap with fencing**	**Cover board**	**Road survey**	**Auditory survey**
AMPHIBIANS											
Northwestern Salamander	X	X	X	X			X			X	
Long-toed Salamander	X	X	X	X			X		X	X	
Blotched Tiger Salamander	X	X	X	X			X	X	X	X	
Roughskin Newt	X	X	X	X			X			X	
Coastal Giant Salamander	X		X			X	?				
Wandering Salamander	X						X		X		
Ensatina	X						X		X	X	
Coeur d'Alene Salamander	X						X				
Western Red-backed Sal.	X						X		X	X	
Coastal Tailed Frog	X					X	X				
Rocky Mountain Tailed Frog	X					X	X				
Great Basin Spadefoot	X	X	X	X			X			X	X
Western Toad	X	X	X	X			X			X	?[1]
Northern Pacific Treefrog	X	X	X	X			X		X	X	X
Boreal Chorus Frog	X	X	X	X			X				X
Northern Red-legged Frog	X	X	X	X			X			X	?
Columbia Spotted Frog	X	X	X	X			X				?
Oregon Spotted Frog	X	X	X	X			X				?
Wood Frog	X	X	X	X			X				X

APPENDIX 5 (CONT'D)

Habitat:	*Terr. & Aquatic*	*Aquatic*					*Terrestrial*			*Terrestrial*	*Aquatic*
Technique:	**VES / Hand Capture**	**Aquatic funnel / Gee trap**	**Dewatering with Dip Netting**	**Seine net**	**Hoop / Fyke trap (and basking trap)**	**Electro-shocking**	**Pitfall trap with fencing**	**Terrestrial funnel trap with fencing**	**Cover board**	**Road survey**	**Auditory survey**
AMPHIBIANS											
Northern Leopard Frog	X	X	X	X			X				X
American Bullfrog	X	X	X	X			X			X	X
Green Frog	X	X	X	X			X			X	X
# amphibian species	**22**	**15**	**16**	**15**	**0**	**3**	**21**	**1**	**6**	**12**	**7**
REPTILES											
Western Pond Turtle	X		X	X	X						
Painted Turtle	X		X	X	X					?	
Pond Slider	X		X	X	X						
Pygmy Short-horned Lizard	X						X	X			
Common Wall Lizard	X							?	X		
Western Skink	X						X	X	X		
Northern Alligator Lizard	X						X	X	X		
Northern Rubber Boa	X							X	X	X	
Sharp-tailed Snake	X						X	X	X	X	
Desert Nightsnake	X						X	X	X	X	
North American Racer	X							X	X	X	
Gopher Snake	X							X	X	X	
Common Gartersnake	X							X	X	X	
Northwestern Gartersnake	X							X	X	X	
Terrestrial Gartersnake	X							X	X	X	
Western Rattlesnake	X							X	X	X	

APPENDIX 5 (CONT'D)

Detection / Capture Technique:	Detection & Capture Techniques									Detection Techniques	
Habitat:	*Terrestrial & Aquatic*	*Aquatic*					*Terrestrial*			*Terrestrial*	*Aquatic*
Technique:	VES / Hand Capture	Aquatic funnel / Gee trap	Dewatering with Dip Netting	Seine net	Hoop / Fyke trap (and basking trap)	Electro-shocking	Pitfall trap with fencing	Funnel trap with fencing	Cover board	Road survey	Auditory survey
# reptile species	**15**	**0**	**2**	**2**	**2**	**0**	**5**	**12**	**12**	**9**	**0**
Total amphibian & reptile species	**37**	**15**	**18**	**17**	**2**	**3**	**26**	**13**	**18**	**21**	**7**

[1] '?' indicates that this technique may be effective depending on local conditions