Selecting Wetland Mitigation Sites Using a Watershed Approach (Eastern Washington)

Thomas Hruby, Kim Harper, and Stephen Stanley

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Or visit our home page at http://www.ecy.wa.gov/programs/sea/shorelan.html

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Due to the dynamic nature of wetland science, this document is subject to revision. As we learn more on the science of wetland restoration, and as we receive suggestions from users for improving this guide, the document will be periodically updated. Make sure you have the most recent version. You can find the most up-to-date version at: www.ecy.wa.gov/mitigation/resources.html.

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Introduction

Introduction

The Washington Department of Ecology (Ecology), U.S. Army Corps of Engineers Seattle District (Corps), and the U.S. Environmental Protection Agency Region 10 (EPA) (collectively the Agencies) prepared this guide on selecting mitigation sites for unavoidable wetland impacts. The Agencies encourage state, federal, and local decision-makers, as well as project applicants, to use this guide as one step in the process of deciding on compensatory mitigation projects. The goals of this guide are to improve mitigation success and to better address the ecological priorities of Washington's watersheds. We provide specific recommendations on how to apply a watershed approach when selecting sites and in choosing between on-site and off-site mitigation in eastern Washington. A similar guide is available for western Washington (Ecology publication #09-06-032, http://www.ecy.wa.gov/biblio/0906032.html).

Use of this guide is not required by the authoring agencies, but the federal rule on compensatory mitigation does require that some type of watershed approach be used in choosing sites for mitigation. This guide is offered as one way to fulfill that requirement.

Background

Permitting agencies require compensatory mitigation when applicants cannot reasonably avoid all impacts to wetlands and their functions and values. State and national studies of wetland mitigation, however, show a disappointingly low success rate in meeting performance measures and replacing wetland functions (Ecology 2002; National Research Council 2001). The studies identify a number of reasons for this including poor site selection. Our past policies and practices have over-emphasized the need to replace lost functions at or near the wetlands impacted (the impact site), rather than choosing mitigation sites that best fit with the mitigation goals of the project and its contributing basin. The studies demonstrate a clear need to change this approach.

***Watershed Approach*:** A *watershed approach* when used in selecting sites for mitigation is based on:

1. Understanding how ecological processes, such as the movement of water, determine the characteristics and ecological functions in a drainage basin (watershed). NOTE: There are no size limits to the drainage basin used for the analysis. A watershed approach can be used in small drainage basins that are only several square miles in size to entire river basins such as the Yakima River.
2. Determining the extent to which the processes have been altered (e.g., change in groundwater flows resulting from loss of forests).
3. Identifying areas where these processes can be most effectively restored, and where they need to be protected.
4. Assessing the role restoration, including compensatory mitigation, can play in repairing those processes and replacing wetland functions lost in the watershed.

In the last ten years we have seen a shift in national and state policies towards using a watershed-based approach to choose mitigation sites. Recent guidance recommends that mitigation be done in areas where ecological processes can best be restored, unless it is necessary to maintain the affected functions on or near the impact site (Ecology et al. 2006, USACE & EPA 2008). While this shift in policy is becoming widespread among regulatory agencies[1], we see a lag in applicants actually using a watershed approach when selecting mitigation sites. This guide clarifies our agencies' support of this change and provides practical tools that will help close this gap.

This guide promotes mitigation that is located appropriately on the landscape, addresses restoration of watershed processes, is sustainable, and has a high likelihood of ecological success. On-site mitigation may achieve these goals in many circumstances. However, we should not risk mitigation success or bypass opportunities for improving ecological processes in a watershed by unnecessarily prioritizing on-site mitigation over more effective and sustainable off-site options.

Appendix A (this document is also available at: www.ecy.wa.gov/mitigation/resources.html) presents more information on the importance of using a watershed planning framework and includes an example of how watershed planning can be applied to identify solutions to specific problems in a watershed. This appendix also explains the connection between ecological processes and wetland structure and functions.

Sustainable mitigation site

Mitigation is often targeted at replacing specific functions at a site. The goal is to maintain these functions for many years into the future. A site is considered sustainable if the functions can be maintained without long-term management or maintenance. Unfortunately, many watersheds have been so heavily disturbed by human activities that the functions at a site can no longer be maintained by ecological processes in that watershed. In this case, a site is considered not sustainable because maintaining the functions in time will require continuous management to counteract the effects of the altered processes.

Scope of this Guide

This guide is meant to help users select the best locations for wetland mitigation sites. The Agencies recognize that selecting a site is a complex process involving many variables. This guide simplifies the process by asking questions that characterize the potential of a site to be sustainable, restore watershed processes, and replace the functions lost in other wetlands. The guide does not help users to design site-specific mitigation plans, although it does identify some issues that need to be addressed in a mitigation plan. There are two parts to this guide: **Part 1 guides users in locating a mitigation site by analyzing the watershed and its general functions.** Analyzing the watershed also helps determine whether a potential site will be sustainable.

Part 2 characterizes the constraints and issues that might be present in, or immediately adjacent to, a site. This analysis can be used to determine what functions can be mitigated at a site. It also identifies the major elements that need to be included in a mitigation plan specific to the site.

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[1] Some local jurisdictions in eastern Washington are revising their critical areas ordinances (CAOs) to allow for off-site mitigation. Typically there is a preference for locating the mitigation within the same drainage basin, sub-basin or watershed as the impact site. In some cases however, limits set by local CAOs may require you to modify the methods used in this guidance.

This guide does not include strategies for avoiding or minimizing impacts. We assume that this step in the mitigation process has been taken before the need for compensatory mitigation is established. For existing information on avoidance and minimization of impacts see the documents listed below. Additional guidance on this topic is being developed by federal agencies and is expected to be published in 2011.

- Compensatory Mitigation for Losses of Aquatic Resources, Final Rule, 33 CFR Parts 325 and 332 and 40 CFR Part 230 (http://www.epa.gov/owow/wetlands/pdf/wetlands_mitigation_final_rule_4_10_08.pdf)
- Regulatory Programs of the Corps of Engineers, Final Rule, 33 CFR Part 320.4(r) (http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&tpl=/ecfrbrowse/Title33/33cfr320_main_02.tpl)

Regional limits of this guide:

- This guide is intended to be used in eastern Washington, east of the Cascade Divide as defined in the Washington Administrative Code (WAC 222-16-010). "Eastern Washington means the geographic area in Washington east of the crest of the Cascade Mountains from the international border to the top of Mt. Adams, then east of the ridge line dividing the White Salmon River drainage from the Lewis River drainage and east of the ridge line dividing the Little White Salmon River drainage from the Wind River drainage to the Washington-Oregon state line." We do not advise using it in the areas west of the Cascade Range where the geology, rainfall and groundwater flow patterns are quite different.
- This guide considers ecological processes in floodplain areas but it does not address mitigating for in-channel stream impacts.

Who Should Use This Guide

This is a technical guide intended for use by wetland consultants, biologists, hydrologists and other practitioners with some familiarity with landscape processes. It is important that the person applying this tool have experience and/or education in hydrologic processes and how they affect wetland functions. The guide will typically be used by those designing wetland mitigation. We advise permit applicants who need to mitigate for impacts to wetlands to hire a qualified consultant to apply the approach explained in this document.

Making Choices Using a Watershed Approach

In urbanizing areas, many functions wetlands provide may not be sustainable long term. This may be particularly true for wetlands in a highly altered landscape where ecological processes are unlikely to be restored. Furthermore, losses in wetland functions are expected to increase with development (Azous and Horner 2001). In such cases, it may be preferable to locate mitigation sites in nearby drainages that have a lesser degree of urbanization. In this way, the mitigation site has greater potential to provide functions over time. By reducing the risk of failure that results from ongoing development, we can achieve a net gain in wetland functions and also restore lost or damaged watershed processes.

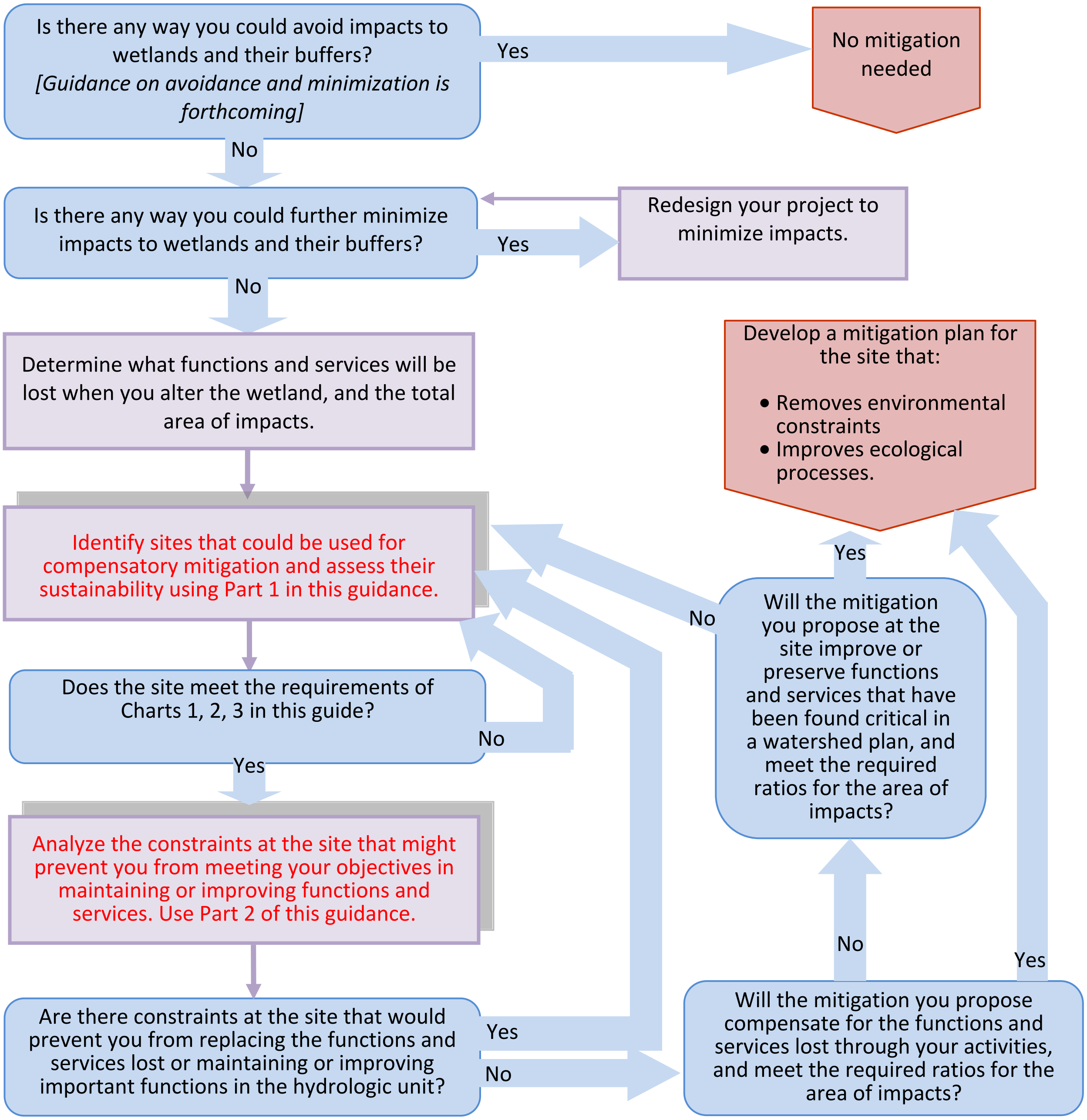
In some cases proposed alterations to a wetland will impact a function or value that is very important in the immediate area of the site. For example, a wetland in an urban area may provide significant recreational and educational opportunities for local residents. Also, the wetland may be receiving untreated stormwater, thus providing water quality and hydrologic functions to the immediate area. These types of functions and services may need to be replaced on-site. If so, it may be necessary to mitigate at two sites: on-site to replace the functions and services that cannot be moved elsewhere and off-site for all the rest. For example, if a wetland that will be impacted is retaining stormwater, a stormwater facility can be built on-site to replace the hydrologic function provied by the wetland. Other functions, such as habitat, can be replaced elsewhere. In many urban areas, the landscape setting may preclude replacing habitat functions on site unless the project sponsor provides intensive long-term management and maintenance.

Current research indicates that on-site mitigation in urban and urbanizing areas is not sustainable without continual monitoring and maintenance to counteract the effects of ongoing human disturbances. For example, re-creating a “natural” plant community that is found in less disturbed conditions will require continual removal of opportunistic (invasive) species that are better adapted to the disturbances in developed areas.

The Process for Selecting Mitigation Sites

Choosing a mitigation site that has a good chance of being sustainable and that also compensates for the functions and services (also called “values”) lost at the impact site is a complex process. First, you must identify the functions and services lost at the impact site, then you must try to find a site where those functions and services can be compensated, and finally you must determine if the mitigation will be feasible and sustainable. Figure 1 provides a graphical representation of the steps that must be taken in selecting an appropriate mitigation site. **This guide addresses only two of the steps in the process (shown in red): 1) selecting potential sites using information from the surrounding hydrologic unit (see definitions below) and 2) identifying constraints that may be found at individual sites.**

Figure 1: Process for Selecting Mitigation Sites [Note: This document provides information on only the two steps that are shown in red with boxes highlighted by a shadow.]



Defining Geographic Scales in Watersheds

This guide uses ***hydrologic unit*** as a term referring to a fundamental hydrologic feature for understanding the movement of water in a landscape (Winter 2001). Most scientists consider the ***drainage basin*** as the fundamental hydrologic unit when trying to understand surface-water systems, and the ***aquifer*** for understanding groundwater dominated systems (Winter 2001).

Hydrologic units in landscapes dominated by surface water are often called watersheds, but over time the latter word has often come to mean a hydrologic unit of a certain size only (e.g., Water Resource Inventory Areas [WRIAs] or the drainage area of a large river such as the Skagit). Smaller hydrologic units are given other names such as basins or sub-basins. This has created much confusion when terms such as ***watershed processes*** or ***watershed characterization*** are used.

In this guidance, ***watershed*** is used as an adjective to describe processes and tools that apply throughout a hydrologic unit dominated by surface water, except as noted below in the classification of hydrologic units. Thus, when used as an adjective, watershed can mean a drainage area at whatever scale is being discussed.

Hydrologic unit: A geographic area representing part or all of a surface drainage basin, a combination of drainage basins, or a distinct hydrologic feature, such as an aquifer. In Washington and Oregon we have standardized names for eight hydrologic units that identify drainage basins of progressively smaller geographical scale. The largest is r***egion***, followed by s***ubregion, basin, subbasin, watershed, subwatershed, catchment*** and ***subcatchment (***Washington and Oregon Hydrography Framework Technical Work Groups Report September 28, 2004). Each unit is identified by a unique ***Hydrologic Unit Code*** (HUC). Scientists and geographers use a shortened version of the code to represent drainage areas of different scales. Thus a region is often called a HUC-1, subregion is HUC-2, and so on. Under this system, watersheds are generally about 200 square miles in size and subwatersheds are about 40 square miles in size. A catchment is generally 10 - 15 square miles in size. A subcatchment (HUC-8) is often only a few square miles in size. Although there is no state-wide map (GIS coverage) of the smaller hydrologic units, maps of subcatchments ,and even smaller drainages, may exist for selected areas where intensive planning is being done.

Watershed characterization: An analysis of existing and potential watershed processes in a hydrologic unit. A characterization can be done at any geographic scale described above. The characterization of the drainages into Birch Bay in Whatcom County is an example of a characterization done at the subcatchment scale. The characterization of Clark County, on the other hand, is at the subwatershed to subcatchment scale. These examples can be found at: http://www.ecy.wa.gov/mitigation/landscapeplan.html . A watershed characterization is the first step in a ***watershed approach*** (see definition on page 1).

Contributing basin: The drainage area of an individual wetland or other specific aquatic resource, such as a stream reach or lake. This is the area that contributes surface and groundwater to the site. The contributing basin may be very small for "kettle-hole" wetlands and very large for riverine wetlands. Most discussions of contributing basin, however, refer only to the areas contributing surface water because it is very difficult to map the sources of groundwater to individual wetlands.

Watershed Processes: The dynamic physical, biological, and chemical interactions that form and maintain the landscape and ecosystems in a hydrologic unit. These processes include the movement of water, sediment, nutrients, pathogens, toxins, and wood as they enter into, pass through, and eventually leave the hydrologic unit.

Drainage Basin: A topographic region in which all surface water from rain and snowmelt drains to a common outlet. The drainage basin includes both the streams and rivers that convey the water as well as the land surfaces from which water drains into those channels. The drainage basin acts like a funnel, collecting all the water within the area covered by the basin and channeling it into a waterway.

Aquifer: A geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

Identifying hydrologic units in eastern Washington

The hydrologic units used for planning and decision making are most often based on surface drainage basins as described in the box above. However, large areas of eastern Washington are hot and dry, and drainage basins do not adequately describe the movement of water across the landscape. For example, there are areas where the annual surface runoff is less than 1 inch/year (lightest color in Figure 2). The lack of surface runoff generally limits wetlands to locations that intersect the groundwater table. Consequently, in much of the central part of the state, groundwater rather than surface water is the major hydrologic process that controls the distribution and functions of wetlands at the landscape scale.

The importance of groundwater and surface water in the movement of water changes in different parts of eastern Washington. Areas where the annual surface runoff is high will be dominated by that surface runoff (as is the case in western Washington). In this case hydrologic units can be defined by surface drainage patterns. However, areas where groundwater is the dominant hydrologic feature the hydrologic units need to be defined by aquifers. In addition there are areas with little runoff in the immediate area, but where the groundwater is mostly a result of subsurface flows linked to a river (called hyporheic flows). Thus, we divide eastern Washington into three zones for identifying hydrologic units when selecting sustainable mitigation sites. These are described below and shown in Figure 3.

Figure 2. Average annual runoff (1951 – 1980) from the National Groundwater Atlas. http://pubs.usgs.gov/ha/ha730/ch_h/index.html The Columbia River is outlined in yellow.

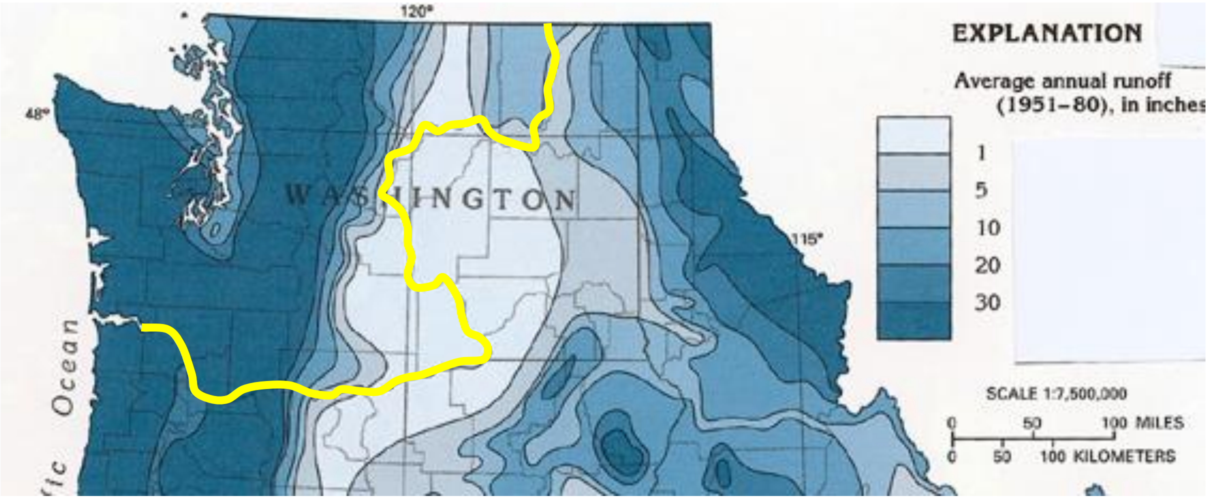
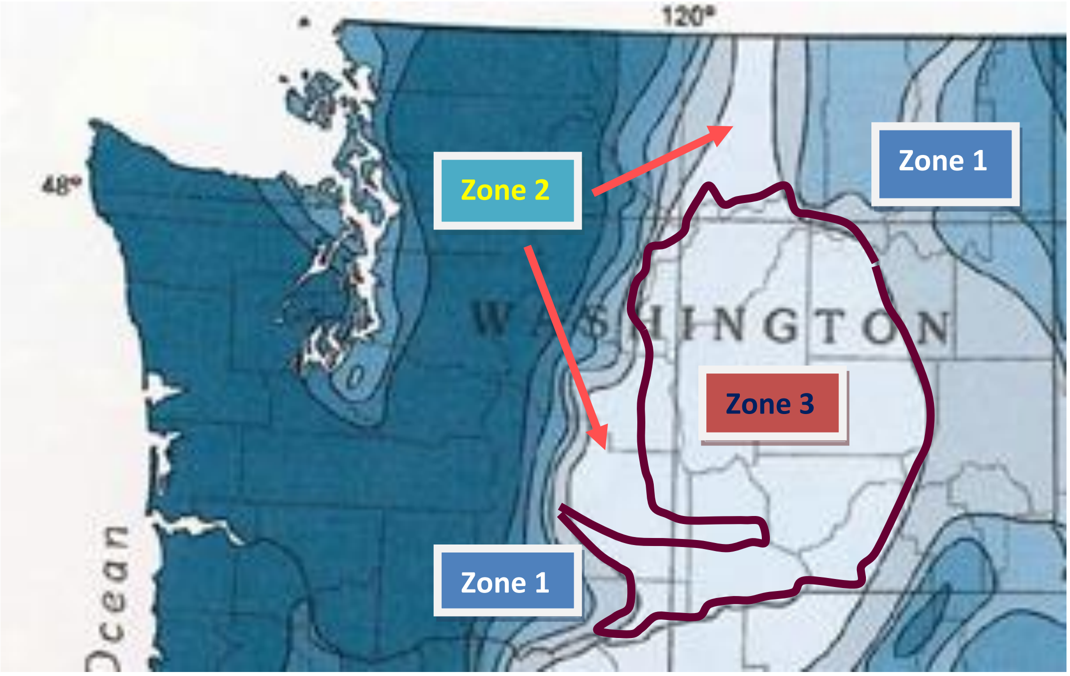


Figure 3: The three zones of eastern Washington for determining hydrologic units. Zone 1 refers to the region where hydrologic units can be defined by drainage basins. Zone 2 is the region where hydrologic units need to be defined by hyporheic aquifers and drainage basins. Zone 3 is the region where aquifers are the primary criterion for identifying hydrologic units.



Zone 1

Hydrologic units in Zone 1 can be established using the surface drainage patterns as in western Washington. The text box on page 6 defines the names used for units at different geographic scales. Zone 1 is the area in eastern Washington where surface runoff has defined the topography and how water moves through that landscape. Although surface runoff in the drier portions of Zone 1 is only 1-5 in/yr, we have found during field visits to the region that this amount of runoff is adequate to create surface drainage basins that can be identified and mapped. Figure 4 is an aerial photograph of the surface topography near Davenport that shows the surface drainage pattern that has resulted from limited surface flows.

Figure 4: Zone 1 - A pattern of drainage channels that have been created the surface runoff in the area of eastern Washington where the annual runoff is between 1-5 inches/yr. (aerial photograph is downloaded from Bing Maps).

Zone 2

Zone 2 is the area where groundwater is the dominant hydrologic feature but it is a hyporheic flow linked to the surface flows in rivers. Typically, the patterns of groundwater flow (even in areas with little surface runoff) reflect the topography that was formed by surface flows. The water table will be at higher altitude in the upland than in the lowland and the flows will be in directions that are similar to the surface flows (Winter 2001). This pattern usually applies to groundwater systems where the sources of water are within the larger drainage basin itself.

For example, the lower Yakima River basin may be very dry with little surface runoff, but the groundwater aquifer near the surface that maintains wetlands is primarily fed by the large amounts of precipitation that fall in higher elevations in the basin. This precipitation enters the river system and in turn recharges the surface aquifer in the drier parts of the river valley. This pattern of precipitation at higher elevations and groundwater maintained by hyporheic flows is fairly common in the low runoff areas of major drainages along the west side and north sides of the Columbia River (Yakima, Wenatchee, Methow and Okanogan Rivers). The boundaries of hydrologic units in these areas (Zone 2 in figure 3) should be based on a combination of surface runoff patterns and the surface aquifer. The larger scale hydrologic unit should be based on the river basin (surface runoff) but within that the smaller scale units should be based on the boundaries of the surface aquifer fed by the river.

When selecting hydrologic units in Zone 2 you will need to first determine the source of the groundwater in the region. Select the hydrologic unit based on the source of the hyporheic flows. For example in the area immediately north of Yakima you will need to determine if the groundwater is fed by the Naches River or the Yakima River. Wetlands in Zone 2 whose source of water is the Naches River should be mapped as being in a separate hydrologic unit from those fed by the Yakima River. The naming of these hydrologic units has not been standardized so for the purposes of this method we can just call these two hydrologic units as the "Hyporheic Zone of the Naches River" and the "Hyporheic Zone of the Yakima River."

There may also be wetlands in Zone 2 that are perched in small basalt depressions above the hyporheic zones of the local rivers. These are maintained by snowmelt and runoff in the immediate vicinity of the wetland. Although they are maintained by surface runoff, the runoff is not linked to any larger landscape features. We suggest that all such isolated wetlands be treated as a separate hydrologic unit within the larger scale river basin. For example, all isolated wetlands in Zone 2 of the Yakima River Basin would be treated as being in one hydrologic unit for the purpose of choosing mitigation sites. These sites may be separated geographically, but the hydrologic processes that maintain the wetlands are very similar.

Zone 3

Zone 3 is the area on the Columbia plateau where the surface topography is not linked to the dominant hydrologic features that maintain wetlands. There is little surface runoff today to shape the landscape. Much of the surface topography was shaped by the ice age floods, not by local surface runoff (Figures 5 and 6). Furthermore, the source of the groundwater on the plateau is from the foothills of the Rocky Mountains along the eastern border of the state not within the valleys created by the ice age floods (Whitehead 1994). Most wetlands are found where the ice age floods eroded the basalt layers down to the level of the regional aquifers, allowing the groundwater to surface.

As a result, it is difficult to define hydrologic units based on the pattern of surface drainage in the low runoff areas east of the Columbia River. In this zone (Zone 3 in Figure 3) we recommend that the large scale hydrologic units be defined based on the aquifers present at or near the surface. There are four aquifers mapped by the USGS for Zone 2: three are in the different layers of basalt (Grande Ronde, Wanapum, Saddle Mountain) and the fourth is in the unconsolidated sediments on top of the basalt (called overburden) (Figure 7) (Whitehead 1994). These four aquifers form the basic hydrologic units in Zone 3.

Figure 5: Areas of eastern Washington where the surface topography was scoured by the ice age floods. From: http://www.nps.gov/history/history/online_books/geology/publications/inf/72-2/

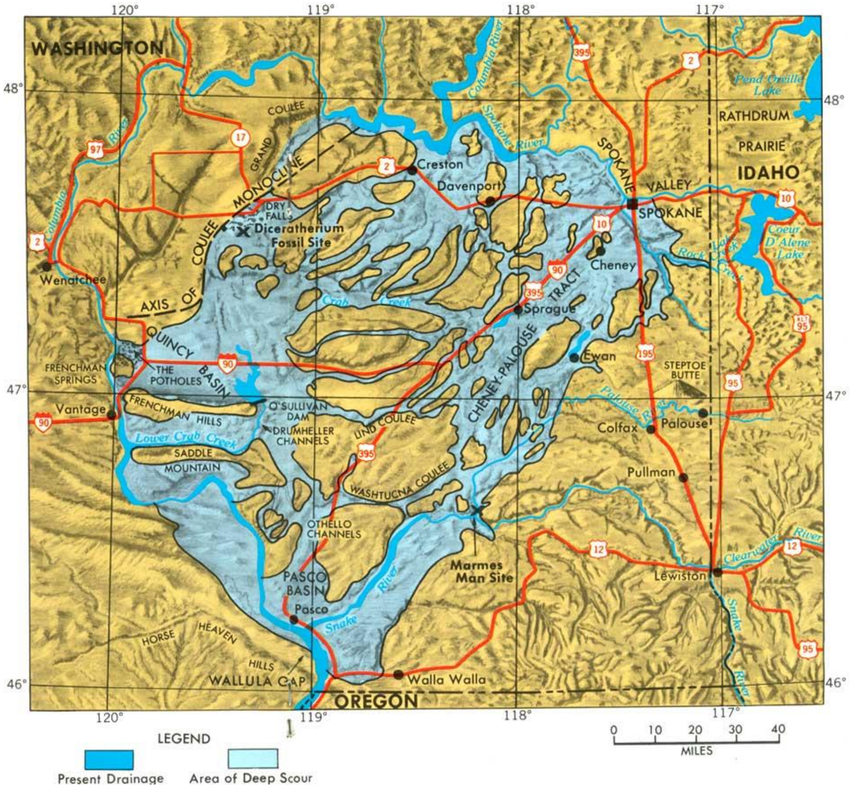


Figure 6: Zone 3 - Surface topography established by the ice age floods. This photograph is of the Drumheller channels (photo from http://hugefloods.com) (Note: There are no surface water channels present in the valleys and little evidence that local surface runoff is an important hydrologic process in the area.)

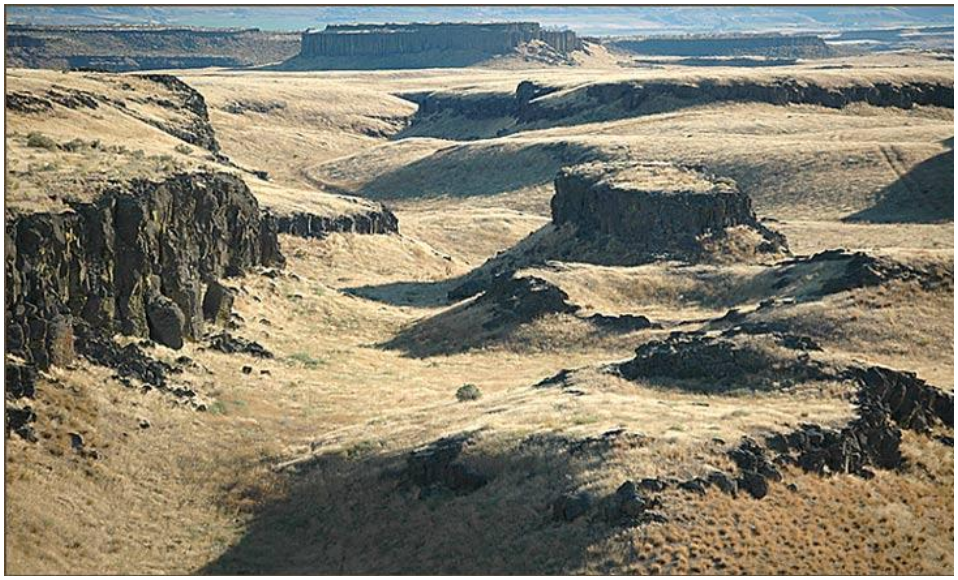
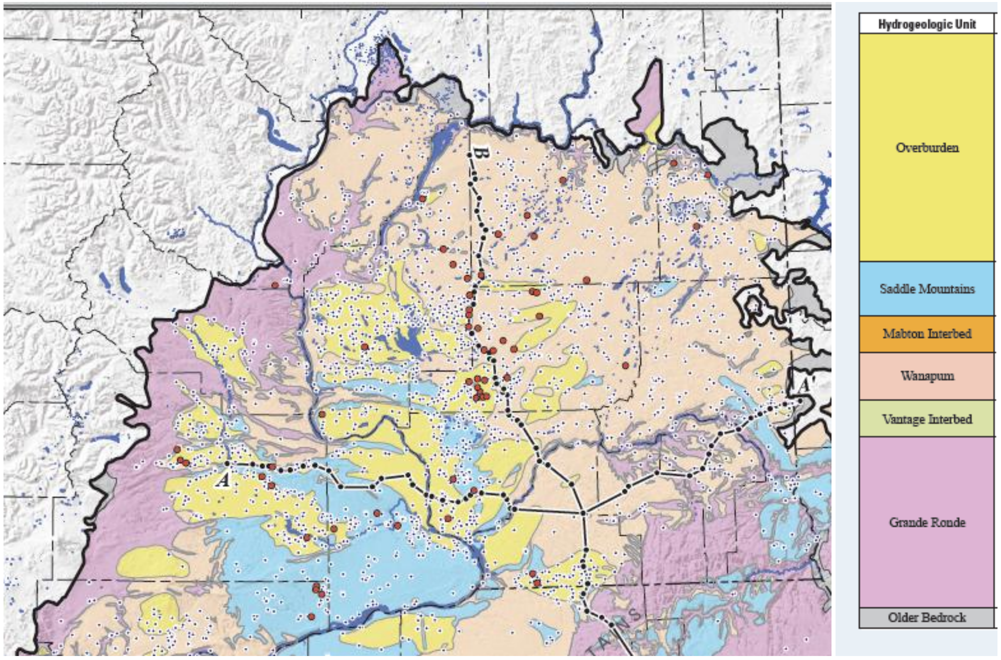


Figure 7: Unconsolidated deposit (overburden) and Miocene basaltic rock aquifers in the Columbia Plateau (from http://pubs.usgs.gov/sim/3088/) Miocene basalt aquifers are the Grande Ronde, Wanapum, and Saddle Mountain. Dots are locations of wells for monitoring levels in groundwater. See Appendix C for maps of the basalt aquifers individually.



A major difference between hydrologic units that are defined by surface drainage and ones defined by aquifers in this region is the horizontal patchiness of the latter. The aquifers in Zone 3 (and thus the hydrologic units) are not distributed horizontally; rather they are distributed by elevation with the "Grande Ronde" being the deepest and the "Unconsolidated Deposit" aquifer on top of the other three. For example, we may find water from the Grande Ronde aquifer near the surface in the bottom of the coulees while the groundwater on top of the plateau immediately adjacent to the coulee is from the "Overburden" aquifer. The water in the bottom of the adjacent coulee will again be from the Grande Ronde aquifer. This pattern of water sources to wetlands does not lend itself to an easy spatial separation of hydrologic units.

The four largest hydrologic units in Zone 3 of the Columbia Plateau are not contiguous but patchy. Choosing mitigation sites within the same aquifer may require going some distance away if the source of water in adjacent areas is from another aquifer.

Human activities in Zone 3 have significantly altered the patterns of groundwater flow and this should also be a factor in choosing appropriate mitigation sites. We therefore suggest that the four large aquifers in Zone 3 be divided into smaller hydrologic units based on whether the site is in, or out, of the Quincy-Pasco Subunit of the Columbia Basin Irrigation Project.

The major source of water that replenishes groundwater in the Quincy Pasco Subunit is irrigation. The groundwater levels in the basalt aquifers have risen by several hundred feet in some areas as a result of increased recharge (Figure 8) (Whitehead 1994). The areas in blue (or darker gray if printed in black and white) in Figure 8 are the areas where groundwater recharge is predominantly a factor of irrigation. This area of higher recharged encompasses most of the Quincy-Pasco Subunit of the Columbia Basin Irrigation Project. The large reservoirs such as the Potholes reservoir have also increased the amount of water in the surface deposits of unconsolidated materials. This has created large complexes of wetlands in what formerly were sand dunes (Figure 9).

Subdividing the aquifers based on irrigation creates eight hydrologic units for Zone 3. These are:

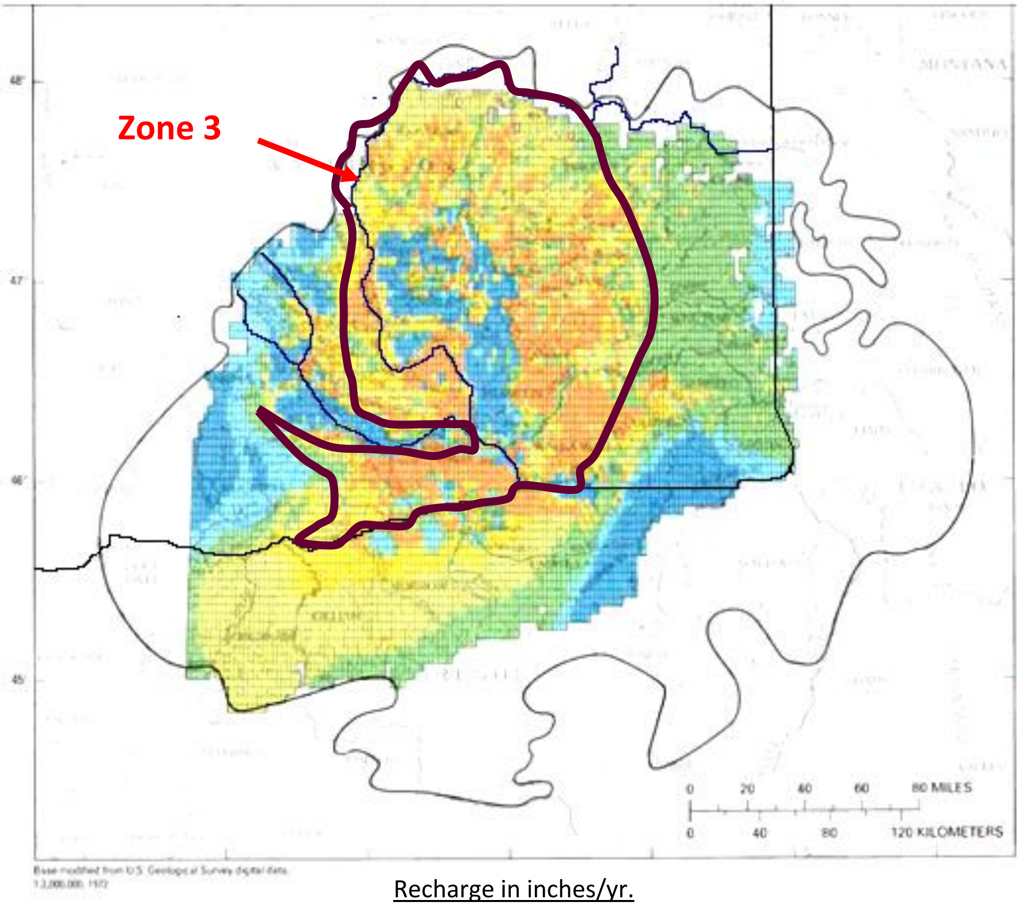
1. Unconsolidated surface deposits outside the Quincy-Pasco Subunit of the Columbia Basin Irrigation Project (CBIP).
2. Unconsolidated surface deposits within the Quincy-Pasco Subunit of the Columbia Basin Irrigation Project.
3. Saddle Mountain Aquifer outside the Quincy-Pasco Subunit of the CBIP.
4. Saddle Mountain Aquiver within the Quincy-Pasco Subunit of the CBIP.
5. Wanapum Aquifer outside the Quincy-Pasco Subunit of the CBIP.
6. Wanapum Aquifer within the Quincy-Pasco Subunit of the CBIP.
7. Grande Ronde Aquifer outside the Quincy-Pasco Subunit of the CBIP.
8. Grande Ronde Aquifer within the Quincy-Pasco Subunit of the CBIP.

Very small seasonal wetlands and vernal pools also occur in depressions on the basalt surface that collect the spring snow melts. In this case however, the wetlands are not connected to any larger scale surface flows. Each wetland has its own contributing basin that may be only a few acres in size; a geographic scale that is too small for regional planning and setting the boundaries of hydrologic units within which to choose mitigation sites. We suggest that all such isolated wetlands be treated as a separate, but single, hydrologic unit within the larger scale hydrologic unit chosen (aquifer + irrigation unit).

Finally, the individual Water Resource Inventory Areas (WRIA) as defined by the Department of Ecology can be used to further sub-divide hydrologic units into smaller ones. WRIA's can be used for locating mitigation sites because much of the environmental planning and analysis is already happening at this scale. The map of WRIA's is available at: http://www.ecy.wa.gov/services/gis/maps/wria/wria.htm.

NOTE: Areas where irrigation is provided by pumping groundwater are not separated into unique hydrologic units because this type of irrigation lowers the levels of groundwater rather than raises it (USGS: http://pubs.usgs.gov/ha/ha730/ch_h/index.html accessed Jan 13, 2010). Lowering the levels of groundwater will tend to dry up wetlands and there is little change wetland restoration can be achieved by pumping water back into the ground to raise the levels of groundwater.

Figure 8: USGS map showing rates of groundwater recharge on the Columbia Plateau. Areas with more than 5 inches of recharge in Zone 3 receive significant amounts of recharge from irrigation and provide a rough outline of the Quincy-Pasco Subunit of the CBIP (map is from Vaccaro 1999).



Base modified from U.S. Geological Survey digital data, 1:2,000,000, 1972

Recharge in inches/yr.

🟧 0.02-0.5
🟨 0.5 – 1.0
🟨 1.0 – 2.0
🟩 2.0 – 5.0
🟦 5.0 – 10.0
🟦 10.0 – 52.2

Figure 9: Large wetland complex near Moses Lake that was created by high groundwater in the surface aquifer of unconsolidated sediments from the nearby Potholes Reservoir (photo from U.S. Geological Survey GeoEye and Bing maps).

PART 1: Analyzing Mitigation Sites at a Watershed Scale

In this guide we urge users to:

1. Locate mitigation activities where they will help protect or restore ecological processes that are important in the hydrologic unit as well as on the site (Dale et al. 2000).
2. Characterize hydrologic units in advance of mitigation to:
   - Determine where critical watershed processes have been altered and where they are still intact, and
   - Prioritize areas for protecting and restoring those processes and related functions.
3. Select a site based on the principles of landscape ecology when a watershed characterization does not exist (see Charts 2 and 3 in this guide).
4. Select on-site mitigation when:
   - The wetland functions at the impact site are important to the ecological processes of the hydrologic unit, and
   - The opportunities for improving functions on-site have a high likelihood of being successful and sustainable.
5. Be aware that the impact site may provide services or values such as “green space” or recreation that cannot be addressed in terms of functions and the sustainability of the proposed mitigation. These may need to be replaced on site and actively managed to counteract the impact of continuous human disturbance that would degrade these functions and services.
6. Allow for options that may sometimes result in wetlands of different types (e.g., a wetland of a different hydrogeomorphic class), or that provide different functions than the impacted wetlands. This may be preferable from an ecological perspective if the watershed characterization shows that the restored processes and functions are more important in the watershed than those lost at the impact site. The final decision however, still lies with the agencies approving the permits.
7. Be aware that it may be difficult to show that trade-offs in functions are appropriate between functions in the absence of a watershed characterization. Applicants will have to provide much more information to the regulatory agencies to support trade-offs.

NOTE: Certain wetlands are not replaceable, or are very difficult to mitigate. Examples include bogs, alkali wetlands, and mature forested wetlands. For guidance on identifying and managing these types of wetlands, refer to:

- Wetland Mitigation in Washington State – Part 1: Agency Policies and Guidance: http://www.ecy.wa.gov/biblio/0606011a.html.
- Washington State Wetland Rating System for Eastern Washington: http://www.ecy.wa.gov/biblio/0406015.html.
- Best Available Science for Wetlands, Volumes 1 and 2: http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html.

Following One of Two Alternatives for Selecting a Mitigation Site

Watershed plans typically require computerized mapping (Geographic Information Services - GIS) and analysis. Such analyses are resource-intensive and are usually done by county or tribal planning departments with the support of state or federal agencies such as Ecology, Washington Department of Fish & Wildlife (WDFW), or EPA. When possible, mitigation sites should be selected using watershed plans that take into account the ecological processes of the area (Alternative 1, Chart 1). When watershed plans of this type do not exist for a hydrologic unit, criteria such as those presented in Chart 2 should be used for choosing a site (Alternative 2).

Alternative 1 (starting with Chart 1)

This alternative should be used when watershed planning has been done for the hydrologic unit in which a possible mitigation site is found. It helps you decide if a watershed plan is appropriate and explains how this information can be applied. Mitigation sites should be located in areas targeted for restoring ecological processes as identified in the plans. Watershed plans may identify specific restoration sites, or they may only target broader areas for mitigation or restoration. This information can be effective in reducing the uncertainties involved in choosing a mitigation site.

Many existing planning efforts focus on improving habitat and stream flow for fish. Other efforts include plans for maintaining biodiversity or restoration to meet the needs of local shoreline master programs. These planning efforts, however, often have not used a systematic approach to identifying the best areas for restoring or protecting ecological processes. To meet the need for finding sustainable mitigation sites, watershed plans need to also analyze the alteration of watershed processes and the consequences of these alterations on the landscape and associated aquatic resources.

There is no standard method for characterizing watersheds, and a variety of tools are available. Ecology has developed one method for western Washington to characterize watershed processes and develop management plans based on the results. The approach is described in *Protecting Aquatic Ecosystems: a Guide for Puget Sound Planners to Understand Watershed Processes* (available at http://www.ecy.wa.gov/biblio/0506027.html). It is our intent to develop a similar approach for eastern Washington. Some local jurisdictions in Washington have completed watershed characterizations based on wetland or shoreline inventories, and others have focused primarily on watershed planning for fish habitat. The following link provides examples of landscape planning documents: http://www.ecy.wa.gov/mitigation/landscapeplan.html.

Shoreline Management Plans:
Updated Shoreline Management Plans provide summaries of environmental information for wetlands and streams, including water quality, quantity and habitat conditions, and recommend restoration actions. Links to completed shoreline planning documents by county are available at: http://www.ecy.wa.gov/programs/sea/shorelines/smp/status.html

Characteristics of Watershed Plans for Selecting Mitigation Sites:

While there is not one "correct" method to follow, and different approaches may have different objectives, watershed plans should generally have the following characteristics if they are to be used to locate mitigation activities:

- Use an analytical approach based on existing data (e.g., precipitation, geology, stream flow, surface water storage and groundwater recharge and discharge, topography) to identify areas important to watershed processes.
- Assess how those areas have been altered, and identify the most suitable areas for protection and restoration.
- Identify specific restoration goals for wetlands and other aquatic resources in the watershed.
- Identify specific areas or individual sites where restoration should be targeted.
- Discuss the connections between the functions of wetlands and other aquatic resources and watershed processes.
- Do not focus on a single species.

Alternative 2 (starting with Chart 2)

This alternative provides criteria for selecting mitigation sites in areas where watershed planning has not been done. It can be difficult to know where to start looking for mitigation sites in areas lacking watershed plans. Applicants often select sites based primarily on technical feasibility of construction, availability of the land, and cost. While these are important considerations, they should be considered only after sites that could contribute to restoration of watershed processes are identified. Alternative 2 can also be applied to areas with an existing watershed plan that does not meet the criteria listed in the preceding box. Watershed plan that do not meet the criteria above can be used to inform your decision. Potential mitigation sites, however, should still be analyzed by working through Chart 2.

Chart 2 in combination with Chart 3, helps users place potential mitigation sites in their landscape context but does not identify important restoration areas based on the level of disturbance to ecological processes. This approach is clearly less desirable than Alternative 1 in that it leaves greater uncertainty as to whether the selected mitigation sites will be effective in restoring ecological processes. However, in the absence of watershed plans, Alternative 2 gives the user basic information on the sustainability of a mitigation site in the long-term.

Using the Charts

Part 1 of this document includes four charts that guide the user through a series of questions on characteristics of the hydrologic unit and potential mitigation sites. The charts help the user determine if a specific mitigation site can address problems at both the landscape and site scale and if it will be likely to be sustainable in the long term.

To use the charts:

- Start with Chart 1 if there is a relevant watershed plan for the hydrologic unit in which the impact occurs (i.e., the plan meets characteristics listed above under Alternative 1). The chart provides guidance on using a watershed plan to choose between on-site and off-site mitigation.
- Start with Charts 2a or 2b if there is no relevant watershed plan for the hydrologic unit where the impact site is located. Chart 2a provides guidance for selecting a mitigation site based on the extent of alterations to the hydrologic unit in Zones 1 and 2 (Figure 3). Chart 2b provides similar guidance for Zone 3 (Figure 3).
- After completing Charts 1 or 2, use Chart 3 to evaluate sites for their potential to address alterations to watershed processes and to provide successful and sustainable mitigation. The answers to some of the questions in Chart 3 require more detailed explanations than can be included in the graph. These are numbered (Question 3A, 3B, etc.) and are described in the text after the charts.

Choosing a Hydrologic Unit

The first step in choosing a mitigation site is to identify the hydrologic unit in which the impact site occurs. If your local city or county has already mapped its hydrologic units, use the smallest unit defined by the local jurisdiction. These units however may be called sub-units, drainages, or other terms not consistent with the terms used at the national level. If the hydrologic units for the areas in Zone 1 and 2 have not yet been mapped, you will have to establish the geographic scale at which you want to work and develop your own map of hydrologic units. A good place to start is the USGS web site: http://nwis.waterdata.usgs.gov/tutorial/huc_def.html . Hydrologic units in Zone 3 can be identified using the criteria described in the previous section. **When the chart suggests looking for off-site mitigation in a different hydrologic unit, it means looking in hydrologic units of the same scale adjacent to the one where the impacts will occur.**

Symbols used in Charts

- **Ovals** = yes/no questions.
- **Rectangles** = information you need to collect and analyze before going on to the next step.
- **Pentagons** = the end point in the chart and where to go as a next step.

Note: The charts include recommendations for selecting mitigation sites. **The final decision is always up to the regulatory agencies.** Those planning mitigation should consult other relevant documents (see "Finding Other Resources") and contact the appropriate permitting agencies (local jurisdictions, the Corps, EPA, Ecology, WDFW, etc.) early in the process.

Chart 1: (Alternative 1) Analyzing Potential Wetland Mitigation Sites Using Existing Watershed Plans in Zones 1, 2, 3 of Eastern Washington

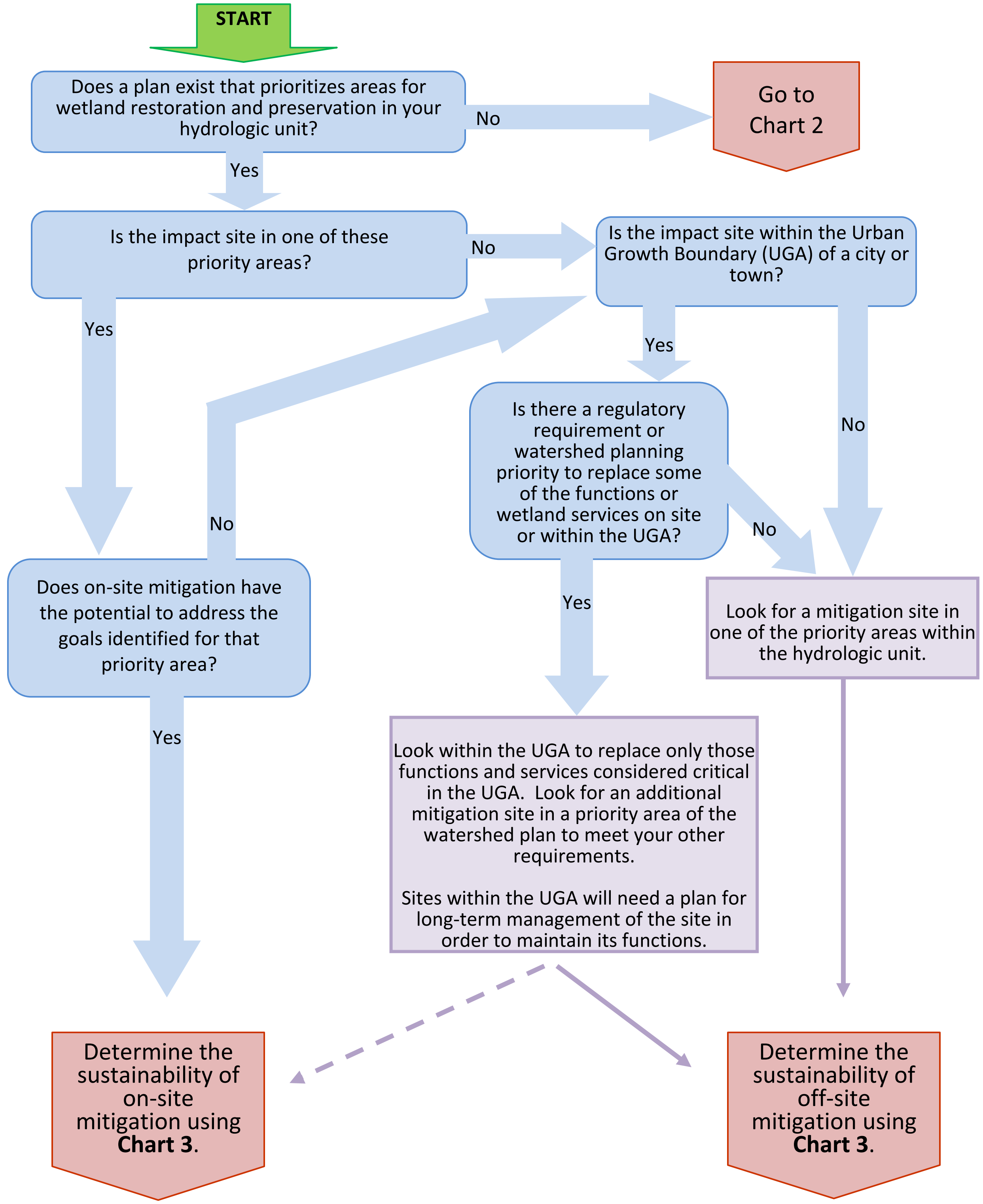


Chart 2a: (Alternative 2) Analyzing Potential Wetland Mitigation Sites without a Watershed Plan in Zones 1 and 2 of Eastern Washington

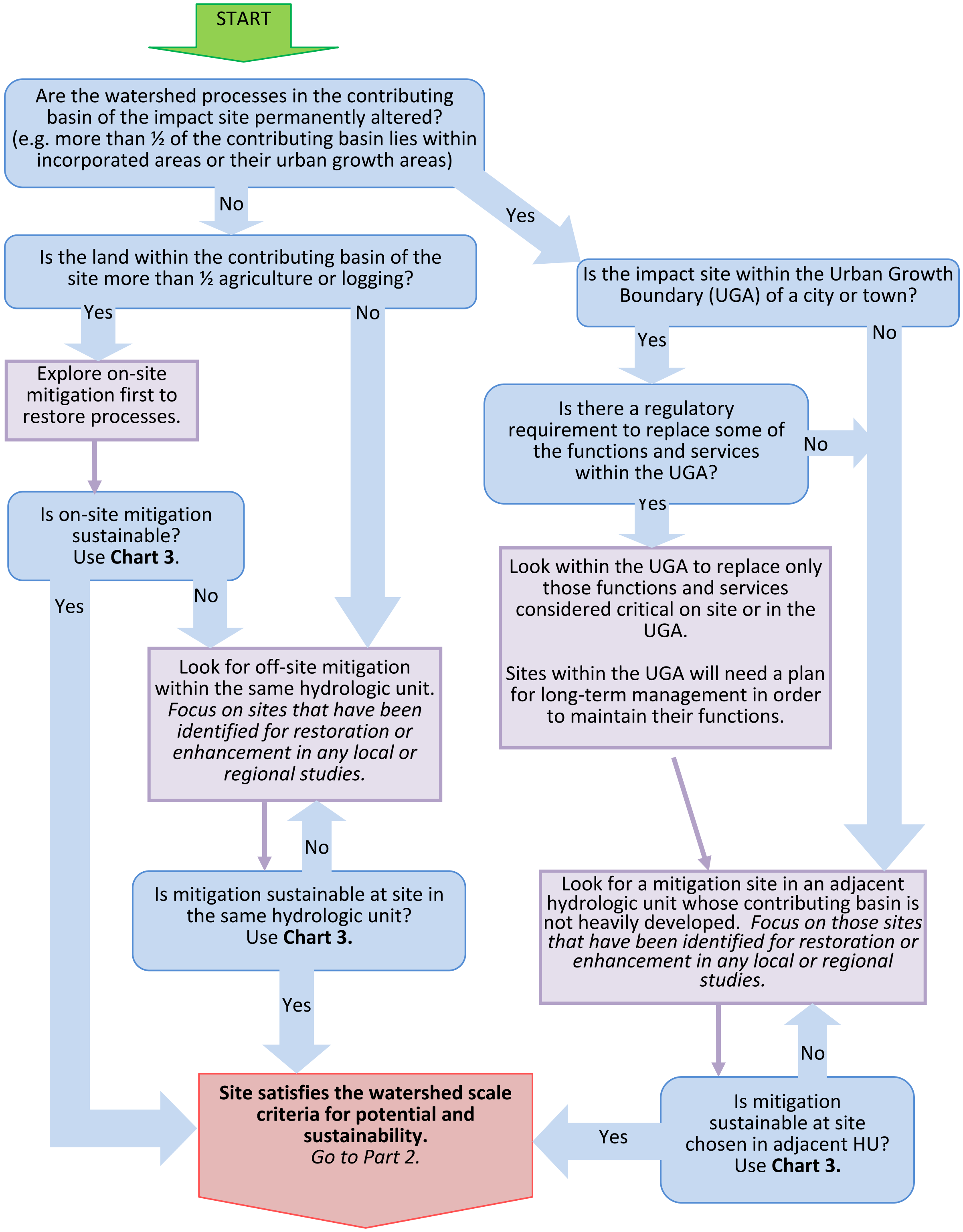


Chart 2b: (Alternative 2)Analyzing Potential Wetland Mitigation Sites Without a Watershed Plan in Zone 3 of Eastern Washington

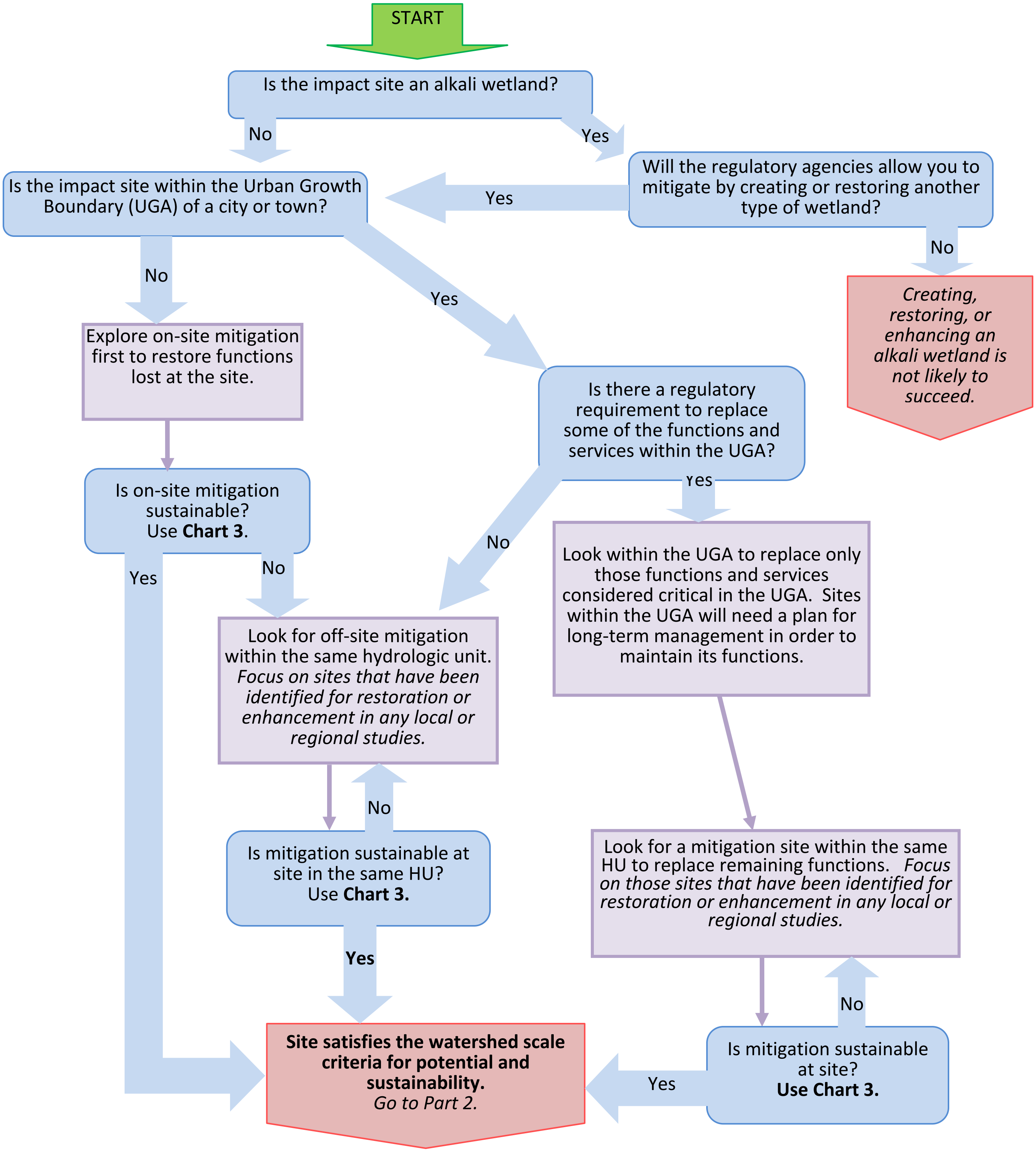
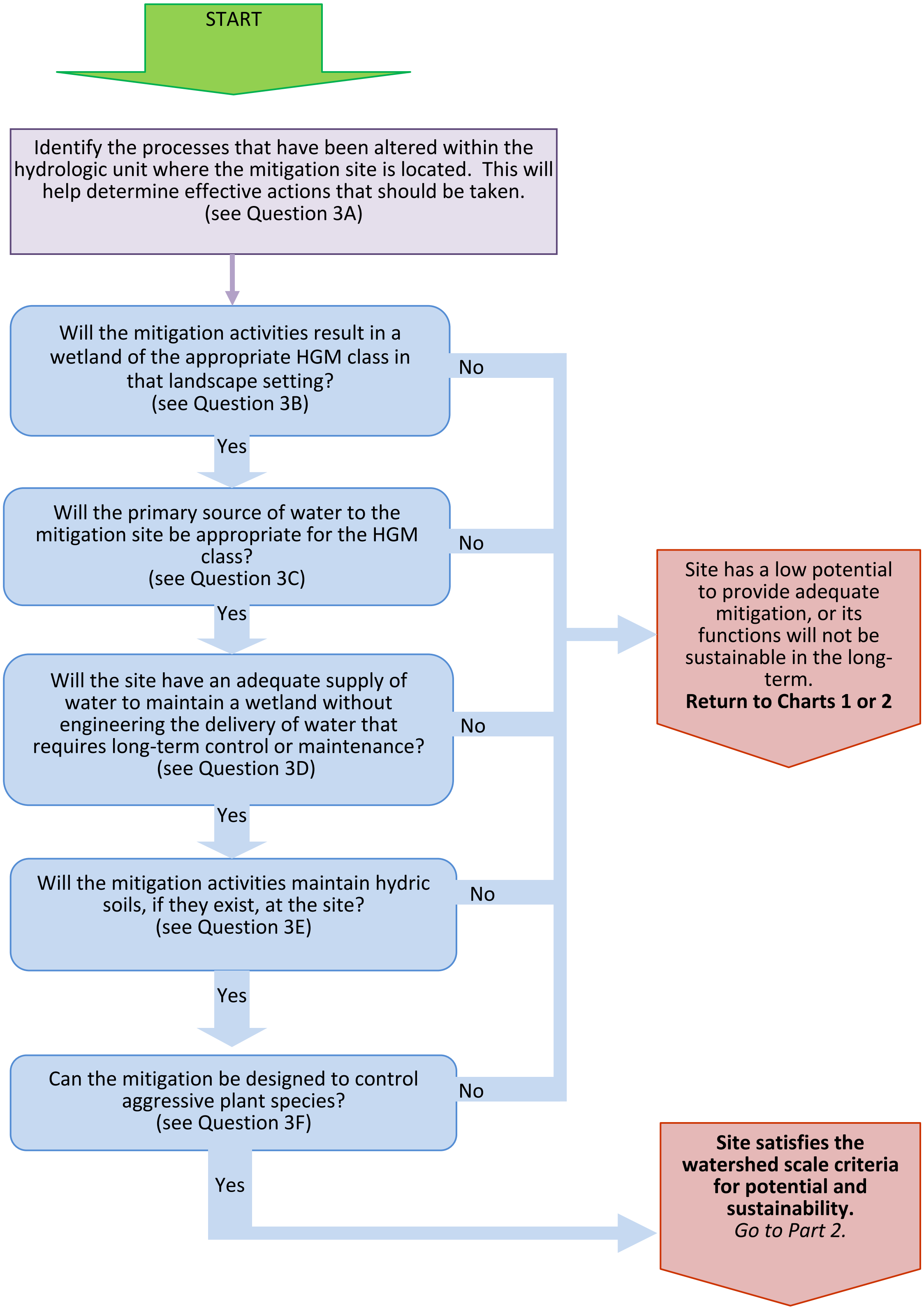


Chart 3: (Use for both Alternatives 1 and 2) Analyzing the Potential of Sites to Provide Sustainable Mitigation in a Watershed in Zones 1 – 3



Question 3A: Identify the watershed processes that have been altered within the hydrologic unit where the mitigation site is located.

Human activities can change watershed processes by changing water flows; introducing nutrients, pollutants, non-native species, sediment, and by fragmenting habitats. Changes in these processes often create environmental problems that can sometimes be improved through mitigation activities.

To begin you need to identify the major landscape-scale problems that could be addressed by mitigation for the hydrologic unit where your site is found. This will help you identify which restoration or enhancement actions will be the most effective in that hydrologic unit. Check the appropriate column in the following tables to identify problems that might exist. Use Table 3A-1 for hydrologic units in Zones 1 and 2. Use Table 3A-2 for hydrologic units in Zone 3 (See Figure 3). The last column notes if the altered process has already been identified in an existing watershed plan as a problem that needs to be addressed.

Table 3A-1: Changes in watershed processes. (Use for hydrologic units in the Zones 1 and 2.)

Problems caused by altered watershed processes in the hydrologic unit	Yes	No	Noted as a problem in a watershed plan?
Increased flooding			
Eutrophication in streams, rivers, and lakes			
Increased sedimentation from agricultural practices including wind erosion			
Impaired water quality (including temperature, toxics, pathogens)			
Erosion of stream and river banks that threaten human and natural resources			
Fragmentation and loss of habitat			
Decreased groundwater levels resulting from pumping			
Increased groundwater levels resulting from irrigation			
Other _____________ (especially if noted in a plan)			

Table 3A-2: Use for hydrologic units in the Zone 3.

Problems caused by altered watershed processes in the hydrologic unit	**Yes**	**No**	**Noted as a problem in a watershed plan?**
Increased sedimentation from agricultural practices including wind erosion and livestock grazing			
Eutrophication in streams, rivers, and lakes			
Impaired water quality			
Increased salinization of surface waters			
Increased levels of nitrogen in groundwater			
Fragmentation and loss of habitat			
Decreased groundwater levels resulting from pumping			
Increased groundwater levels resulting from irrigation			
Other ____________ (especially if noted in a plan)			

Question 3B: Will the mitigation result in a wetland of the appropriate hydrogeomorphic (HGM) class for the landscape setting?

Wetland mitigation sites are sustainable only if the type of wetland being proposed is appropriate for its position in the landscape. The HGM classification of wetlands is based on characteristics of water movement and position in a landscape. Therefore, it can be used to identify appropriate wetland types for different locations in a hydrologic unit.

Use Table 3-B to verify if your mitigation plan is of the appropriate HGM class. For more detailed guidance on determining HGM class, see the Washington State Wetland Rating System, pp. 21-25 of the eastern Washington volume. This document can be found at: http://www.ecy.wa.gov/programs/sea/wetlands/ratingsystems/index.html. For example, creating a depression in a slope to impound water is not appropriate for the landscape setting.

NOTE: Alkali wetlands in eastern Washington are depressional. This type of depressional wetland however, should not be targeted for creation, restoration, or enhancement. We do not know enough about how the alkali ecosystem functions nor do we have any examples of the successful creation of this type of wetland. Thus alkali wetlands should not be a target for mitigation.

Table 3-B: Hydrologic and geomorphic characteristics of HGM classes.

Landscape Setting	HGM Class	Major Characteristics of Site
Fringe along lakes	Lake-fringe	Mitigation site is on shores of body of permanent open water that is greater than 20 acres, and at least 30% of the open water area is deeper than 10 feet (3 meters).
Hillside slopes	Slope	Mitigation site would have water flowing through the wetland in one direction without being impounded.
Areas that are flooded at least once every ten years from a river or stream	Riverine	Mitigation site would be in a valley or stream channel, inundated by overbank flooding from that stream or river at least once every ten years. The primary source of water, however, can be groundwater or the hyporheic water in the valley.
Topographic depressions	Depressional	Mitigation site would be in topographic depression where water ponds or is saturated to the surface some time of the year.

Question 3C: Will the primary source of water to the mitigation site be appropriate for the HGM class?

Use Table 3-C to verify if the source of water for the wetland you propose as mitigation is appropriate for the HGM class.

Table 3-C: Primary sources of water for HGM classes.

HGM Class	Primary Source of Water
Lake fringe	Water from a lake or reservoir
Slope	Groundwater discharge
Riverine	Most of the time from the hyporheic zone, but should have overbank flow from stream or river at least once every ten years
Depressional	Groundwater, or surface flows from precipitation on the surrounding landscape.

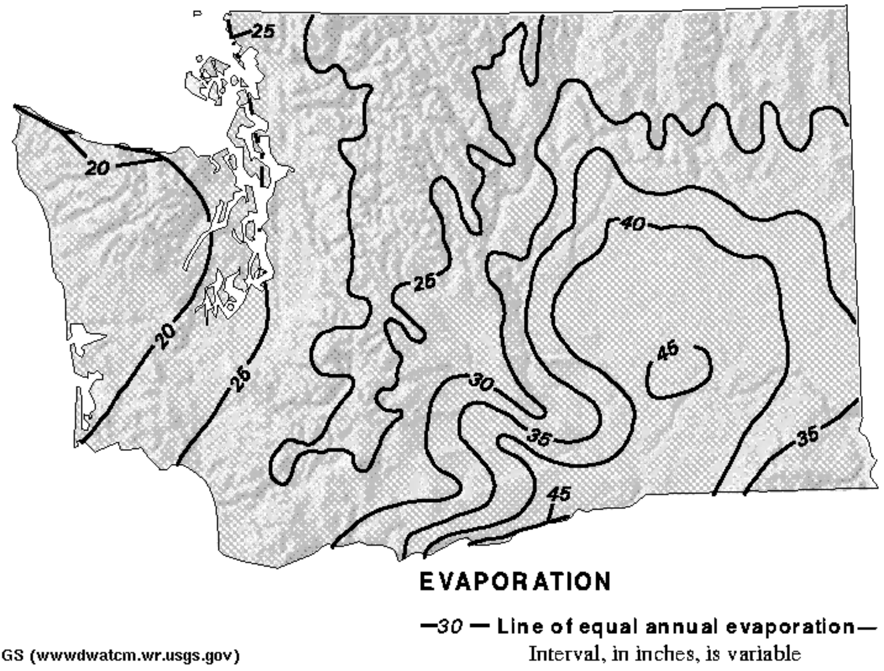
Question 3D: Will the site have an adequate supply of water to maintain a wetland without engineering the delivery of water that would require long term control or maintenance?

A mitigation site will provide functions over time if there is an adequate source of water to maintain wetland conditions. You will need to determine that there will be adequate water available (including water rights if needed) to maintain the predicted levels of ponding or saturation in your plan. At this stage, you will need to understand the basic movement of water in and out of the site.

Some issues you need to think about when selecting the site include:

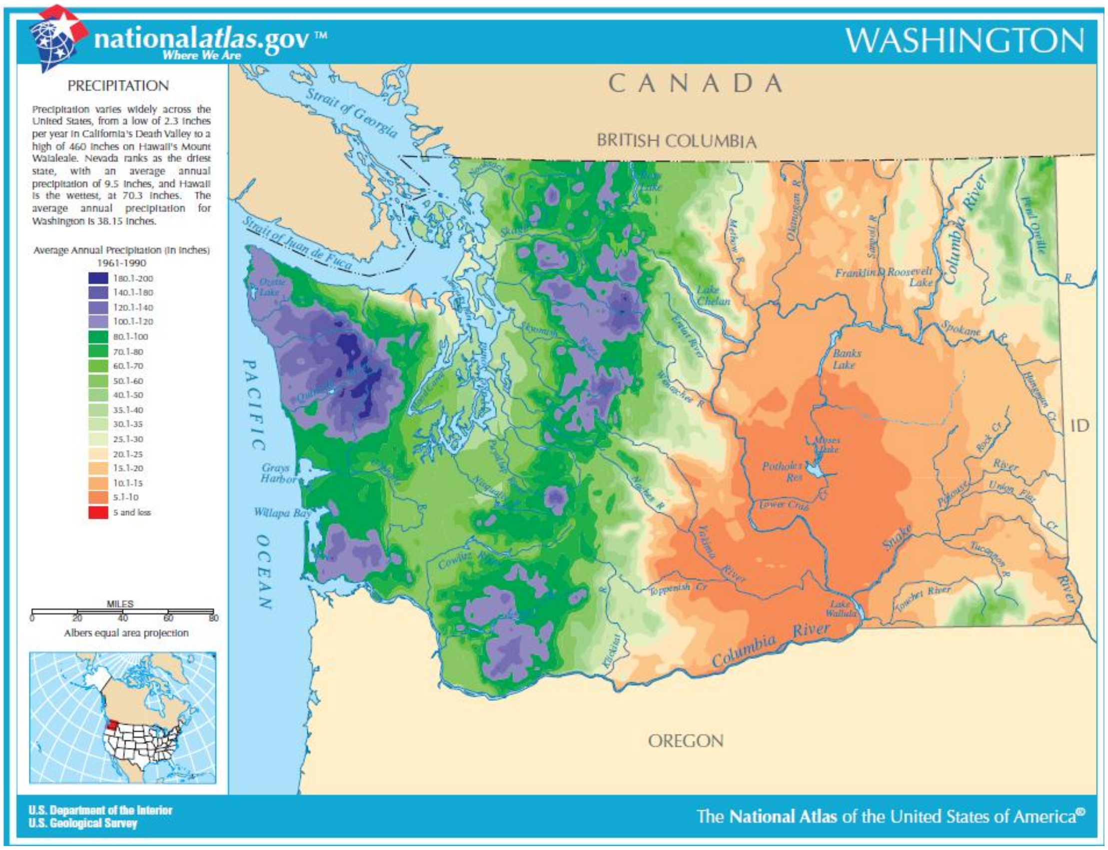
1. Determine if the water regime at the site will be dominated by groundwater, surface, water, hyporheic water, or a combination of sources. Vernal pools and depressions on the surface of the basalt flows will require a source of surface water. No other sources are appropriate for this type of wetland. On the other hand depressions with seasonal or permanent ponding in Zone 3 will require significant inputs of groundwater.
2. If your site is to be maintained by groundwater or hyporheic water you will need some information on the depth to saturation over the growing season at several locations on your site using shallow monitoring wells. If the mitigation involves plugging ditches or culverts, or breaking tiles in an area that was once a wetland you can assume that soil saturation will be raised at least to the elevation of the bottom of the outlet.
3. If surface flows are the main source of water, you will need to identify the contributing basin to your site and make some estimates on the water regime in the mitigation site based on the current and future flows into the site, the outlet characteristics, and infiltration and evapotranspiration rates. This is a difficult calculation and usually requires a hydrologist. Designing a mitigation site that relies mostly on surface run-off may require engineering a system to reduce infiltration such as adding a clay layer, If you decide at this stage that surface run-off will be the main source of water, the site will most likely require a detailed design and complex monitoring of the water regime both before construction and for at least five to ten years afterward.
4. Areas with very high rates of evaporation will be difficult to maintain as a wetland. Figure 10 shows the map of evaporation rates in Washington. In general, it will be difficult to create or restore a wetland (even vernal pools) whose main source of water is surface runoff in areas where the evaporation rate is higher than 35 inches/yr (Figure 10) and the rainfall is less than 15 inches/yr (Figure 11).

Figure 10: Annual evaporation rates in Washington.



USGS (wwwdwatcm.wr.usgs.gov)

Figure 11: Average annual rainfall in Washington.



Precipitation varies widely across the United States, from a low of 2.3 inches per year in California's Death Valley to a high of 460 inches on Hawaii's Mount Waialeale. Nevada ranks as the driest state, with an average annual precipitation of 9.5 inches, and Hawaii is the wettest, at 70.3 inches. The average annual precipitation for Washington is 38.15 inches.

Question 3E: Will the mitigation activities maintain hydric soils, if they exist, at the site?

Removing hydric soils by excavation or grading can decrease the potential for success of wetland restoration or enhancement. Hydric soils often contain a seedbank of wetland plants that supplement any planting you may propose. Removing these soils decreases the potential that the mitigation will succeed.

Question 3F: Can the mitigation be designed to control aggressive plant species?

Aggressive species are often also called invasive. These are the species that can come to dominate a wetland ecosystem in areas that have been disturbed by human activities. Such species have evolved to take advantage of disturbances and can come to dominate an area that was previously colonized by many different species. They are often considered to be an unwanted part of the plant or animal community at a mitigation site because they can change the way a wetland functions from the way it did before the disturbance occurred.

Most of the aggressive species are erroneously called “invasive.” Recent research has shown that the species do not “invade” wetlands that are not disturbed. Rather they should be considered as “opportunistic” species that come into a wetland after a disturbance has removed or reduced the vigor of the existing plant community (Zedler and Kercher 2004, MacDougall and Turkington 2005, Kercher and others 2007, McGlynn 2009). Once established however, they will exclude the re-colonization of the site by the species that were found there originally. The dominance by these aggressive species can be considered an “alternate state” of the wetland ecosystem (see the introduction to part 2). Common aggressive plant species in the wetlands of eastern Washington include reed canarygrass (*Phalaris arundinacea*), soft rush (*Juncus effusus*), purple loosestrife (*Lythrum salicaria*), Russian Olive (*Elaeagnus angustifolia*) and cattails (*Typha spp.*). Aggressive animal species include the Norway rat (*Rattus norvegicus*), the American Bullfrog (*Rana catesbeiana*), common carp (*Cyprinus carpio*) and in heavily stocked ponds, trout (*Salmo spp.*).

Since a common restoration goal is to change a wetland ecosystem that has become dominated by one or more of the aggressive species, it is important to understand the types and duration of the disturbances that allowed the colonization in the first place. Restoration of a pre-disturbance plant or animal community will be very difficult if the disturbances that facilitated the original “invasion” are not understood and controlled.

Many disturbances, such as changes in the water regime, the introduction of excess nutrients, and the introduction of toxic compounds occur at the landscape scale over large areas of the hydrologic unit. If a mitigation site is chosen in an area where disturbances will continue as a result of permanent changes in land use, then controlling aggressive species becomes a major issue in the design of the project. If the project cannot be designed to control aggressive species in the long-term, then the site is not suitable for restoration or enhancement of native populations.

A number of different tactics have proved successful at controlling aggressive species. Since the information on this topic is continually being updated in the scientific literature, we suggest you do a web search on ways to control the species most likely to colonize your site. For example, recent articles that describe effective control of reed canary grass include:

- Kima, K.D., K. Ewing, and D.E. Giblin (2006). Controlling *Phalaris arundinacea* (reed canarygrass) with live willow stakes: A density-dependent response. *Ecological Engineering* 27:219-227.
- Wilcox, J.C., M.T. Healy, and J.B. Zedler (2007). Restoring native vegetation to an urban wet meadow dominated by reed canarygrass (*Phalaris arundinacea* L.) in Wisconsin. *Natural Areas Journal* 27:354–365.
- Hovick, S.M., and J.A. Reinartz (2007). Restoring forest in wetlands dominated by reed canarygrass: the effects of pre-planting treatments on early survival of planted stock. *Wetlands* 27:24-39.

PART 2: Analyzing the Suitability of an Individual Site for Mitigation

Part 2 discusses the constraints and issues that might be present within a site or immediately adjacent to it. This analysis at the site scale can help you determine what functions can be mitigated at a site. It also identifies the major elements that need to be included in a mitigation plan. The approach presented here differs from that commonly used in wetland restoration. This change in approach is based on new research on the success and sustainability of wetland mitigation and restoration.

The Changing Science of Mitigation

In the last 15 years ecologists have focused on improving mitigation by incorporating newly developed ecological principles in the planning and design of a mitigation project. Traditionally, efforts have focused on ways to re-establish the native plants and physical structure at a site. It is often assumed that, once the historical structure is re-established, natural "successional" processes will return the biotic system to its original condition. This approach, however, has had limited success. It usually works when the original degradation was a result of only one type of human disturbance that did not last. Sites degraded by multiple disturbances, or those where disturbances continue in time, are not successfully restored using this approach (Suding and others 2004).

As a result, ecologists are developing a new framework for designing mitigation activities. First, one must recognize that some ecosystems are in an alternative state. This alternative state may be a result of major changes in ecological processes throughout the watershed as well as changes at the site. The success of mitigation will depend on identifying and addressing the changes to the ecological processes that create and maintain the alternative states.

Alternative states are different combinations of species and environmental conditions that can persist at a particular site. These specific combinations are often mutually exclusive; one group of species will move in and eliminate the previous one. A change in the "state" of a location is often caused by a disturbance or a change in ecological processes. It is, however, very difficult to change the new state of the ecosystem and restore a previous one even if the disturbances that caused the change are removed.

Lakes provide a good example of alternative states. In the absence of high nutrient levels, lakes are usually dominated by large plants such as water lilies. When the amount of nutrients are increased as a result of human activities, the plant community changes to one dominated by algae and the large plants disappear. However, the large plants will not come back if the nutrients levels are reduced to the concentrations present at the time of the switch. To get the water lilies to come back nutrient levels have to be reduced to levels that were significantly lower than those found at the time of the "switch."

If only a single environmental constraint exists, decisions regarding the mitigation strategy can be relatively straightforward. Often, re-establishing the historical "natural" disturbance regime and/or physical processes will enable the rest of the system to restore itself with little or no further management intervention (Prach and others 2001, Mitsch and Wilson 1996). If several environmental constraints exist, research indicates that actions need to be taken simultaneously to be successful (e.g., burning and adding native seeds) (Zedler 2000). However, if resources are limited and not all constraints can be addressed, it may be difficult to successfully restore a site.

Changing the structure and functions of an existing site are not easy tasks, especially if the ecosystem has shifted to an alternative state. Ecosystems represent a balanced set of conditions, processes, and structure. Changing one element often means many other elements will also change. Altering a site without understanding the basic environmental processes that maintain the current and future conditions at a site can often result in unforeseen changes. For example, a wetland that has changed to a reed canarygrass ecosystem requires modifications to the water regime and soils as well as the plant community to restore the "natural" system. Removing the reed canarygrass alone will not result in a "natural" system even if it is planted with native vegetation.

Key Points in Designing the Restoration or Enhancement of Wetlands

Part 2 includes a series of linked charts, one for each major group of wetland functions. The charts guide the user through a list of questions about conditions in the watershed and at the site. Please be careful and choose the appropriate chart depending on where you are proposing to do mitigation (Zone 1,2 or 3 in Figure 3). Blank worksheets are provided in Appendix B where you can record your answers. The answers to the questions will help you determine appropriate tactics when designing a mitigation plan. The goal of a mitigation plan should be to improve wetland functions by removing the environmental constraints that currently limit them.

A good mitigation plan should (from Suding and others 2004):

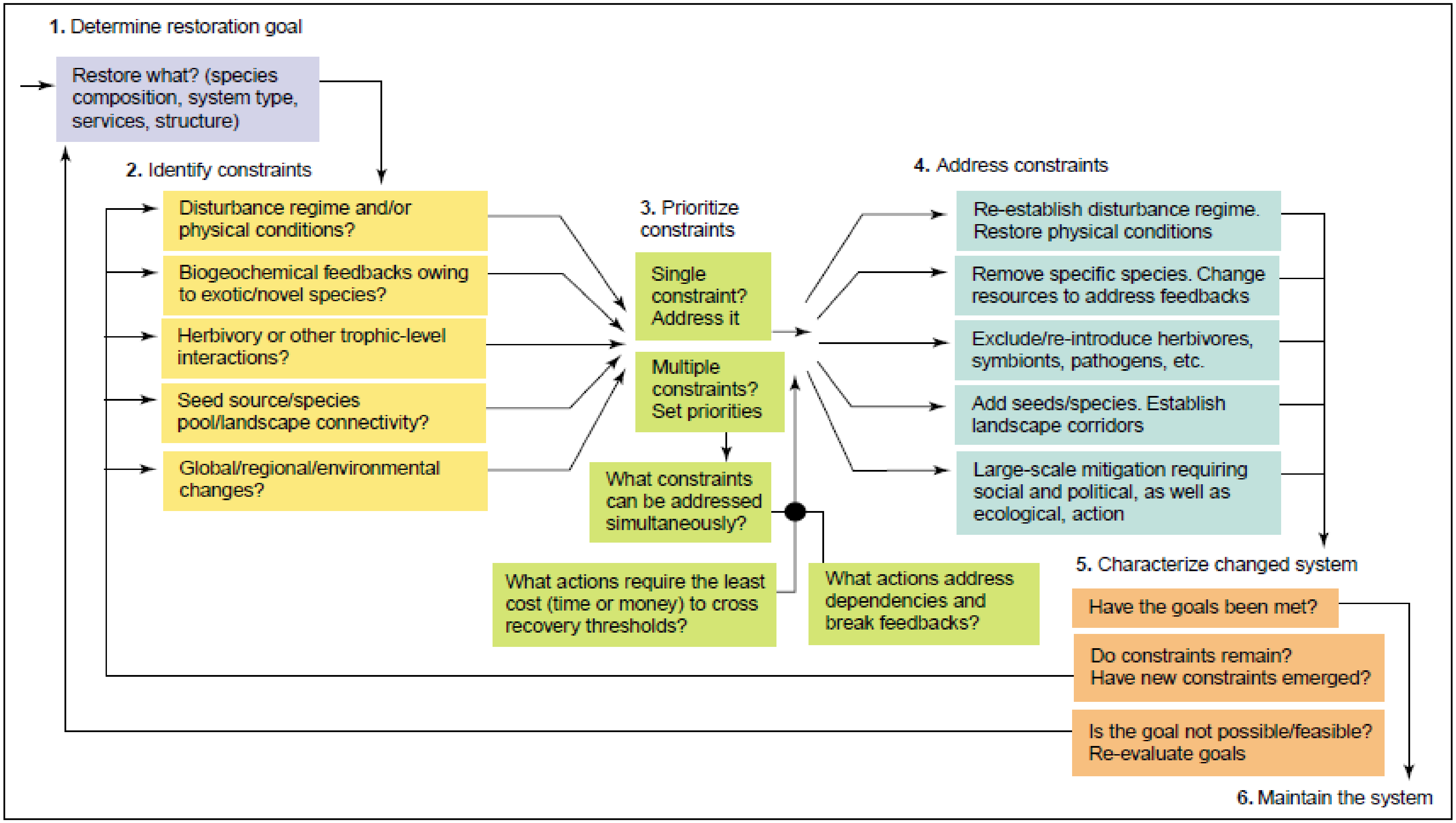
1. Establish specific goals that are appropriate for the site based on an analysis of the surrounding landscape.
2. Identify limiting factors (constraints caused by human activities) instead of focusing on the physical structure of the habitat or a single species.
3. Identify a range of possible outcomes instead of setting a goal of matching one reference condition.
4. Ensure there are good buffers and connectivity at the site, if habitat is a goal.
5. Focus on ecological processes rather than physical structure of the environment.

Guidance on the first point is provided in watershed plans, where they exist. If no watershed plan exists, refer to *Wetland Mitigation in Washington State* (Ecology et al. 2006) for guidance in developing mitigation goals. Part 2 of this guide addresses the second point: identifying the constraints on the ecosystem that might be removed to restore or enhance the site. Points 3, 4, and 5 are to be addressed in the mitigation plan, based on the functions and values that need to be replaced. **If the site does not have any constraints that limit its functions, it is not suitable for restoration or enhancement but may be suitable for preservation. Sites where constraints cannot be removed are not suitable for mitigation unless you are planning to expand an existing wetland into the surrounding uplands.**

Suding and others (2004) provide a basic outline for developing a mitigation plan as shown in Figure 12. Figure 12 also provides a few examples of questions that can be asked and tactics used. There are six major steps in the process, and **all six need to be addressed in a mitigation plan.** These are:

1. Determine goals.
2. Identify constraints.
3. Prioritize constraints, if needed.
4. Address constraints by developing specific tactics for their removal.
5. Monitor system to determine if constraints have been removed and system is achieving initial goals.
6. Maintain the system through adaptive management as necessary. This is absolutely critical if the mitigation site is in within an urban area or within an Urban Growth Area (UGA). Sites in developed areas or where development will occur in the future need to be continually managed to maintain the functions for which they were designed. Urban areas and development impose disturbances on ecosystems that are continuous and need to be continually countered by active management of the resource.

Figure 12: Six Steps in Planning a Mitigation Project (copied from Suding and others 2004).



It is assumed that the objectives of most mitigation activities will be to replace one or all of the three groups of functions provided by wetlands – flood control, improving water quality and habitat. The guide is organized to help you identify environmental constraints on these functions through a series of questions. These questions are presented as decision trees, organized by each major function. Within each function, separate decision trees (charts) are provided for different geomorphic settings. A separate set of decision trees has been developed for Zone 3 because the hydrologic drivers of the wetland ecosystem are quite different there.

The last columns in the decision trees describe some of the issues that have to be addressed when removing the constraints that impair functions. Constraints can occur both within the hydrologic unit and at the site itself. Thus, both types of constraints need to be identified and corrected if restoration or enhancement is to be successful and sustainable. The charts do not, however, attempt to prioritize constraints. Priorities should be determined by site conditions and by the needs of the mitigation project.

A worksheet for each chart, where you can enter specific site information, is included in Appendix B. This information should be the basis for your mitigation plan, and the worksheets should be provided as an appendix to the plan.

The questions in the decision trees assume you are planning to re-establish a former wetland or rehabilitate or enhance an existing one. If you are planning to create more wetland by expanding an existing wetland, analyze the constraints on the adjacent wetland to determine if there are any that need to be addressed. If there are no constraints on the functions of the adjacent site then you should attempt to create the same suite of functions for your project that are present in the adjacent wetland. **Avoid creating wetlands in uplands where no adjacent wetlands are found.** Our understanding of many of the processes (e.g. hydrodynamics, development of soils) needed to establish and maintain wetlands in areas where none exist now is not sufficient to guarantee success.

Charts 4 – 5: Can a site be used to improve hydrologic functions?

Use Chart 4a for a site in a floodplain or stream corridor in Zones 1 and 2. This includes the stream corridors and large valleys created by the ice age floods (called coulees) that are found in Zone 1.

Use Chart 4b for a site in the coulees or valleys with seasonal streams in Zone 3.

Use Chart 5 for a site that is, or will become, a depressional wetland outside the floodplain in Zones 1 and 2.

Lake-fringe and slope wetlands are not suitable for restoring hydrologic functions. These wetlands cannot perform the functions to the same level as riverine or depressional wetlands, and not much can be done to increase hydrologic functions as a replacement for their loss elsewhere.

In addition, depressional wetlands outside the floodplains of the existing streams in Zone 3 do not perform important hydrologic functions. These wetlands are usually maintained by groundwater since there is little runoff for them to store. Some wetlands in Zone 3 are created in small depressions in the basalt by local runoff (Figure 13), but these are hydrologically disconnected from the surrounding landscape. Wetlands in the corridors of seasonally flowing streams in Zone 3 however, can store water and reduce the speed of surface flows because localized flooding does occur as a result of intense summer storms or spring melting.

Figure 13: Small, short duration, depressional wetland in Zone 3 that is created by local runoff from the immediately surrounding landscape. It dries out completely by mid-June.

Charts 6 – 9: Can a site be used to improve water quality functions?

Use Chart 6 for a site in a floodplain or stream corridor in Zones 1-3. **You will not, however, be able to improve the water quality functions in alkali systems** [see the wetland rating system for eastern Washington (Ecology publication #04-06-150 for a definition of alkali wetlands]. We lack the scientific understanding of the environmental processes related to this function in alkali systems to be able to create or restore them with any certainty.

Use Chart 7 for a site that is, or will become, a depressional wetland outside the floodplain in Zones 1-3. Do not expect, however that you can improve the water quality functions in alkali systems.

Use Chart 8 for a site along the shores of a lake in Zones 1-3. This includes any reservoirs that are larger than 20 acres and meet the other criteria that define lakes (see classification key in the field form).

Use Chart 9 for sites on slopes in Zones 1-3. See the classification key in the field form for the criteria that define slope wetlands.

NOTE: Improving hydrologic and water quality functions does not require planting native species or eradicating non-native or invasive species. These functions are performed by wetlands based on topography, the local water regime, soils, and the presence or absence of herbaceous species.

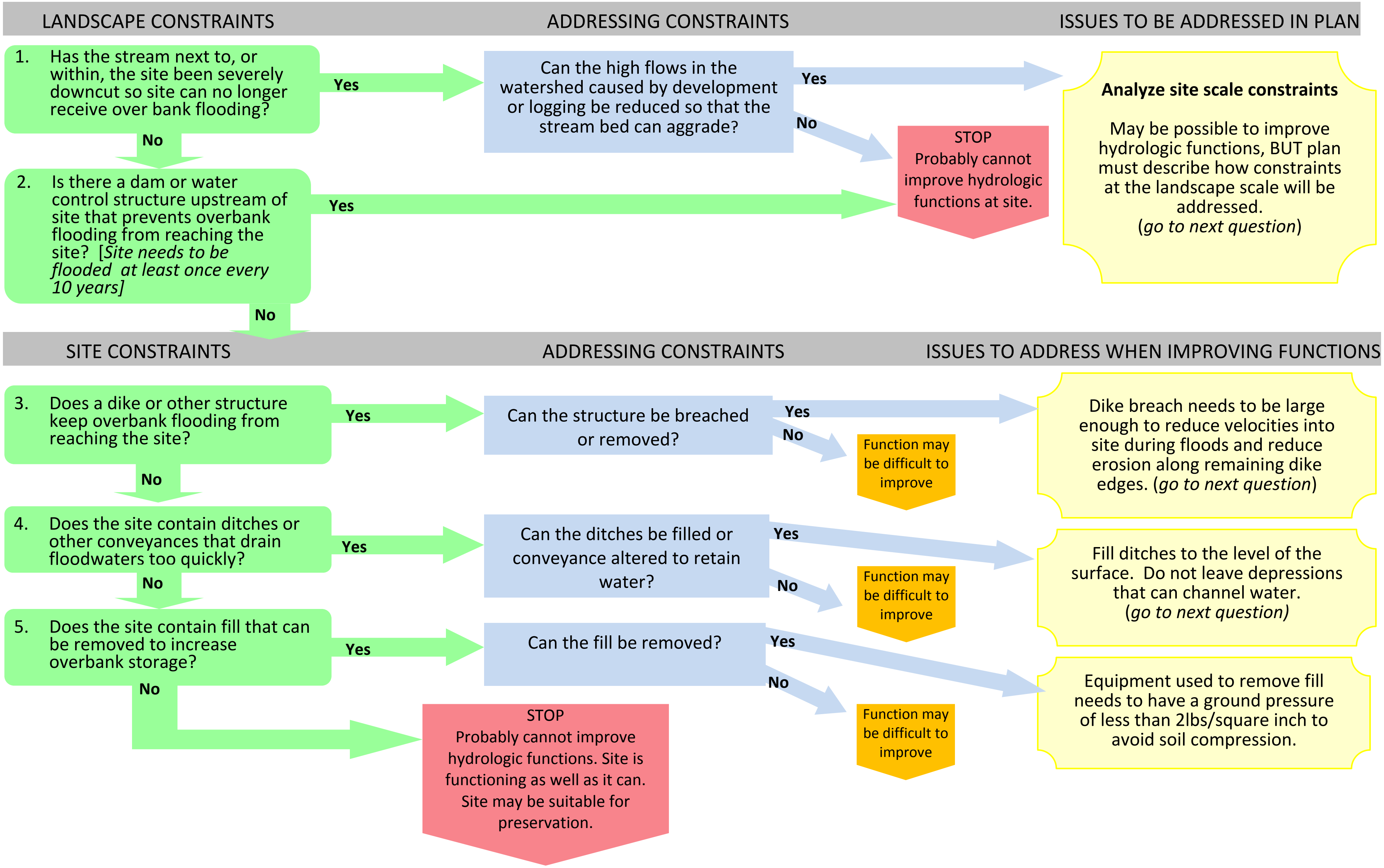
Charts 10 – 11: Can a site be used to improve habitat?

Individual species respond differently to disturbances in their environment. Thus the constraints on habitat are specific to the different groups of species that might be using the site. For example, a major constraint on salmon habitat in a wetland may be a culvert that restricts access. This constraint, however, has little effect on the wetland's ability to provide habitat for mammals, invertebrates, or amphibians.

One way to improve the habitat function of a wetland is to target individual species or small groups of species and develop a mitigation plan that addresses the constraints specific to that group. It is not the purpose of this guide, however, to provide such species-specific information. The Washington State Department of Fish and Wildlife has already developed management guidance for individual species and groups of species. This information is available on their web site at: http://wdfw.wa.gov/conservation/phs/ .

A second approach is to target biodiversity in general. Charts 10 and 11 identify the constraints and possible solutions for species richness. Chart 10 describes general constraints on all wildlife, including invertebrates, and Chart 11 does the same for plant species.

Chart 4a: Goal – Improving Hydrologic Functions in Riverine/Floodplain Systems in Zones 1 and 2.



LANDSCAPE CONSTRAINTS

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ISSUES TO BE ADDRESSED IN PLAN

1. Has the stream next to, or within, the site been severely downcut so site can no longer receive over bank flooding?

Yes → Can the high flows in the watershed caused by development or logging be reduced so that the stream bed can aggrade?

Yes → **Analyze site scale constraints**

May be possible to improve hydrologic functions, BUT plan must describe how constraints at the landscape scale will be addressed.
(*go to next question*)

No → STOP
Probably cannot improve hydrologic functions at site.

No ↓

2. Is there a dam or water control structure upstream of site that prevents overbank flooding from reaching the site? [*Site needs to be flooded at least once every 10 years]*

Yes → STOP
Probably cannot improve hydrologic functions at site.

No ↓

SITE CONSTRAINTS

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ISSUES TO ADDRESS WHEN IMPROVING FUNCTIONS

3. Does a dike or other structure keep overbank flooding from reaching the site?

Yes → Can the structure be breached or removed?

Yes → Dike breach needs to be large enough to reduce velocities into site during floods and reduce erosion along remaining dike edges. (*go to next question*)

No → Function may be difficult to improve

No ↓

4. Does the site contain ditches or other conveyances that drain floodwaters too quickly?

Yes → Can the ditches be filled or conveyance altered to retain water?

Yes → Fill ditches to the level of the surface. Do not leave depressions that can channel water.
(go to next question)

No → Function may be difficult to improve

No ↓

5. Does the site contain fill that can be removed to increase overbank storage?

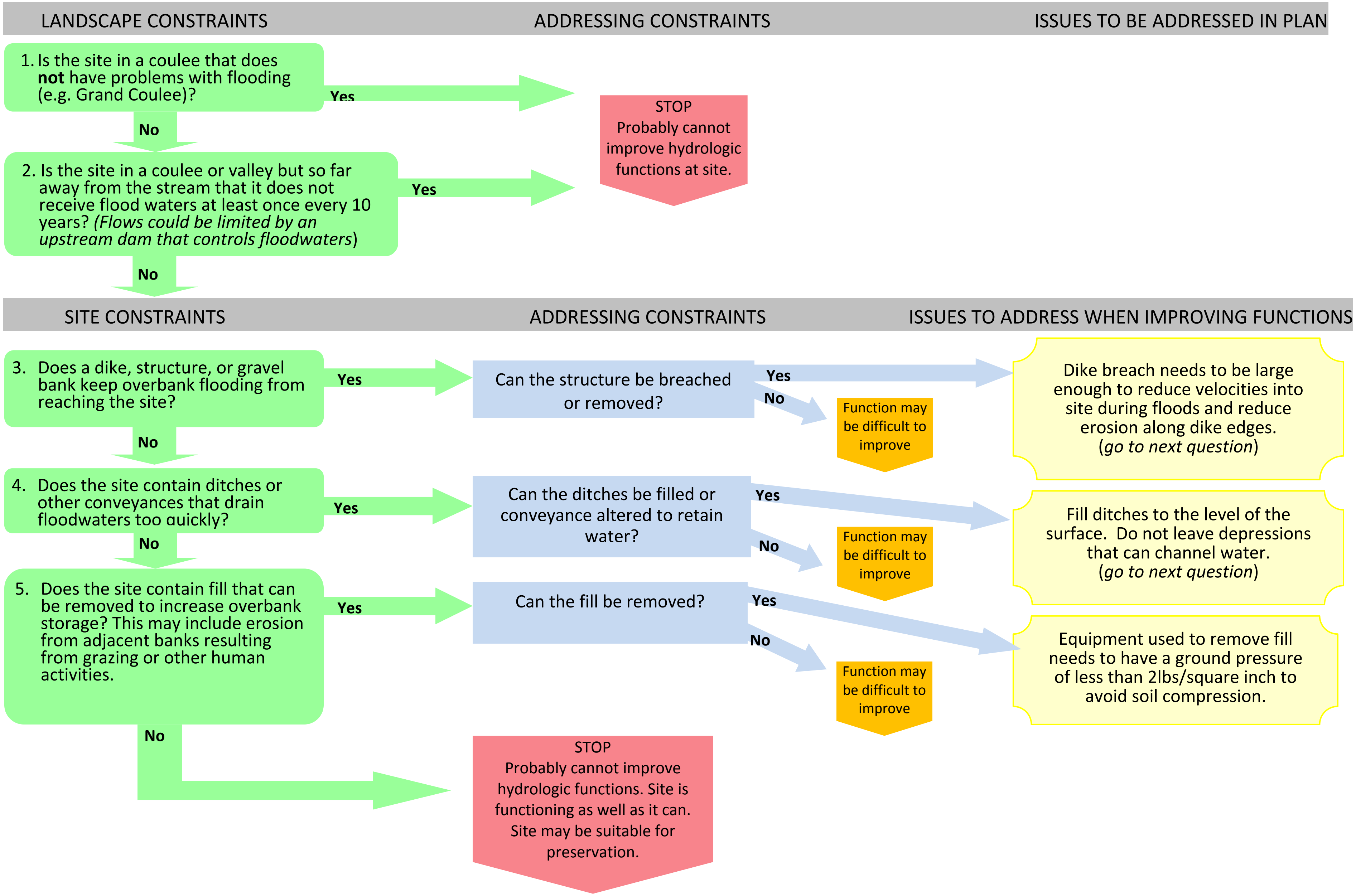
Yes → Can the fill be removed?

Yes → Equipment used to remove fill needs to have a ground pressure of less than 2lbs/square inch to avoid soil compression.

No → Function may be difficult to improve

No → STOP
Probably cannot improve hydrologic functions. Site is functioning as well as it can. Site may be suitable for preservation.

Chart 4b: Goal – Improving Hydrologic Functions in Coulees and Valleys with Streams in Zone 3



LANDSCAPE CONSTRAINTS | ADDRESSING CONSTRAINTS | ISSUES TO BE ADDRESSED IN PLAN

1. Is the site in a coulee that does **not** have problems with flooding (e.g. Grand Coulee)?

Yes

No

2. Is the site in a coulee or valley but so far away from the stream that it does not receive flood waters at least once every 10 years? *(Flows could be limited by an upstream dam that controls floodwaters*)

Yes

STOP
Probably cannot improve hydrologic functions at site.

No

SITE CONSTRAINTS | ADDRESSING CONSTRAINTS | ISSUES TO ADDRESS WHEN IMPROVING FUNCTIONS

3. Does a dike, structure, or gravel bank keep overbank flooding from reaching the site?

Yes

Can the structure be breached or removed?

Yes

Dike breach needs to be large enough to reduce velocities into site during floods and reduce erosion along dike edges.
(*go to next question*)

No

Function may be difficult to improve

No

4. Does the site contain ditches or other conveyances that drain floodwaters too quickly?

Yes

Can the ditches be filled or conveyance altered to retain water?

Yes

Fill ditches to the level of the surface. Do not leave depressions that can channel water.
(*go to next question*)

No

Function may be difficult to improve

No

5. Does the site contain fill that can be removed to increase overbank storage? This may include erosion from adjacent banks resulting from grazing or other human activities.

Yes

Can the fill be removed?

Yes

Equipment used to remove fill needs to have a ground pressure of less than 2lbs/square inch to avoid soil compression.

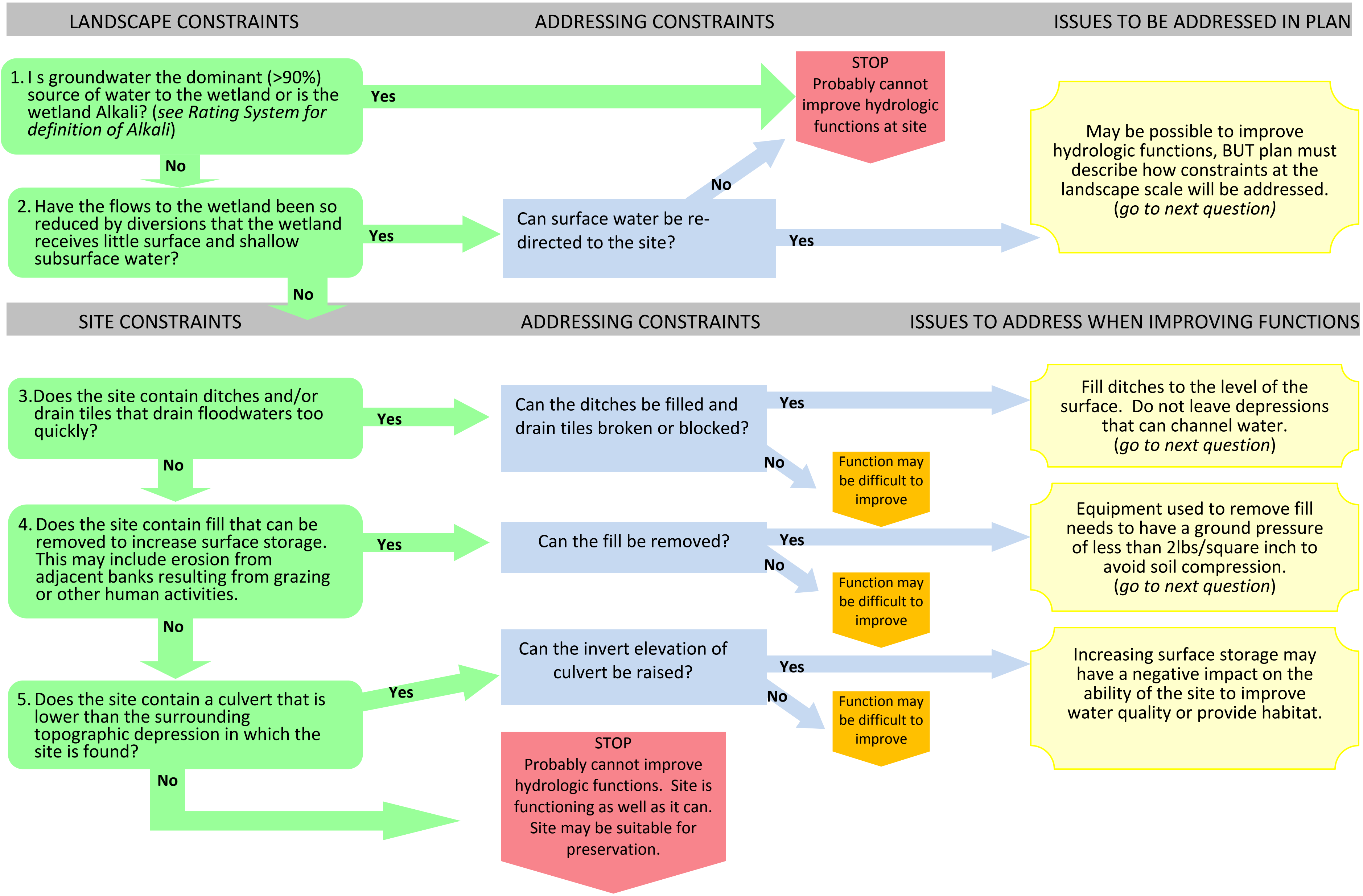
No

Function may be difficult to improve

No

STOP
Probably cannot improve hydrologic functions. Site is functioning as well as it can. Site may be suitable for preservation.

Chart 5: Goal – Improving Hydrologic Functions in Depressional Systems Outside the Floodplains in Zone 1 and 2



LANDSCAPE CONSTRAINTS | ADDRESSING CONSTRAINTS | ISSUES TO BE ADDRESSED IN PLAN

1. I s groundwater the dominant (>90%) source of water to the wetland or is the wetland Alkali? (*see Rating System for definition of Alkali*)

Yes → STOP Probably cannot improve hydrologic functions at site

No ↓

2. Have the flows to the wetland been so reduced by diversions that the wetland receives little surface and shallow subsurface water?

Yes → Can surface water be re-directed to the site?

No → STOP Probably cannot improve hydrologic functions at site

Yes → May be possible to improve hydrologic functions, BUT plan must describe how constraints at the landscape scale will be addressed. (*go to next question)*

No ↓

SITE CONSTRAINTS | ADDRESSING CONSTRAINTS | ISSUES TO ADDRESS WHEN IMPROVING FUNCTIONS

3. Does the site contain ditches and/or drain tiles that drain floodwaters too quickly?

Yes → Can the ditches be filled and drain tiles broken or blocked?

Yes → Fill ditches to the level of the surface. Do not leave depressions that can channel water. (*go to next question*)

No → Function may be difficult to improve

No ↓

4. Does the site contain fill that can be removed to increase surface storage. This may include erosion from adjacent banks resulting from grazing or other human activities.

Yes → Can the fill be removed?

Yes → Equipment used to remove fill needs to have a ground pressure of less than 2lbs/square inch to avoid soil compression. (*go to next question*)

No → Function may be difficult to improve

No ↓

5. Does the site contain a culvert that is lower than the surrounding topographic depression in which the site is found?

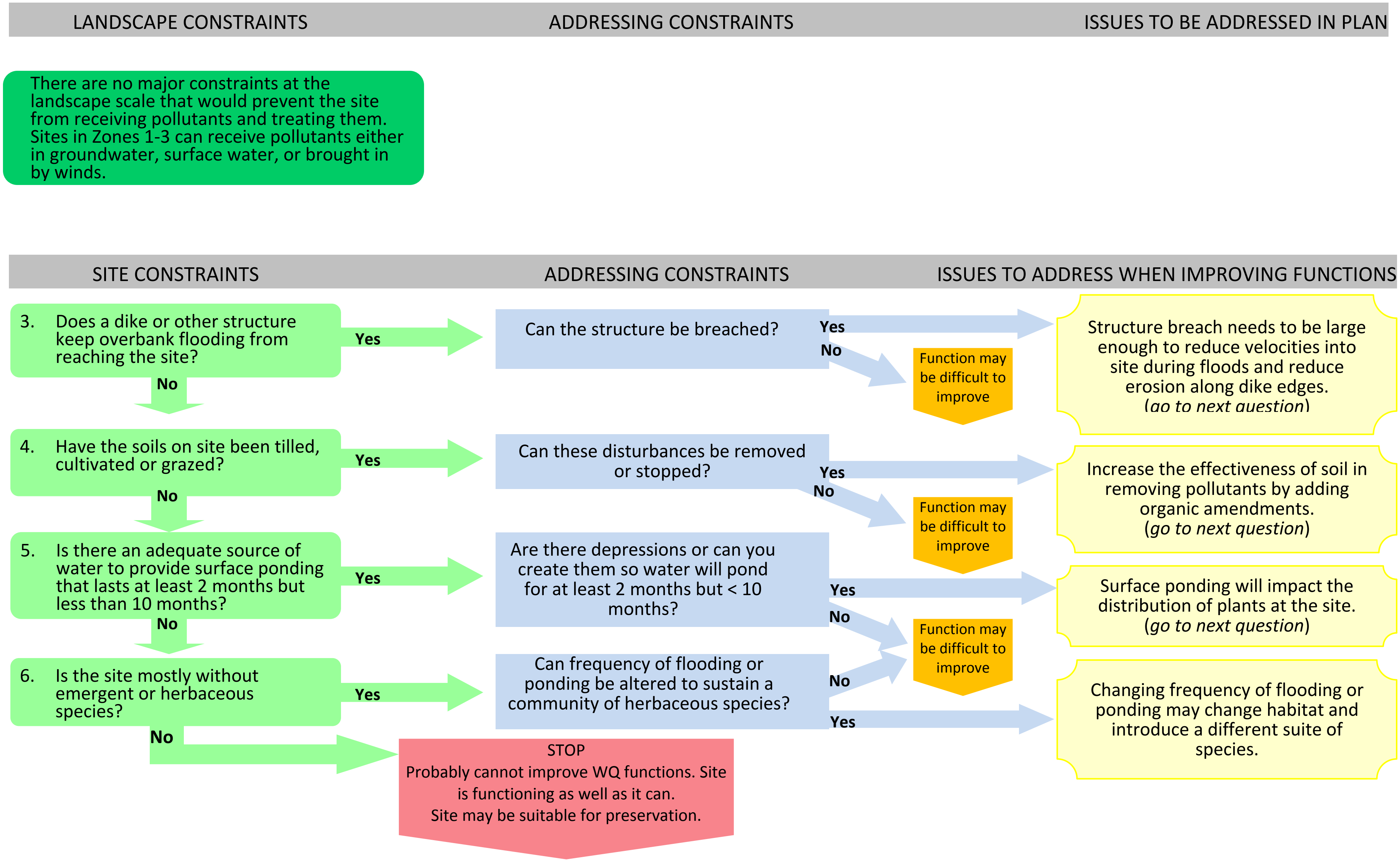
Yes → Can the invert elevation of culvert be raised?

Yes → Increasing surface storage may have a negative impact on the ability of the site to improve water quality or provide habitat.

No → Function may be difficult to improve

No → STOP Probably cannot improve hydrologic functions. Site is functioning as well as it can. Site may be suitable for preservation.

Chart 6: Goal - Improving Water Quality Functions in Floodplains and Coulees in Zones 1-3 (does not apply to Alkali systems)



There are no major constraints at the landscape scale that would prevent the site from receiving pollutants and treating them. Sites in Zones 1-3 can receive pollutants either in groundwater, surface water, or brought in by winds.

3. Does a dike or other structure keep overbank flooding from reaching the site?

Can the structure be breached?

Function may be difficult to improve

Structure breach needs to be large enough to reduce velocities into site during floods and reduce erosion along dike edges. (*go to next question*)

4. Have the soils on site been tilled, cultivated or grazed?

Can these disturbances be removed or stopped?

Function may be difficult to improve

Increase the effectiveness of soil in removing pollutants by adding organic amendments. (*go to next question*)

5. Is there an adequate source of water to provide surface ponding that lasts at least 2 months but less than 10 months?

Are there depressions or can you create them so water will pond for at least 2 months but < 10 months?

Function may be difficult to improve

Surface ponding will impact the distribution of plants at the site. (*go to next question*)

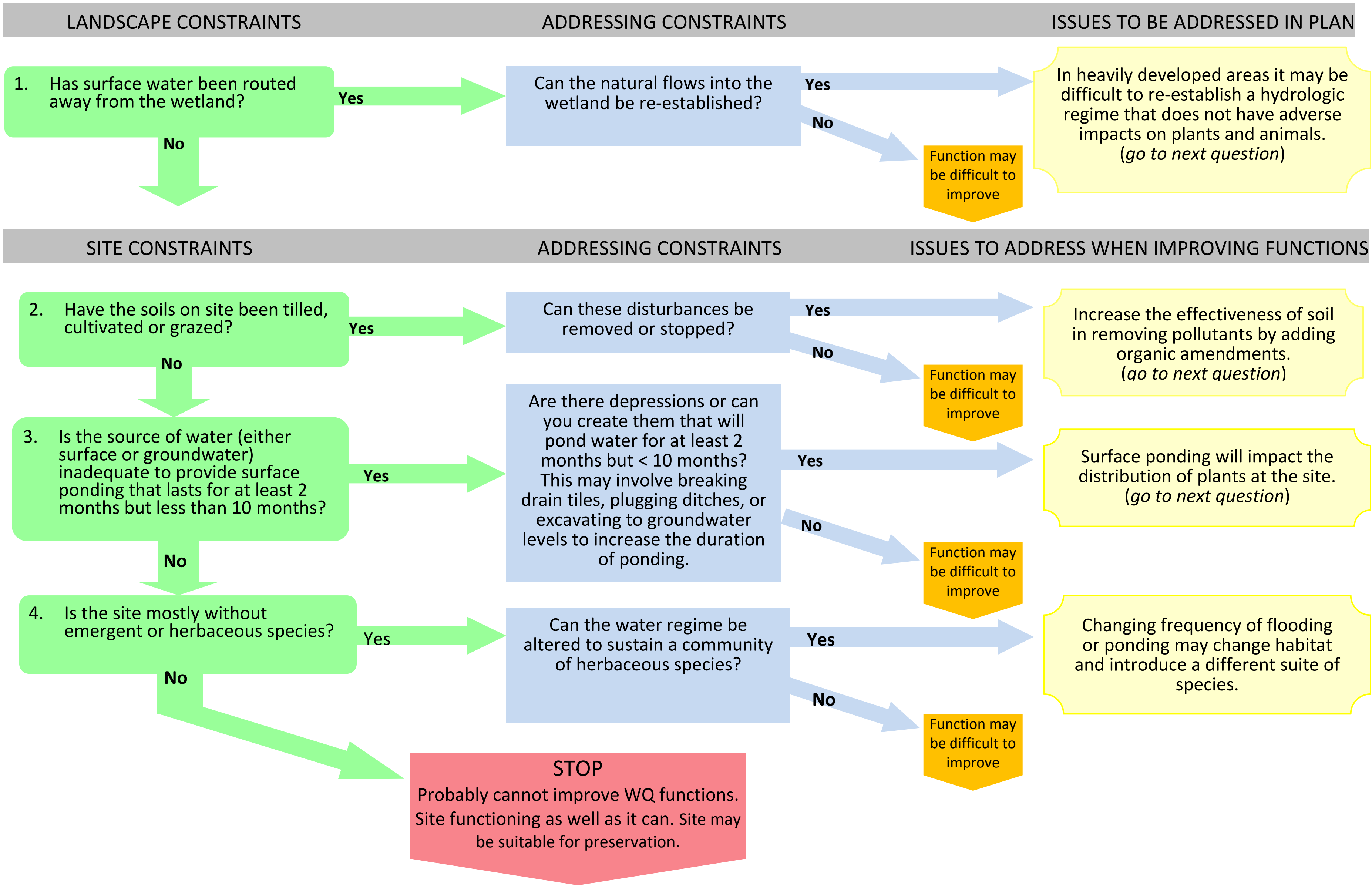
6. Is the site mostly without emergent or herbaceous species?

Can frequency of flooding or ponding be altered to sustain a community of herbaceous species?

Changing frequency of flooding or ponding may change habitat and introduce a different suite of species.

STOP
Probably cannot improve WQ functions. Site is functioning as well as it can.
Site may be suitable for preservation.

Chart 7: Goal - Improving Water Quality (WQ) Functions in Depressional Systems Outside of Floodplains and Coulees in Zones 1-3 (does not apply in Alkali systems)



LANDSCAPE CONSTRAINTS | ADDRESSING CONSTRAINTS | ISSUES TO BE ADDRESSED IN PLAN

1. Has surface water been routed away from the wetland?

Yes → Can the natural flows into the wetland be re-established?

Yes → In heavily developed areas it may be difficult to re-establish a hydrologic regime that does not have adverse impacts on plants and animals. (*go to next question*)

No → Function may be difficult to improve

No ↓

SITE CONSTRAINTS | ADDRESSING CONSTRAINTS | ISSUES TO ADDRESS WHEN IMPROVING FUNCTIONS

2. Have the soils on site been tilled, cultivated or grazed?

Yes → Can these disturbances be removed or stopped?

Yes → Increase the effectiveness of soil in removing pollutants by adding organic amendments. (*go to next question*)

No → Function may be difficult to improve

No ↓

3. Is the source of water (either surface or groundwater) inadequate to provide surface ponding that lasts for at least 2 months but less than 10 months?

Yes → Are there depressions or can you create them that will pond water for at least 2 months but < 10 months? This may involve breaking drain tiles, plugging ditches, or excavating to groundwater levels to increase the duration of ponding.

Yes → Surface ponding will impact the distribution of plants at the site. (*go to next question*)

No → Function may be difficult to improve

No ↓

4. Is the site mostly without emergent or herbaceous species?

Yes → Can the water regime be altered to sustain a community of herbaceous species?

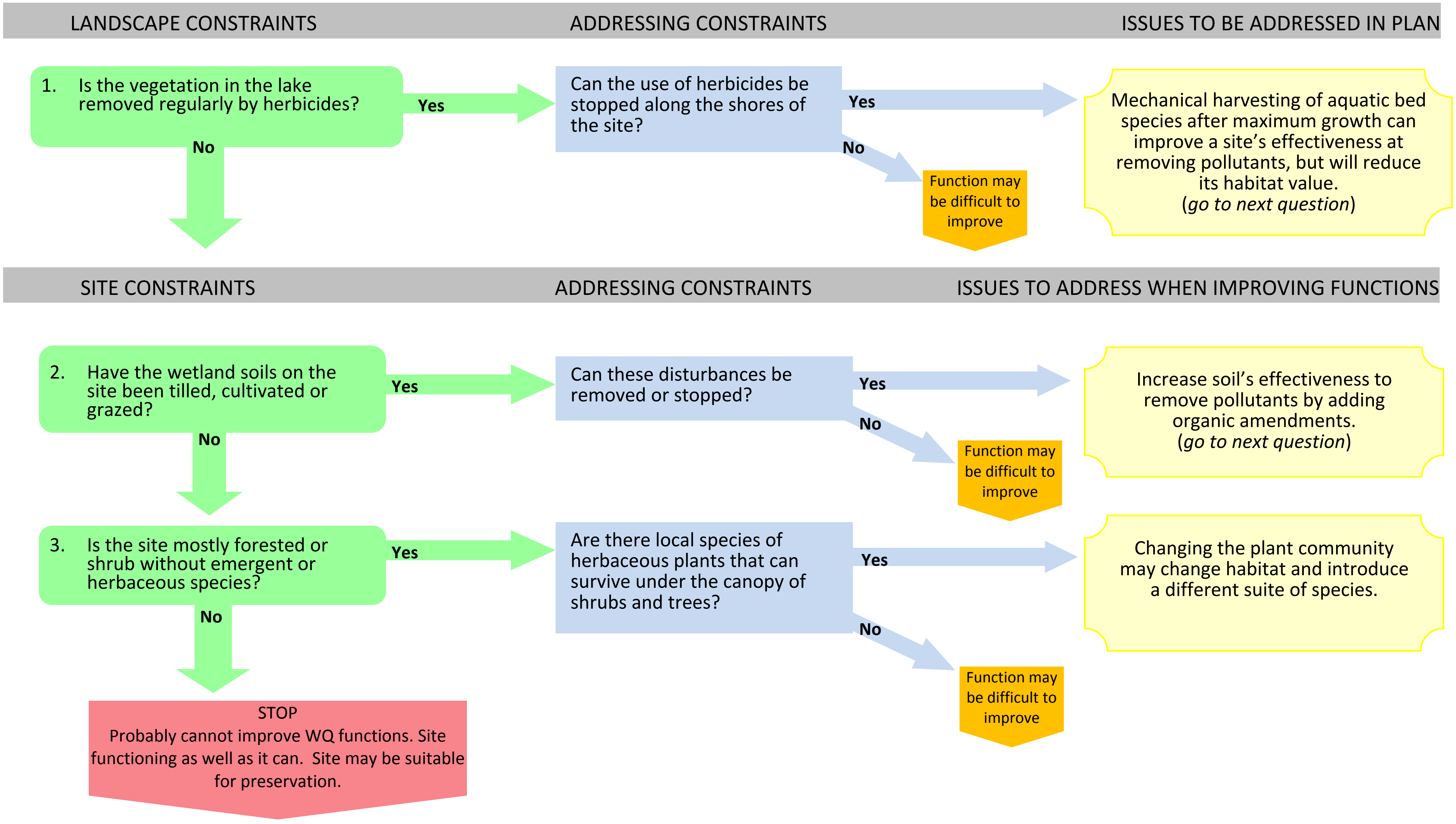
Yes → Changing frequency of flooding or ponding may change habitat and introduce a different suite of species.

No → Function may be difficult to improve

No → STOP

Probably cannot improve WQ functions. Site functioning as well as it can. Site may be suitable for preservation.

Chart 8: Goal - Improving Water Quality (WQ) Functions along the Shores of Lakes in Zones 1-3



LANDSCAPE CONSTRAINTS | ADDRESSING CONSTRAINTS | ISSUES TO BE ADDRESSED IN PLAN

1. Is the vegetation in the lake removed regularly by herbicides?

Yes → Can the use of herbicides be stopped along the shores of the site?

Yes → Mechanical harvesting of aquatic bed species after maximum growth can improve a site's effectiveness at removing pollutants, but will reduce its habitat value. (*go to next question*)

No → Function may be difficult to improve

No ↓

SITE CONSTRAINTS | ADDRESSING CONSTRAINTS | ISSUES TO ADDRESS WHEN IMPROVING FUNCTIONS

2. Have the wetland soils on the site been tilled, cultivated or grazed?

Yes → Can these disturbances be removed or stopped?

Yes → Increase soil's effectiveness to remove pollutants by adding organic amendments. (*go to next question*)

No → Function may be difficult to improve

No ↓

3. Is the site mostly forested or shrub without emergent or herbaceous species?

Yes → Are there local species of herbaceous plants that can survive under the canopy of shrubs and trees?

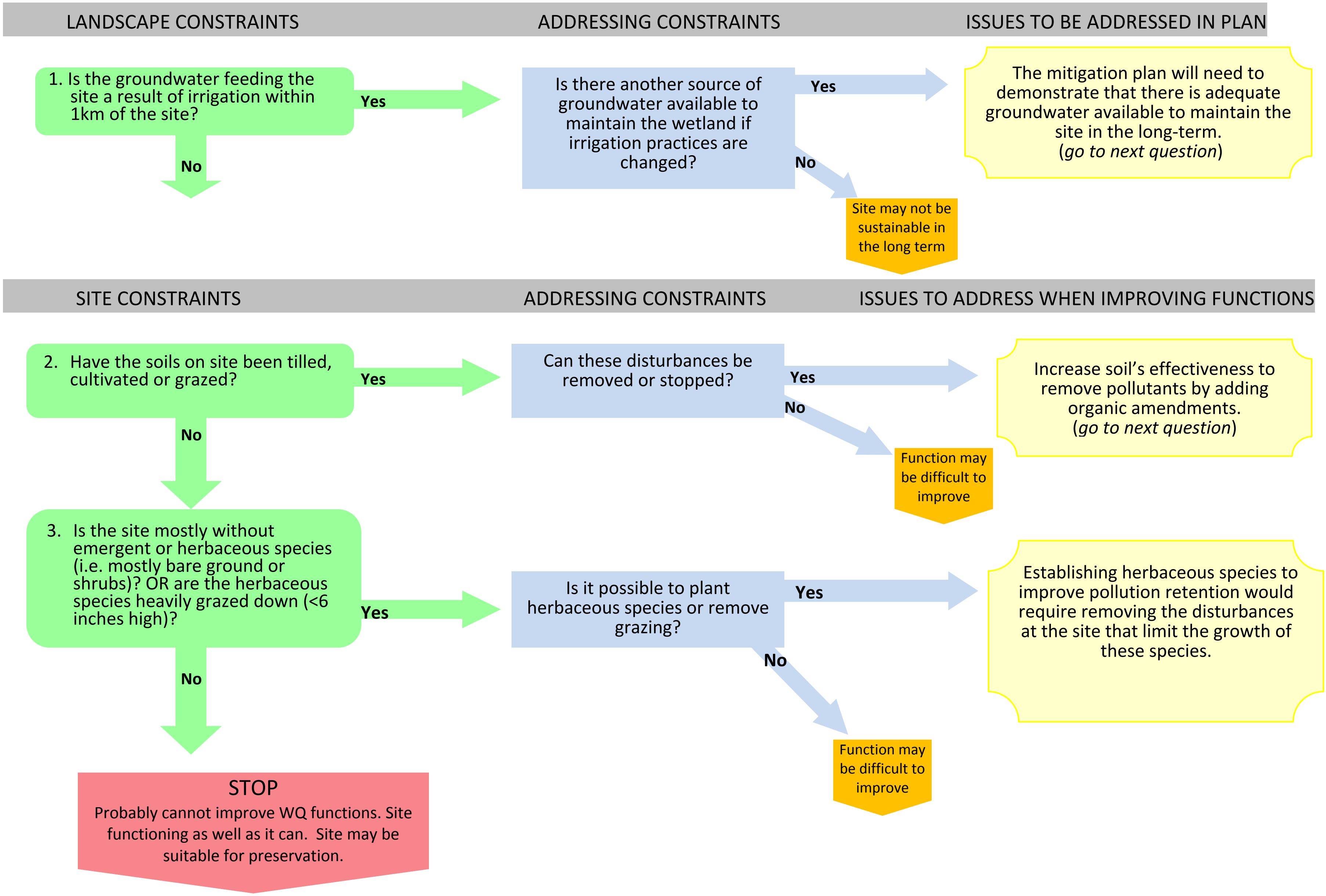
Yes → Changing the plant community may change habitat and introduce a different suite of species.

No → Function may be difficult to improve

No ↓

STOP
Probably cannot improve WQ functions. Site functioning as well as it can. Site may be suitable for preservation.

Chart 9: Goal - Improving Water Quality (WQ) Functions in Slope Systems in Zones 1-3



LANDSCAPE CONSTRAINTS

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ISSUES TO BE ADDRESSED IN PLAN

1. Is the groundwater feeding the site a result of irrigation within 1km of the site?

Is there another source of groundwater available to maintain the wetland if irrigation practices are changed?

The mitigation plan will need to demonstrate that there is adequate groundwater available to maintain the site in the long-term. (*go to next question*)

Site may not be sustainable in the long term

SITE CONSTRAINTS

ADDRESSING CONSTRAINTS

ISSUES TO ADDRESS WHEN IMPROVING FUNCTIONS

2. Have the soils on site been tilled, cultivated or grazed?

Can these disturbances be removed or stopped?

Increase soil's effectiveness to remove pollutants by adding organic amendments. (*go to next question*)

Function may be difficult to improve

3. Is the site mostly without emergent or herbaceous species (i.e. mostly bare ground or shrubs)? OR are the herbaceous species heavily grazed down (<6 inches high)?

Is it possible to plant herbaceous species or remove grazing?

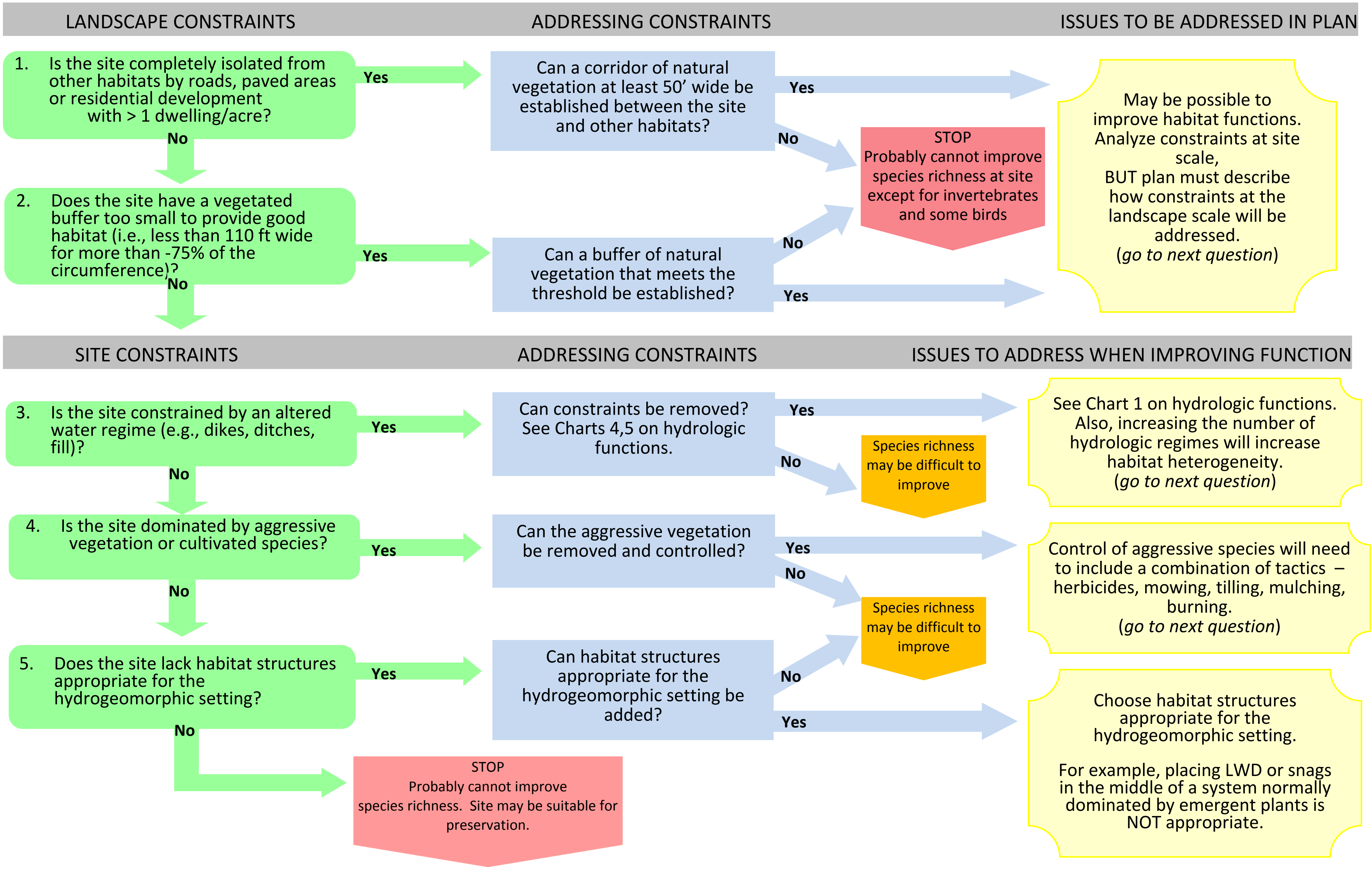
Establishing herbaceous species to improve pollution retention would require removing the disturbances at the site that limit the growth of these species.

Function may be difficult to improve

STOP

Probably cannot improve WQ functions. Site functioning as well as it can. Site may be suitable for preservation.

Chart 10: Goal - Improving Species Richness of Wildlife in Zones 1-3



LANDSCAPE CONSTRAINTS

ADDRESSING CONSTRAINTS

ISSUES TO BE ADDRESSED IN PLAN

1. Is the site completely isolated from other habitats by roads, paved areas or residential development with > 1 dwelling/acre?

Yes

No

Can a corridor of natural vegetation at least 50’ wide be established between the site and other habitats?

Yes

No

STOP
Probably cannot improve species richness at site except for invertebrates and some birds

May be possible to improve habitat functions. Analyze constraints at site scale,
BUT plan must describe how constraints at the landscape scale will be addressed.
(*go to next question*)

2. Does the site have a vegetated buffer too small to provide good habitat (i.e., less than 110 ft wide for more than -75% of the circumference)?

Yes

No

Can a buffer of natural vegetation that meets the threshold be established?

No

Yes

SITE CONSTRAINTS

ADDRESSING CONSTRAINTS

ISSUES TO ADDRESS WHEN IMPROVING FUNCTION

3. Is the site constrained by an altered water regime (e.g., dikes, ditches, fill)?

Yes

No

Can constraints be removed? See Charts 4,5 on hydrologic functions.

Yes

No

Species richness may be difficult to improve

See Chart 1 on hydrologic functions. Also, increasing the number of hydrologic regimes will increase habitat heterogeneity.
(*go to next question*)

4. Is the site dominated by aggressive vegetation or cultivated species?

Yes

No

Can the aggressive vegetation be removed and controlled?

Yes

No

Species richness may be difficult to improve

Control of aggressive species will need to include a combination of tactics – herbicides, mowing, tilling, mulching, burning.
(*go to next question*)

5. Does the site lack habitat structures appropriate for the hydrogeomorphic setting?

Yes

No

Can habitat structures appropriate for the hydrogeomorphic setting be added?

No

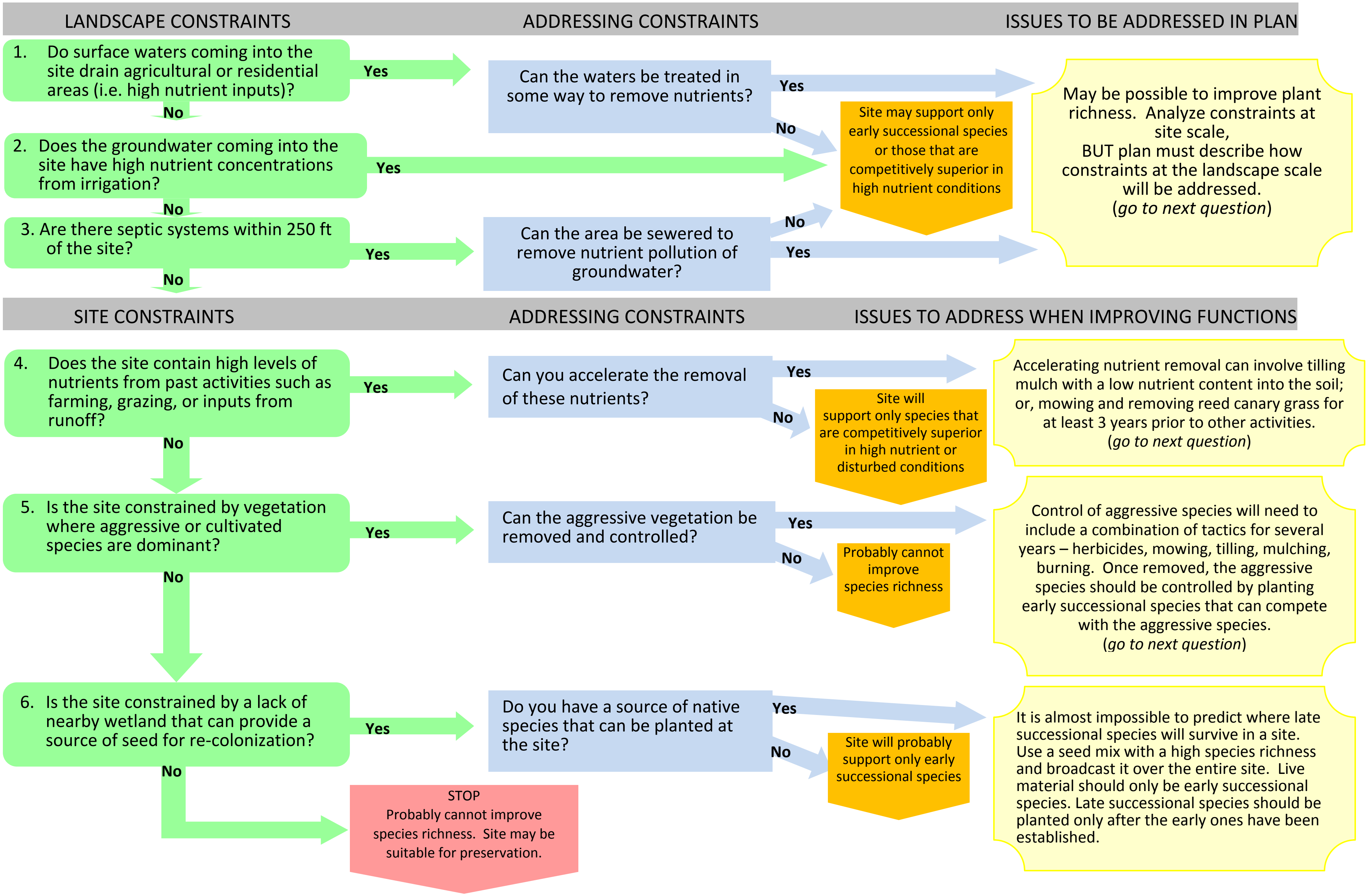
Yes

Choose habitat structures appropriate for the hydrogeomorphic setting.

For example, placing LWD or snags in the middle of a system normally dominated by emergent plants is NOT appropriate.

STOP
Probably cannot improve species richness. Site may be suitable for preservation.

Chart 11: Goal - Improving Species Richness of Plants in Zones 1-3 (does not apply to alkali systems)



LANDSCAPE CONSTRAINTS

ADDRESSING CONSTRAINTS

ISSUES TO BE ADDRESSED IN PLAN

1. Do surface waters coming into the site drain agricultural or residential areas (i.e. high nutrient inputs)?

Yes → Can the waters be treated in some way to remove nutrients?

Yes → May be possible to improve plant richness. Analyze constraints at site scale, BUT plan must describe how constraints at the landscape scale will be addressed. (*go to next question*)

No → Site may support only early successional species or those that are competitively superior in high nutrient conditions

No

2. Does the groundwater coming into the site have high nutrient concentrations from irrigation?

Yes → Site may support only early successional species or those that are competitively superior in high nutrient conditions

No

3. Are there septic systems within 250 ft of the site?

Yes → Can the area be sewered to remove nutrient pollution of groundwater?

No → Site may support only early successional species or those that are competitively superior in high nutrient conditions

Yes → May be possible to improve plant richness. Analyze constraints at site scale, BUT plan must describe how constraints at the landscape scale will be addressed. (*go to next question*)

No

SITE CONSTRAINTS

ADDRESSING CONSTRAINTS

ISSUES TO ADDRESS WHEN IMPROVING FUNCTIONS

4. Does the site contain high levels of nutrients from past activities such as farming, grazing, or inputs from runoff?

Yes → Can you accelerate the removal of these nutrients?

Yes → Accelerating nutrient removal can involve tilling mulch with a low nutrient content into the soil; or, mowing and removing reed canary grass for at least 3 years prior to other activities. (*go to next question*)

No → Site will support only species that are competitively superior in high nutrient or disturbed conditions

No

5. Is the site constrained by vegetation where aggressive or cultivated species are dominant?

Yes → Can the aggressive vegetation be removed and controlled?

Yes → Control of aggressive species will need to include a combination of tactics for several years – herbicides, mowing, tilling, mulching, burning. Once removed, the aggressive species should be controlled by planting early successional species that can compete with the aggressive species. (*go to next question*)

No → Probably cannot improve species richness

No

6. Is the site constrained by a lack of nearby wetland that can provide a source of seed for re-colonization?

Yes → Do you have a source of native species that can be planted at the site?

Yes → It is almost impossible to predict where late successional species will survive in a site. Use a seed mix with a high species richness and broadcast it over the entire site. Live material should only be early successional species. Late successional species should be planted only after the early ones have been established.

No → Site will probably support only early successional species

No → STOP
Probably cannot improve species richness. Site may be suitable for preservation.

Permitting Requirements

This guidance does not affect the requirements of any permits or rules that may apply to wetland (or other regulated waters) impact projects. The Governor's Office of Regulatory Assistance (www.ora.wa.gov/resources/permitting.asp) can help you understand your permitting requirements. The following is a brief list of current wetland permitting authorities:

- Impacts to wetlands, streams, lakes and other waters of the state must be authorized by Ecology because the Environmental Protection Agency delegated the administration of Section 401 of the Federal Clean Water Act to Ecology and the authority granted the agency in the Washington Water Pollution Control Act (RCW 90.48). Wetlands designated as non-jurisdictional by the Corps are regulated by Ecology under RCW 90.48. Section 401 is administered by the EPA on federal lands (e.g., military bases, national parks) and some Indian reservations and tribal lands located off-reservation. To date, the EPA has delegated its authority to administer Section 401 on their respective reservations and off-reservation lands to eight Indian tribal governments in Washington.
- Impacts to wetlands, streams, lakes and other waters that occur on Indian reservations must typically be authorized by one or more tribal governmental agency (e.g. Natural Resources Departments, Planning Departments, Cultural Resources Departments/Historic Preservation Offices).
- Impacts associated with the discharge of dredged or fill materials to jurisdictional wetlands, streams, lakes, and other waters of the United States must be authorized by the Corps under Section 404 of the Federal Clean Water Act.
- Impacts to streams, rivers, and lakes must be authorized by WDFW under a Hydraulics Project Approval permit process.
- All requirements of local government regulations must be met, including Shoreline Master Plans and Critical Areas Ordinances.
- Regulatory requirements and guidance on stormwater treatment must be followed (consult with Ecology Water Quality Program).
- Projects must meet all federal, state, and local floodplain requirements.

Definitions

Contributing Basin – The watershed of an individual wetland or other specific aquatic resource such as a stream reach or lake. This is the area that contributes surface and groundwater to the individual site. The contributing basin may be very small for “kettle-hole” wetlands and very large for riverine wetlands near the mouth of large rivers. Most discussions of contributing basin, however, refer only to the areas contributing surface water because it is almost impossible to map the sources of groundwater to individual wetlands.

Ecological processes - The five basic processes at work in all landscapes: geological changes, water cycle, mineral cycle, energy flow, and community dynamics that link all living organisms and their environment. Ecological processes occur at multiple scales from the microscopic to the global and can often extend beyond watershed boundaries. Community dynamics include a wide range of interactions among different species such as predation, competition, and colonization.

Hydrogeomorphic (HGM) class – An approach to classifying wetlands to aid in distinguishing the functions that each class can perform. The classification is based on the hydrologic and geomorphic "controls" responsible for maintaining many of the functions of wetland ecosystems. These hydrogeomorphic characteristics include geomorphic setting, water source, and hydrodynamics.

In-kind mitigation – Replacing an affected wetland with one of a similar HGM class and similar functions.

Off-site mitigation – Compensating for lost wetland area and functions at a site other than where the impact will occur.

On-site mitigation – Compensating for lost wetland area and functions on or adjacent to the impact site.

Out-of-kind mitigation – Replacing an affected wetland with one of a different HGM class, different functions, or with resources other than wetlands.

Watershed – The drainage area contributing water, organic matter, dissolved nutrients, and sediments to aquatic resources. This includes the area that contributes groundwater to aquatic ecosystems, which may be different from the area contributing surface water. Watersheds can be drawn at varying scales from the smallest watershed of a first order stream to that of a major river (tens to thousands of square miles).

Watershed characterization – A process of collecting information and data within a watershed on factors that control watershed processes and analyzing this information. The purpose is to identify and rank the areas most suitable for protection, restoration and development. These results are then synthesized into a management framework that provides clearly defined regulatory and non-regulatory actions.

Watershed processes – The dynamic physical, biological, and chemical interactions that form and maintain the landscape and its ecosystems. These processes include the movement of water, sediment, nutrients, wildlife and other biota, pathogens, toxins, and wood as they enter into, pass through, and eventually leave the hydrologic unit. Watershed processes can operate at any geographic scale, from regions to sub-catchments.

Other Resources

The following is a list of other federal and state rules, policies, guidelines and resources that provide guidance on mitigation planning:

- Wetland Mitigation in Washington State, Parts 1 and 2 (2006) (http://www.ecy.wa.gov/programs/sea/wetlands/mitigation/guidance/index.html)
- State of Washington Wetland Mitigation Banking Law, RCW 90.84 (http://apps.leg.wa.gov/RCW/default.aspx?cite=90.84)
- Washington Department of Ecology, Wetland Mitigation Banking Resource Documents (www.ecy.wa.gov/programs/sea/wetlands/mitigation/banking/guidance.html)
- State Water Pollution Control Act, RCW 90.48 (http://apps.leg.wa.gov/RCW/default.aspx?cite=90.48)
- Compensatory Mitigation for Losses of Aquatic Resources, Final Rule, 33 CFR Parts 325 and 332 and 40 CFR Part 230 (2008) (http://www.epa.gov/owow/wetlands/pdf/wetlands_mitigation_final_rule_4_10_08.pdf)
- Center for Watershed Protection (http://www.cwp.org)
- Federal Clean Water Act Section 401 (http://www.epa.gov/OWOW/wetlands/regs/sec401.html)
- Federal Clean Water Act Section 404 (http://www.epa.gov/OWOW/wetlands/regs/sec404.html)

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APPENDIX A

Achieving an Ecosystem Based Approach to Planning in the Puget Sound

This is a “stand-alone” document. If it is not attached here, please download the appendix at:
http://www.ecy.wa.gov/mitigation/docs/stanleyetal.pdf

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APPENDIX B

Worksheets for Charts 4 through 11

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Chart 4a Worksheet: Goal - Improving Hydrologic Functions in Riverine/Floodplain Systems in Zones 1 and 2.

Landscape Constraints	Constraint present? (yes/no)	Tactics to address constraint	Special features of your project	How will tactics impact other functions?
Downcutting				
Reduced Flows				
Site Constraints	**Constraint present? (yes/no)**	**Tactics to address constraint**	**Special features of your project**	**How will tactics impact other functions?**
Dikes				
Ditches				
Fill				

Chart 4b Worksheet: Goal - Improving Hydrologic Functions in Riverine/Floodplain Systems in Zone 3.

Landscape Constraints	Constraint present? (yes/no)	Tactics to address constraint	Special features of your project	How will tactics impact other functions?
Coulee without flooding problems		STOP Probably cannot improve function.		
No overbank flooding		STOP Probably cannot improve function. .		
Site Constraints	Constraint present? (yes/no)	Tactics to address constraint	Special features of your project	How will tactics impact other functions?
Dikes				
Ditches				
Fill				

Chart 5 Worksheet: Goal - Improving Hydrologic Functions in Depressional Systems Outside Floodplains in Zones 1 and 2.

Landscape Constraints	Constraint present? (yes/no)	Tactics to address constraint	Special features of your project	How will tactics impact other functions?
Groundwater dominant source of water or system is alkali		STOP Probably cannot improve function.		
Reduced Flows				
Site Constraints	**Constraint present? (yes/no)**	**Tactics to address constraint**	**Special features of your project**	**How will tactics impact other functions?**
Ditches				
Fill				
Culverts				

Chart 6: Goal - Improving Water Quality Functions in Floodplains and Coulees in Zones 1-3 (does not apply to Alkali systems)

Site Constraints	Constraint present? (yes/no)	Tactics to address constraint	Special features of your project	How will tactics impact other functions?
Dikes				
Altered Soils				
Source of water to created ponding				
No emergent or herbaceous plant species				

Chart 7: Goal - Improving Water Quality (WQ) Functions in Depressional Systems Outside of Floodplains and Coulees in Zones 1-3 (does not apply in Alkali systems)

Landscape Constraints	Constraint present? (yes/no)	Tactics to address constraint	Special features of your project	How will tactics impact other functions?
Flows to wetland have been diverted				
Site Constraints	**Constraint present? (yes/no)**	**Tactics to address constraint**	**Special features of your project**	**How will tactics impact other functions?**
Altered Soils				
Source of water to created ponding				
No emergent or herbaceous plant species				

Chart 8 Worksheet: Goal - Improving Water Quality Functions Along Shores of Lakes in Zones 1-3.

Landscape Constraints	Constraint present? (yes/no)	Tactics to address constraint	Special features of your project	How will tactics impact other functions?
Vegetation in lake removed by herbicides				
Site Constraints	**Constraint present? (yes/no)**	**Tactics to address constraint**	**Special features of your project**	**How will tactics impact other functions?**
Altered Soils above OHWM				
No emergent or herbaceous plant species				

Chart 9 Worksheet: Goal - Improving Water Quality Functions in Slope Systems in Zones 1-3.

Landscape Constraints	Constraint present? (yes/no)	Tactics to address constraint	Special features of your project	How will tactics impact other functions?
None				
Site Constraints	**Constraint present? (yes/no)**	**Tactics to address constraint**	**Special features of your project**	**How will tactics impact other functions?**
Altered Soils				
No emergent or herbaceous plant species				

Chart 10 Worksheet: Goal - Improving Species Richness of Wildlife in Zones 1-3.

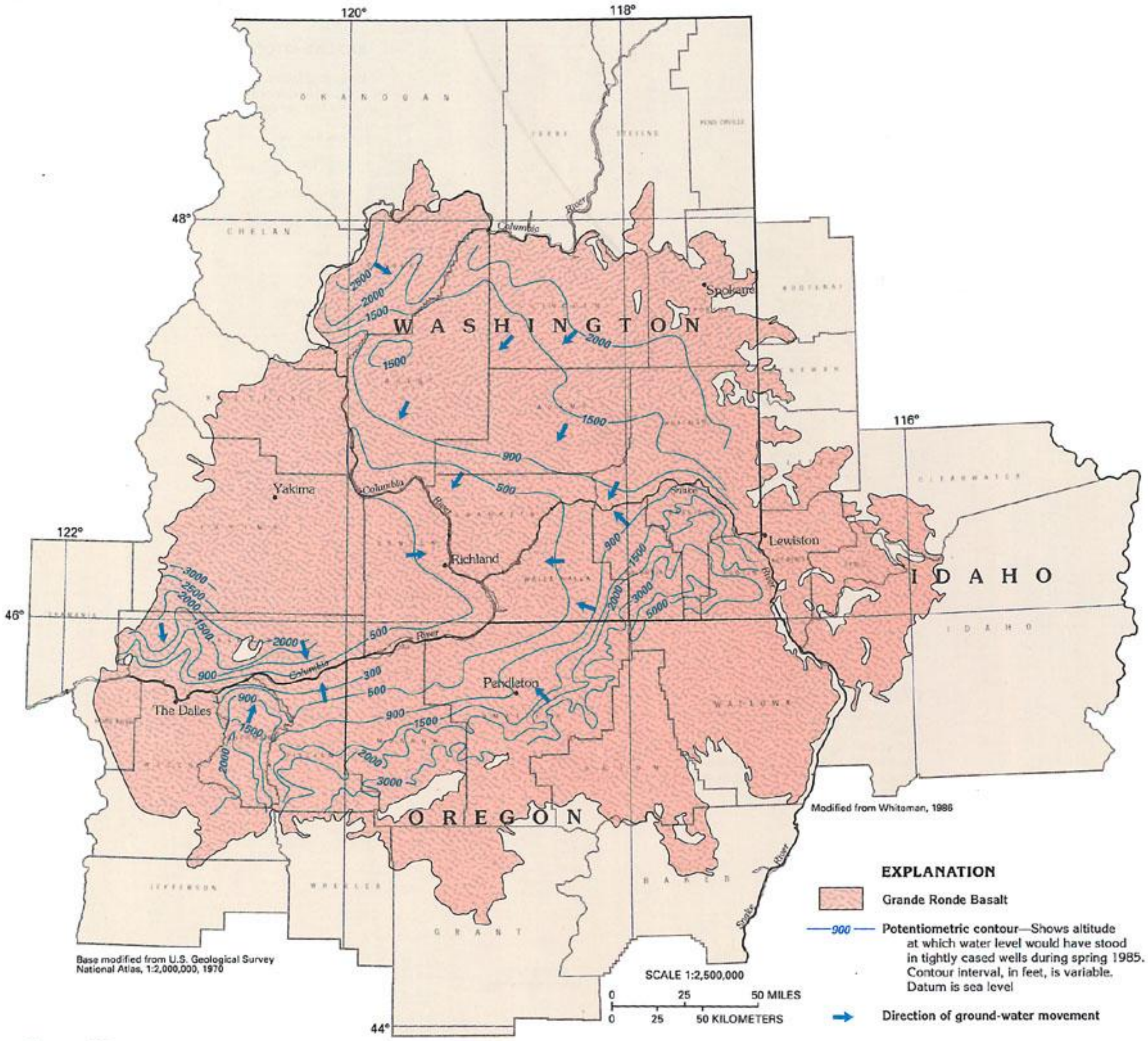
Landscape Constraints	Constraint present? (yes/no)	Tactics to address constraint	Special features of your project	How will tactics impact other functions?
Isolated from other habitats				
Poor buffers				
Site Constraints	**Constraint present? (yes/no)**	**Tactics to address constraint**	**Special features of your project**	**How will tactics impact other functions?**
Altered water regime				
Invasive or cultivated plant species				
Lack of habitat structure				

Chart 11 Worksheet: Goal - Improving Species Richness of Plants in Zones 1-3 (does not apply to alkali systems)

Landscape Constraints	Constraint present? (yes/no)	Tactics to address constraint	Special features of your project	How will tactics impact other functions?
High nutrient inputs from watershed or groundwater				
Septic systems				
Site Constraints	**Constraint present? (yes/no)**	**Tactics to address constraint**	**Special features of your project**	**How will tactics impact other functions?**
High nutrients on site				
Invasive or cultivated plant species				
Lack of seed sources nearby				

Appendix C

Maps of the three basalt aquifers on the Columbia Plateau and the direction of groundwater flows



Modified from Whitoman, 1986

Base modified from U.S. Geological Survey National Atlas, 1:2,000,000, 1970

Figure 79. *Potentiometric contours show that the general direction of water movement in the Grande Ronde Basalt is from recharge areas near the boundary of the Columbia Plateau regional aquifer system toward the Snake and Columbia Rivers.*

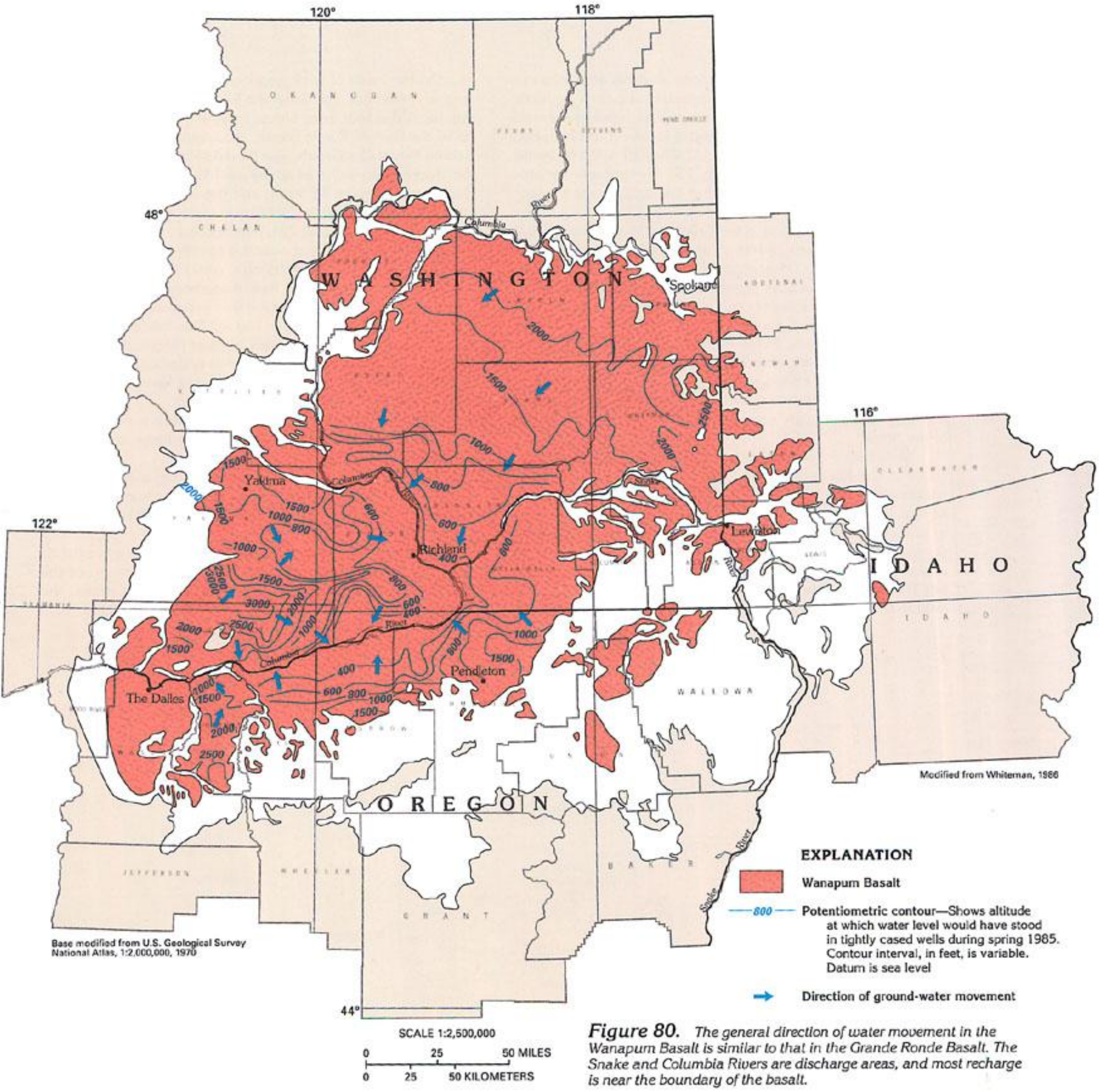
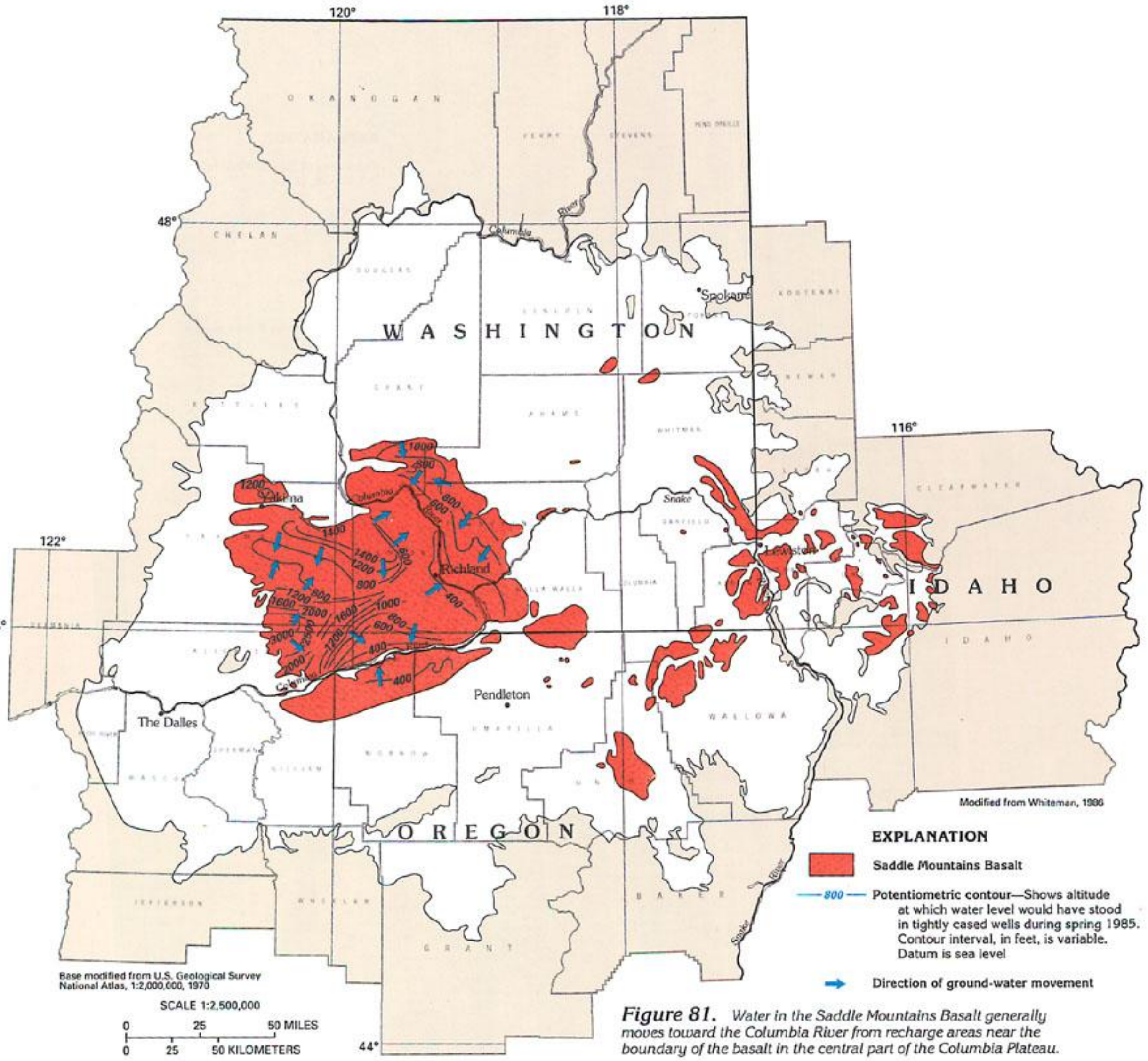


Figure 80. The general direction of water movement in the Wanapum Basalt is similar to that in the Grande Ronde Basalt. The Snake and Columbia Rivers are discharge areas, and most recharge is near the boundary of the basalt.



Modified from Whiteman, 1986

Base modified from U.S. Geological Survey National Atlas, 1:2,000,000, 1970

Figure 81. *Water in the Saddle Mountains Basalt generally moves toward the Columbia River from recharge areas near the boundary of the basalt in the central part of the Columbia Plateau.*