Road Impounded Wetlands

Planning Guidance
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Road impounded wetlands are the result of undersized or perched culverts in combination with impermeable road fills that create wetland conditions in the upstream impoundment. Often these same culverts block fish and wildlife passage up and down the stream course and interrupt natural channel processes.

State law requires that road owners provide fish passage at road crossings. There are basically two alternatives to address this situation. One, lower and enlarge the culvert to create passage and encourage the continuity of stream processes (e.g., sediment and debris transport). This alternative removes the control that created the wetland and causes it to return to a stream.

The other alternative is to construct hydraulic control using artificial structures that provide fish passage and maintain either all or part of the wetland. This can be expensive, not always possible, and often not in keeping with naturally sustainable stream processes.

In spite of state law requiring fish passage in streams affected by road crossings, state and federal policies also call for a no net loss of wetland. This document is intended to help biologists, landowners and designers evaluate road crossings with wetlands impounded above them so that they may intelligently and legally choose between the two alternatives discussed above. This guidance was completed in cooperation with various concerned groups, including state and federal regulatory agencies and a number of prominent forest land owners. The focus here is overall ecological health and compliance with Washington State regulations, although one must pay careful attention to other relevant laws, including the Clean Water Act sec. 404 and local critical areas ordinances.

Guiding principles concerning wetlands upstream of road fills when replacing culverts.

- ❖ As a basic principle, pre-disturbance processes should be restored. Through examination of the hydrologic and biological systems, the form and function of the watercourse that approaches the unaltered condition should be identified and restored.

- ❖ At the same time, we should strive for no net loss of habitat, function, and acreage of wetlands where possible, and strive for an overall increase in the quantity and quality of wetlands when the opportunity arises.

- ❖ High value wetlands that are important features in the local or regional ecosystem should be preserved.

- ❖ Wetlands that can serve an ecological function that has been lost or significantly diminished elsewhere in the system should be preserved.

- ❖ For each instance where a road fill and the associated culvert has created or increased a wetland, the wetland's fate is a negotiated decision between the landowner, area habitat biologist and any other agency with jurisdiction.

Notes on the Principles

The paradox of the first two principles is what drives the analysis of road impounded wetlands (RIWs). This is intentional. Each principle alone would result in either removing or maintaining every wetland that occurs above a road fill. No considered decisions or negotiations would be possible.

Truly "natural" processes may be long gone in a watershed and impossible to restore. "Naturally sustainable" conditions should be an alternative in those cases.

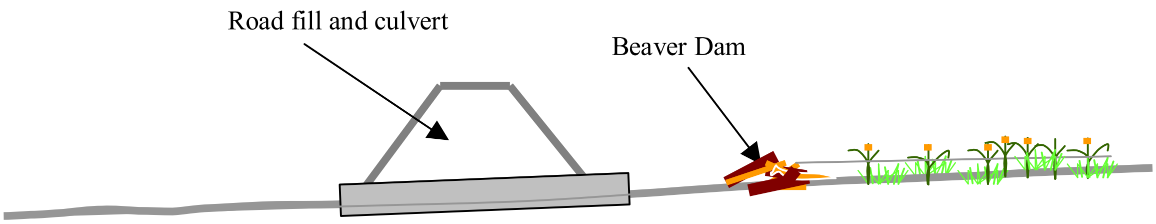
Significant RIWs warrant the attention of a wetland specialist and geomorphologist in the evaluation and decision-making process. These evaluations and decisions should be documented. The remainder of the document outlines considerations and procedures for this evaluation.

Road Impounded Wetland Scenarios

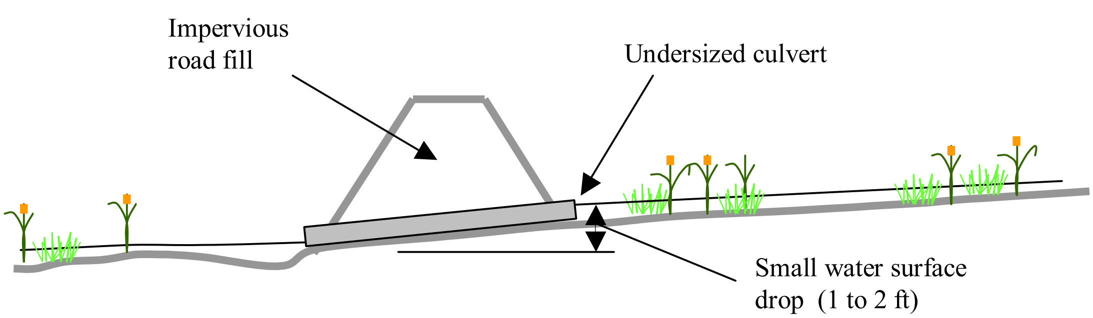
Three types of wetland-generating crossings have been observed in the field and serve to simplify our approach to solving the situation.

1. **Independent:** The wetland is generated by a structure that may once have been associated with the crossing but is now independent of it. Two instances are immediately obvious: a beaver dam that appears above the culvert, or a debris flow that terminated at the road fill. The actual drop occurs upstream of the

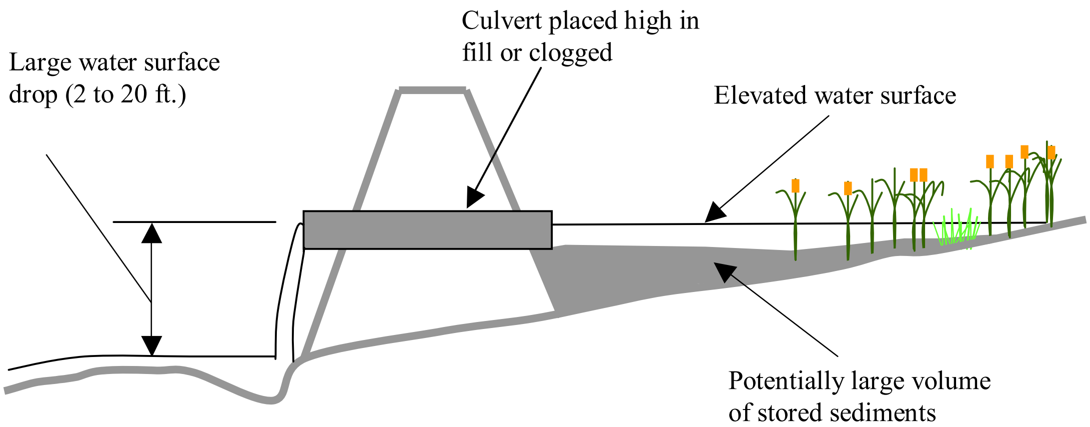
culvert and would maintain the wetland regardless of the hydraulic control offered by the crossing structure



2. **Continuous:** The road fill was originally placed over an existing wetland or low-gradient stream reach. The hydraulic control created by the culvert and road fill increase the water surface elevation above the original condition. This may result in a change in character of the wetland from downstream to upstream of the road, such as from marsh to open water habitat. Alternatively, it may change a low gradient, free-flowing stream into a backwatered wetland. In any case, the change in character is not dramatic, and the overall drop in water surface elevation through the road fill is not great (on the order of 1 or 2 feet). Wrapped up in this scenario is the tendency to form wetland habitat in the given reach because of soil type, ground water elevation and valley slope. The road impounded wetland is less an anomaly in the continuous scenario and more easily maintained in a variety of culvert and bridge design options.



3. **Distinct:** The road fill creates a totally different type of upstream habitat, distinct from the rest of the reach. Wetlands that appear above undersized or elevated culverts on high gradient streams are of a clearly different habitat type and interfere with the continuity of stream processes. The drop in water surface is generally large -- greater than 2 feet and reaching 15 or 20 feet in some cases.



These three types of RIWs lead to different approaches to making decisions about the fate of the wetland and the type of crossing structure and hydraulic control. In the case of the independent type, the crossing itself has little to do with the wetland (although it should be constructed to accommodate the movement of the debris when it fails) and removing it might not change wetland conditions.

Continuous type wetlands may be easily maintained with simple hydraulic controls, provided that the functions and values found in the created wetland are consistent with overall stream health. It should be noted that such control creates a sediment and debris trap that will change the trajectory of the RIW. Consideration should also be given to the role of disturbance regime in healthy, productive habitat when permanent structures are proposed. Mitigation may be necessary in cases were loss in productivity is clearly identifiable.

Distinct RIWs are much more difficult to address. To maintain them would require complex and expensive fish passage structures that interfere with stream continuity, including non-target fish passage and the movement of sediment and debris. On the other hand, the habitat may be so unique that heroic efforts to preserve it are justified. The accumulated sediment upstream may have a harmful and prolonged impact on the downstream habitat if the control is removed.

The role of beavers in all three of these types cannot be overemphasized. In some regions beavers are present at every road crossing, tirelessly creating wetlands. When beavers are included in the solution to a road impounded wetland problem, the final design may be very different than if they were absent. By relying on the activity of beavers, we can lower and enlarge a culvert and, without adding artificial grade control, still count on wetland formation. This may not be immediate, but likely in the long run.

Sediment Concerns

Road fills and undersized culverts decrease the capacity of the upstream reach to transport sediment and debris. This material then accumulates in the backwatered area and may even extend further upstream. If the culvert is lowered and/or increased in size, this material will be released as a channel cuts down through it and widens out into an equilibrium configuration. This is the same sequence of events associated with channel incision.

The volume of material liberated from this process may be large and have lasting effects on the downstream channel habitat. Sediment may also be transported at low flow and adversely affect organisms that need clear water conditions, rather than just at storm flow when all streams have a high level of sediment transport. The sediment above these culverts may have to be removed during construction of the new crossing to prevent downstream impacts.

Evaluation Process

Road impounded wetlands may be placed in two categories. Some clearly serve important functions, while others provide marginal functions. In order to simplify the evaluation process, it is reasonable to have two levels of analysis, one for each of these categories. The first establishes a threshold of concern, and the second weighs important stream and wetland functions. Examples of important wetland functions might be habitat for special species or maintenance of base flow conditions in the downstream channel.

WDFW Priority Habitat and Species maps, the WDFW Wildlife Heritage Database, DNR Natural Heritage Program, and the Washington State Wetlands Rating System (Ecology) are important references in this and subsequent sections.

Threshold of concern

The following criteria will help to distinguish between important RIWs that require careful analysis from those that can be easily evaluated on site.

1. If high quality wetlands are abundant nearby in the watershed, the RIW may best be restored to a pre-disturbance condition, especially if stream processes have been impaired and affect overall stream health. Expert opinion should be employed at this stage in the evaluation.

2. If special species are at stake in the road-impounded wetland, it should have a full evaluation. Special species are indicators of management concerns in a given wetland, and their presence in the RIW elevates its status. The following are species of concern to the agency and/or WDFW staff with species expertise:
    a. Western and Woodhouse's toads (*Bufo boreas* and *B. woodhousei*)
    b. Oregon spotted frog (*Rana pretiosa*) (require large area wetland)
    c. Columbia spotted frog (*Rana luteiventris*) (do not require large area wetland)
    d. Cascade frog (*Rana cascadae*)
    e. Olympic mudminnows (*Novumbra hubbsi*)
    f. Cavity-nesting ducks (wood duck [*Aix sponsa*], Barrow's goldeneye [*Bucephala islandica*], common goldeneye [*Bucephala clangula*],

bufflehead [*Bucephala albeola*], hooded merganser [*Lophodytes cucullatus*])

3. Overall stream health may be improved by returning low quality RIWs to free-flowing streams. Indicators of low quality include:
    a. Low plant diversity. Low quality RIWs have limited plant diversity and often an unequal abundance among the species present.
    b. Presence of exotic species. Species such as bullfrogs, warm water fish, purple loosestrife and reed canary grass may dominate, thereby suppressing native species and diversity.
    c. A completely closed tree canopy. The lack of insolation retards wetland development and limits RIW quality.

Full Evaluation

The following outlines a process to evaluate the habitat functions and values at a given site and determine their contribution to overall stream health. The ecological issues are then weighed against the physical constraints of the road crossing and the desires of the landowner. Ultimately, one must document and justify a decision on a given course of action at an RIW site.

The in-depth evaluation process begins by examining the stream system at the appropriate scale (watershed, subbasin, stream). Scale can be determined by any number of criteria. For instance, an RIW that is home to a sensitive species should be examined at a larger scale to determine if it is unique habitat, if it is the only habitat available in the watershed, or if it is widely available and already colonized by the sensitive species.

1) Determine the extent of alteration of "natural" processes at the site. How far has the system departed from unaltered conditions, and what can we now expect from it in terms of habitat and health? Important parameters include:
    a. Stream and valley gradient and the channel type, particularly whether the natural channel has a flood plain. Steep valley gradients with confined channels are unlikely to have fostered riverine wetlands, while low-gradient, unconfined channels are more likely to have wetlands, including wetlands that could be maintained with simple hydraulic control.
    b. Base flow conditions and the RIW's role in their maintenance. If a stream has chronic low flow problems, removing a RIW will likely exacerbate them. If, on the other hand, the stream has good summer flow, then draining a small RIW will have little effect.
    c. Presence of existing wetlands or the tendency to form wetlands in the reach.
    d. Size and elevation of culvert relative to the stream and the water surface drop through road fill. The profile of the stream through the culvert determines the RIW scenario (outlined above) and the range of practical solutions.

e. Time since impoundment. The alteration of the stream channel and the development of the wetland are both time-dependent. Short time frames lead to simpler solutions with less impact. Old RIWs have had a chance to develop complex, well-entrenched structure that may be difficult to revert back to free-flowing stream.
f. Volume and composition of sediment wedge, especially in the area that would potentially be regraded to form a natural channel with a flood plain. Large upstream deposits make restoration costly, either in their removal or the impacts to downstream habitat and water quality.
g. Beaver activity -- past, current and expected. Beavers build wetlands, and their presence may simplify restoration efforts.
h. Wetland type and serial stage. The type and age of a wetland must be known to determine what is being maintained or lost and to determine the trajectory of any design option.

2) List stream and wetland functions present, lost, and/or gained in maintaining the RIW (including the fish passage structure and artificial grade control) as well as in restoring historical processes. Below is a general list of paired functions for evaluation purposes. Note that these functions will vary with wetland and stream channel type under consideration.

RIW Functions and Values	Stream Functions and Values
Wetland temperature regime	Stream temperature regime
Water quality improvement	Pollutant transport downstream
Nutrient storage and transformation	Nutrient leakage
Sediment storage	Sediment transport
Large woody debris storage	Large woody debris transport
Stillwater fish, amphibian and reptile habitat (species and life stage)	Flowing water fish, amphibian and reptile habitat (species and life stage)
Wetland plant habitat	Riparian plant habitat
Wetland invertebrate habitat	Stream invertebrate habitat
Flood storage (size dependant)	Flood wave transported
Waterfowl habitat	
Groundwater recharge	Hyporheic flow
Base flow storage	No base flow storage
Anaerobic soil conditions	Aerobic soil conditions in riparian
Fine soil texture and associated habitat	Coarse soil texture and associated habitat

3) Inventory wetlands to determine losses associated with the RIW in question and prioritize wetland value within the watershed. The object of this exercise is to get a sense of how important this RIW is in the immediate landscape and the relative importance of the functions it provides. This information is necessary to determine if the third and fourth guiding principles apply or not. A suggested reference is the Wetland Rating System (Department of Ecology, publication #91-58,1991 and

publication #93-74,1993). The level of detail here may range from expert opinion to a thorough watershed-scale inventory and assessment. Large blocks of land with multiple crossings involving impounded wetlands would lead to extensive inventories. Small landowners with only one crossing might employ the expert opinion method. There is no specific percentage of total wetlands in a watershed removed through the replacement of culverts that is considered critical for ecological integrity. The purpose of this step is to provide a watershed context, and no target value is implied.

The RIW can then be evaluated using the guiding principles:

4) Weigh the habit functions and values determined in the steps above. If overall stream health and the greatest benefit to fish and wildlife lies with maintaining the RIW, then preliminary designs should seek to maintain it. If the greatest benefits lie with a return to natural stream processes, then design and permitting should proceed in that direction.

5) Examine the design alternatives available given the site restraints and intended use.

6) Take into consideration the social and economic impacts of each design alternative.

7) Negotiate a design alternative that maintains or improves the overall stream health of the watercourse and that meets the needs of the landowner.

Design Alternatives

These are some alternatives that should be considered at each site. This is not a complete list, so new and creative designs are encouraged.

1. **Status Quo:** do not modify the crossing at this time.

2. **Regrade**: remove hydraulic control, drain RIW and return to a free-flowing stream.

3. **Streambed controls**: step up channel to maintain existing RIW water surface elevation.

4. **Fishway**: construct a formal facility to pass fish upstream and maintain RIW.

5. **Roughened channel**: increase downstream channel slope to maintain RIW.

6. **Bypass channel**: lengthen channel reach on a different alignment to maintain RIW.

Fish-related RIW Considerations

Draining a road-impounded wetland is not likely to significantly affect fish in the former wetland because these fish were present before the road fill and culvert were installed and they survived under those natural conditions. Abundance and survival strategies may change as competition and predation are reintroduced with fish passage and a return to natural processes, but the population should survive.

There could be exceptions to this if species of concern are involved. A notable example is mudminnows, which cannot survive in the free-flowing stream environment. How mudminnows came to be present in an RIW may be lost in a complex stream history. Their unique habitat should not be lost by the removal of a road-associated hydraulic control.

Providing fish passage into an RIW that is to be maintained as a wetland is not likely to significantly affect resident populations. Once again, abundance and survival strategies may change as competition and predation are reintroduced with fish passage and a return to natural processes, but the population should survive.

Again, there may be exceptions to this if species of concern are involved. Examples might include pure strains of westslope cutthroat or red band trout in specific Eastern Washington geographic regions that could be impacted by interbreeding with hatchery strains and competition. However, these examples are more likely to occur by opening up passage to upstream flowing reaches rather than road impounded wetlands. If providing natural connectivity (and restoring natural stream processes) poses a potential risk to a species of concern, fishery managers should develop alternatives to the use of permanent man-made barriers.

It is worthwhile to electroshock road impounded wetlands in order to give an indication of fish species present. However, because of the complex cover, sediment, and deeper areas of water, electroshocking does not provide a very high sampling efficiency and should not be used to rule out presence of other species that are not detected. Minnow traps may also provide some indication of species present. (Electroshocking in waters with ESA-listed stocks may drive a project into formal consultation with federal Services.)

Sampling the downstream plunge pool also gives an indication of what species could be present in the RIW, but their presence does not necessarily mean that they will utilize the upstream reach once fish passage is restored.

The number and kinds of fish species potentially utilizing the RIW will depend on various factors such as summer low flows, summer maximum temperatures, etc. The RIW may or may not provide good summer rearing habitat, but it may provide important winter habitat. Therefore, summer conditions without passage may preclude the existence of resident populations; however, with passage, certain species may utilize the habitat when seasons and conditions are favorable.

One of the more difficult issues relating to this issue is: Should it be our priority to restore natural stream processes and accept whatever species adaptations occur as a result of restoration to those natural processes? This might even mean significant changes in some populations. Or should we try to take charge of those natural processes so that we can try to control the outcome (e.g., isolate species of concern, mitigate for lost wetlands in other places, etc.)?

RIWs as Dams

In many ways RIWs are similar to dams and we can follow the lead of research on the impacts of such structures. Road impounded wetlands covered by this process are on small, low order streams either in headwaters or direct tributaries to larger rivers. Large river issues (such as flood pulse effects on flood plains or islands) don't necessarily apply. Some of the important areas of concern are:

- ❖ Size ratio of particulate **organic matter**. Transport of larger debris (consider leaf-sized pieces as opposed to small particles) blocked by the road and/or culvert may change invertebrate feeding groups, particularly downstream.
- ❖ The effects of impoundment on the **sediment quantity and size distribution** behind the impoundment and in the downstream reach. Effects of sediment deposition could be significant in the remaining length of the tributary.
- ❖ Effects on the maximum and daily range of stream **temperature**. Effects may be less important in forested situations but more important in open water systems with minimal ground water input.
- ❖ Effects on **discharge patterns**. Moderated flow fluctuations and a muted flood wave that reduces sediment and debris transport may be issues.
- ❖ Regulation of the headwaters will suppress the **biotic diversity** in the receiving stream, primarily because of the disruption of detrital transport and the spiraling of nutrients and organic matter.
- ❖ **Nutrient levels** will increase downstream of headwater impoundments, but decrease downstream of middle-order stream impoundments.

RIWs as Reservoirs

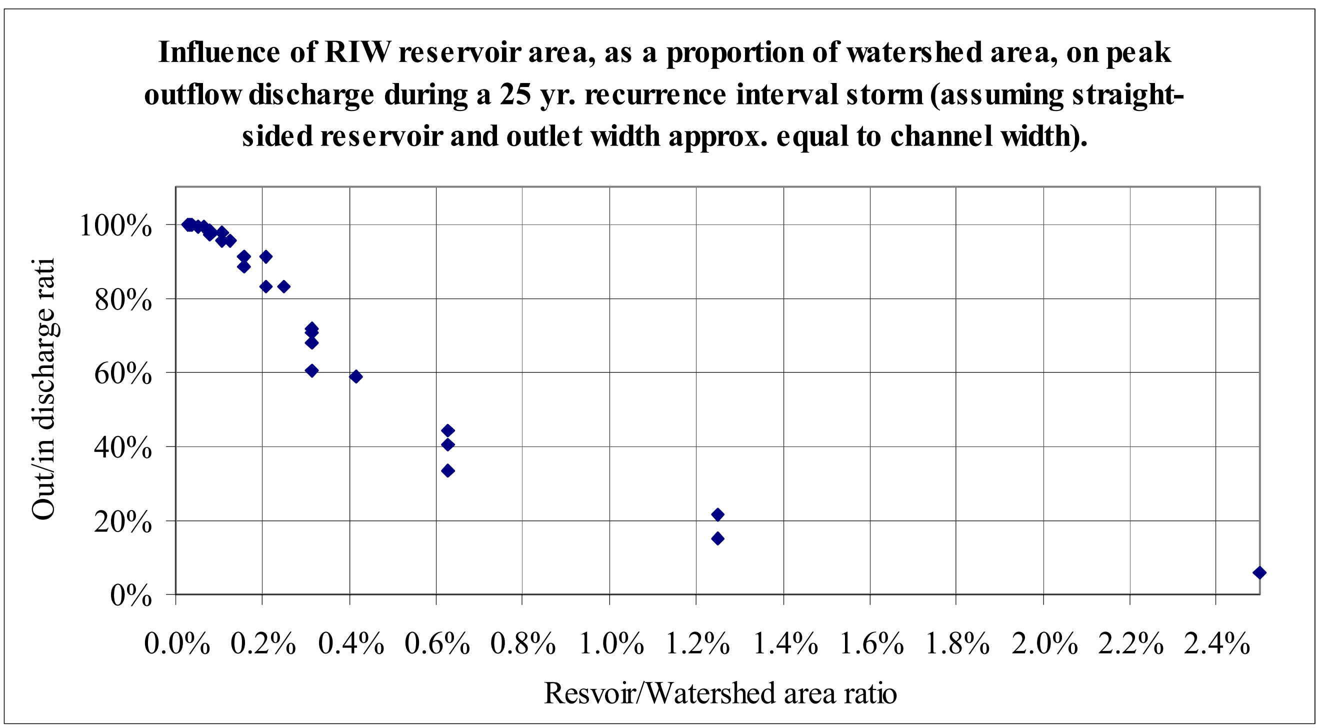
The existence of a road impounded reservoir indicates some level of hydraulic control on stream flow. The degree to which the road fill and culvert influence important stream functions is difficult to determine without detailed analysis and modeling. This section of the guidance looks at a method to help decide when analysis is necessary.

RIWs act as detention basins that reduce and delay flood peaks. This may be a benefit to downstream property owners, but it is at the detriment to the natural channel. The following is a short list of stream functions affected by RIWs:

- ❖ Reduction in habitat-forming processes such as channel scour and pool formation.
- ❖ Limited wood and gravel recruitment because of reduced erosion.
- ❖ Reduced extent and/or frequency of flood plain inundation.

Basic principles indicate that the combination of a steep-sided or urbanized watershed (with a short time-to-peak flow) with a large RIW area and a small outlet structure (culvert) leads to a significantly reduced and delayed flood peak. Conversely, a low gradient landscape with a high percentage of wetlands with a small RIW area and a large outlet structure may lead to no change in outlet discharge.

In order to determine when to expect significant effects, I modeled various watershed sizes and RIW areas and computed the effect on the downstream discharge peak flow. A number of assumptions were made in order to simplify the analysis. The watersheds were on the west side of the Cascades, but not in coastal areas (USGS region 2). A 25-year recurrence interval storm was chosen since it is relatively common and likely to scour the channel. The RIW reservoir was modeled as a straight-sided cylinder, which is not at all like a natural valley that gets wider as it gets deeper. The outlet of the reservoir was assumed to be a weir that is as wide as a channel that would be expected in the watershed area modeled. Rainfall was assumed to be 50 inches a year. The chart below shows the results of 21 independent simulations.



The general observation is that RIWs that impound wetlands less than about 0.2% of the area of the watershed are not likely to significantly affect the downstream flood peak flow in USGS region 2. As seen from the graph, out flow peak discharge is about 90% or more of the inflow. 0.2% of a one square mile watershed is about 1¼ acre. On the other hand, RIWs with an area greater than 0.4% of the watershed may reduce peak flow by 50%.

This analysis does not address low flow. As mentioned above, wetlands recharge groundwater and store water during wet periods, releasing it during dry periods. Clearly, some RIWs influence the low flow characteristics of their streams. Unfortunately, the factors involved are subtle, complex and poorly understood and cannot be evaluated without extensive, site-specific information.