MID-SNAKE WATERSHED ADVISORY GROUP MEETING

Idaho Department of Environmental Quality
650 Addison Avenue West, Suite 110, Twin Falls, Idaho

Tuesday, July 11, 2017
Time: 2:00 p.m.

AGENDA:

I. Welcome and Introductions 2:00
Mike Trabert, WAG Chairman

II. Business 2:05
Mike Trabert, WAG Chairman

1. Review of minutes for last two WAG meetings (still being compiled by DEQ)
2. WAG letter to DEQ about TMDL revision
3. WAG letter to Upper Snake BAG on accepting Dan Suhr representing Middle Snake Water Resources Commission
4. Letters from Water Resource Commission to DEQ and EPA
5. Follow up on DEQ's position on TMDL revision

III. A Discussion about Nuisance Aquatic Plant Growth 2:25
Sonny Buhidar, DEQ

1. Video: "Action on the River"
2. A Manager's Definition of Aquatic Plant Control (M.D. Netherland & J.D. Schardt)
3. Defining nuisance - Chlorophyll-a as an indicator of nuisance

IV. Exploring the Extent of Opening the TMDL as Components to Review.............. 2:55
Sonny Buhidar, DEQ

1. Flow and seasonality
2. TP as a limiting nutrient
3. TSS values are < 25 mg/L except during high stormwater events & spring flush. Should delisting be considered?
4. E. coli values are < 125 cfu/100 mL (geometric mean) except during high stormwater events & spring flush. Should delisting be considered?
5. Other parameters & issues

V. Exploring the Scope of the Flow Data.. 3:15
Sonny Buhidar, DEQ

1. IPC – Exploring the low flow scenario
2. USGS – Staff assigned to assist DEQ with flow

3. Tributary flow information
4. Spring flows & eastern Snake River aquifer discharge into mid Snake River

VI. Version 14 Database 3:40
Sonny Buhidar, DEQ

1. Point sources
2. Nonpoint sources
3. BLM & USFS
4. IDL – state lands
5. ISWCC – private lands

VII. Adjourn 4:00
Mike Trabert, WAG Chairman

Next Meeting: August 08, 2017

II. Business

MIDDLE SNAKE RIVER WATERSHED ADVISORY GROUP

May 19, 2017

Mr. David Anderson
Regional Administrator
Department of Environmental Quality
650 Addison Avenue West, Suite 110
Twin Falls, ID 83301

RE: WAG recommends reopening the Mid-Snake/Upper Rock TMDL

Dear Mr. Anderson:

On April 11, 2017, the US Environmental Protection Agency (EPA) presented the Mid-Snake Watershed Advisory Group (WAG) with two options: either all point-source discharges operating with an National Pollutant Discharge Elimination System (NPDES) permit in the watershed would be limited to a gross, end-of-pipe discharge limit of 0.075 mg/L total phosphorous (TP) or re-open the Total Maximum Daily Load (TMDL) for the purpose of revising estimates of the TP assimilative capacity of the Mid-Snake River based on more recent water flow estimates. EPA stated that in revising assimilative capacity estimates, waste load and load allocations would likely require revision. EPA did encourage the WAG to re-open the TMDL because there would likely be greater flexibility in how water quality targets could be achieved.

On May 2, 2017, the WAG convened to discuss the two options and current condition of the Mid-Snake River. There was very good representation of Mid-Snake WAG stakeholders. After considerable discussion, it was unanimously agreed that the WAG recommend to the Department of Environmental Quality (DEQ), that the TMDL should be re-opened to address concerns about water flow, any needed changes in waste load and load allocations, and to address additional mechanisms needed to improve water quality.

The next meeting of the WAG is scheduled for June 13, 2017 at 2pm.

Sincerely,

Mike Trabert
WAG Chairman

cc: Mid-Snake WAG
Dr. Balthasar Buhidar

MIDDLE SNAKE RIVER WATERSHED ADVISORY GROUP

June 5, 2017

Matt Woodard, Chairman
Upper Snake Basin Advisory Group
151 North Ridge Avenue, Suite 120
Idaho Falls, ID 83402

RE: Recommendation for membership on the Mid-Snake Watershed Advisory Group

Dear Mr. Woodard:

The Mid-Snake Watershed Advisory Group (WAG) has accepted and recommends the following individual to become an appointed member of the Mid-Snake WAG representing the Middle Snake Regional Water Resource Commission.

> Dan Suhr, Associate Broker, CRB, GRI
> 500 South 167 West
> Jerome, Idaho 83338

The Mid-Snake WAG believes this individual will provide valuable information and insight to the WAG and DEQ in accordance with Idaho state water quality law.

Please consider our recommendation for membership to the Mid-Snake WAG.

Sincerely,

Mike Trabert
WAG Chairman

cc: Dr. Balthasar Buhidar

MIDDLE SNAKE REGIONAL WATER RESOURCE COMMISSION

Lew Pence, Chairman (pence5302@msn.com)
Bob Muffley, Executive Director
122 5th Ave. W
Gooding, Idaho 83330
PH: 208-934-4781 Fax: 208-934-5648

June 1, 2017

Barry Burnell
Water Quality Division Administrator
1410 N Hilton
Boise, ID 83706

Dear Mr. Burnell:

The Middle Snake Regional Water Resource Commission, representing the counties of Cassia, Gooding, Jerome, Lincoln and Twin Falls, following the lead of the Mid-Snake WAG, ask that DEQ reopen the Total Maximum Daily Load limits (TMDL) on the Middle Snake.

We believe the EPA has crossed the line with threats made to permit holders in the region and thus, made this a political matter. We also believe, however, the best way for our counties to exert influence is through the TMDL revision process. The predecessor to our commission was the Middle Snake Study Group. The study group was formed in 1989 and represented the counties of Gooding, Jerome, Lincoln and Twin Falls. It was this study group, made up of county commissioners and their appointees, that used its political influence with an Idaho congressman and others to get the EPA to look at this section of the river in the first place. The EPA, at the time, had little or no interest in the condition of the Middle Snake. It was also members of this group who furnished a boat so the EPA could take their original samples. This action led to the cooperative development of the original TMDL by the EPA, DEQ and the public.

Several of the original members of the Middle Snake Study Group are still serving with this commission and can attest to the betterment of the river since a TMDL was first established. These improvements can be attributed to the actions of both point and nonpoint source contributors in the region. While we concur with DEQ and the Mid-Snake WAG that the current TMDL is working, we also believe, in the short term, it may be in the best interest of the region to reopen the TMDL. The threat by the EPA to unilaterally adopt extreme measures on permit holders, while out of line, seems very real. Be assured we will use whatever political means available to this commission to ensure a cooperative spirit by the EPA during this process.

Sincerely

Lew Pence

Lew Pence, Chairman

STATE OF IDAHO
DEPARTMENT OF
ENVIRONMENTAL QUALITY

1410 North Hilton • Boise, Idaho 83706 • (208) 373-0502
www.deq.idaho.gov

June 9, 2017

Lew Pence, Chairman
Middle Snake Regional Water Resource Commission
122 5th Ave. W.
Gooding, ID 83330

RE: Your letter of June 1, 2017 asking that DEQ reopen the Middle Snake TMDL

Dear Mr. Pence,

We are aware of and appreciate the Middle Snake Regional Water Resource Commission's and its member's long-standing involvement in water quality protection in the Magic Valley. While we share your reaction to EPA's heavy-handed approach, we also share your belief that it is in our mutual best interest to engage in the TMDL revision process and craft a better TMDL.

For this reason, DEQ thanks you for your support in reopening the Middle Snake TMDL for total phosphorus loading to address recent concerns raised by EPA. We look forward to your help in this endeavor.

Sincerely,

Barry N. Burnell

Barry N. Burnell
Water Quality Program Administrator

BNB:DAE:lf

c: Sonny Buhidar, Water Quality Scientist, Twin Falls Regional Office
TRIM file: 2017AKV50

MIDDLE SNAKE REGIONAL WATER RESOURCE COMMISSION

Lew Pence, Chairman (pence5302@msn.com)
Bob Muffley, Executive Director
122 5th Ave. W
Gooding, Idaho 83330
PH: 208-934-4781 Fax: 208-934-5648

June 22, 2017

Christine Psyk
Acting Director - Office of Water & Watersheds
USEPA Region 10
1200 6th Avenue
Mail code WW-192
Seattle, WA 98101

Dear Ms. Psyk:

The Middle Snake Regional Water Resource Commission represents the county commissioners of Cassia, Gooding, Jerome, Lincoln and Twin Falls in south-central Idaho. All except Lincoln County border the Middle Snake River. Reluctantly this commission followed the lead of the Mid-Snake WAG and sent a request to the Idaho Department of Environmental Quality asking that the current TMDL be reopened. I say reluctantly because we believe the current TMDL is working well given the hydrologic profile of the river.

I believe a little history into the establishment of the TMDL for the Mid-Snake is important to all parties. The predecessor to this commission was the Middle Snake Study Group. The study group was formed in 1989 and represented the counties of Gooding, Jerome, Lincoln and Twin Falls. It was this group, made up of county commissioners and their appointees, who recognized that 80 years of hard use had put this section of the Snake River at risk. This recognition didn't come because of any effort by the EPA. As a matter of fact, the study group had to use its political influence with Idaho congressmen and others to get the EPA to look at this section of the river in the first place. The EPA, at this time, had little or no interest in the condition of the Middle Snake. It was also members of the study group who furnished the boat and guides so the EPA could take their original samples. This action by the study group led to the cooperative development of the original TMDL by the EPA, DEQ, WAG, county commissioner and the public.

Between 1989 and 1992, developers were proposing hydroelectric facilities on the five remaining rapids in this section of the river. A hydrologist from CH2M Hill, out of Boise, was hired by a developer proposing to build such facility at Boulder Rapids. The hydrologist, however, gave an oral report to the study group describing how the rapids helped clean this section of the river and said that, if the remaining rapids were developed, the river would be a swamp within 20 years.

He also told us that this part of the river is no longer free flowing through much of the year, because of storage facilities in the upper Snake and the fact that nearly all water in the river stops at Milner dam. He concluded that sediments already deposited, over the many years of hard use, would remain in the Mid-Snake for many years to come. The Federal Energy Regulatory Commission (FERC), at the time, held a public hearing for another proposed hydroelectric facility at Star Falls on the Mid-Snake. The study group, commissioners and many members of the public filled the hearing room, speaking against the development of the falls, and FERC agreed. Their ruling essentially killed the other proposed developments and 27 years later, the Middle Snake is far from being a swamp.

The counties also developed a water quality plan, now incorporated in the Coordinated Water Resource Management Plan, which was adopted by the counties in 1992 and continually updated since that time. The approved plan established this commission, whose long term goal is to improve water quality throughout the region. The commission does this by education and cooperative efforts with point and nonpoint source water users, and the public. All county zoning ordinances must also recognize the plan and use it when revising their ordinance and entertaining requests for special use permits. There is none other like our commission in Idaho and, I would venture, few in the nation.

Several of the original member of the Middle Snake Study Group are still serving as member of this commission and can attest to the continued betterment of the river since a TMDL was first established. These improvements can be attributed to the actions of both point and nonpoint source contributors in the region. You must remember there is 80 years worth of sediment build up in the river which, because of upstream developments, can't simply be washed away. Consideration must also be given to recent agreements that will result in increasing spring flows to their 1991-2001 levels. You need to see what the Middle Snake looked like in 1989 so I recomment you go into our web site www.midsnakewater.org and click on Video. The first describes the history of the region and the river as it was in 1989. The second describes the problem and actions to be taken, while the third video discusses the complexity of our region's water.

If the TMDL is opened, this commission and the counties we represent will closely follow the proceedings. We assume your agency will maintain a spirit of cooperation during the process. Be assured we are serious about protecting our water quality as well as the continued economic viability of our region.

Sincerely

Lew Pence, Chairman

Follow up on DEQ's position on TMDL revision
July 11, 2017

1. DEQ's position is to continue with the WAG recommendation to update the Mid-Snake TMDL.

2. DEQ recognizes the WAG's anxiety and appreciates the Water Resource Commission positions.

   - As such DEQ has raised these issues via direct discussions with EPA about their methodology/approach on NPDES permitting and the tactics used in the Mid-Snake Watershed.

   - The Director has voiced these concerns to the EPA Acting Regional Administrator Michele Prizada.

3. DEQ believes that the TMDL time period for flow should be updated, from the existing approved TMDL and from the EPA funded Tetra Tech report.

   - However, the IDWR $5M recharge program activities need to be accounted for in the flow analysis.

   - This year 318,000 acre feet of water has been recharged into the ESPA. This is more than any other year, with the Big Wood River at 41KAF and the Snake River below Minidoka at 138KAF and the Snake River above Minidoka at 318KAF.

4. DEQ believes that there could be seasonal allocations developed for the Mid-Snake River similar to the Lower Boise TMDL.

5. DEQ believes that the TMDL implementation actions completed should be memorialized in the TMDL revision and in relation to the associated sediment and nutrient reductions.

III. A Discussion about Nuisance Aquatic Plant Growth

Source: **http://plants.ifas.ufl.edu/manage/developing-management-plans/a-managers-definition-of-aquatic-plant-control/#APPENDIX A**

A Manager's Definition of Aquatic Plant Control

Michael D. Netherland
US Army Engineer Research and Development Center
Environmental Laboratory
Editor, Journal of Aquatic Plant Management

Jeffrey D. Schardt
Florida Fish and Wildlife Conservation Commission
Invasive Plant Management Section

At the most basic level there are three possible aquatic plant control approaches: 1) no attempt to control, 2) control efforts to eradicate a plant species, or 3) some level of intermediate control that is either incomplete or temporary.

No Attempt to Control
Despite its connotation, the "no control" option is a valid management decision whose potential outcomes must be considered by managers and explained to stakeholders. Factors that influence a manager not taking active control measures may include:

- **Plant species** – Is the plant invasive? Is it a native plant impairing water body uses or is it just unwanted by stakeholders?
- **Size of infestation** – Is this a pioneer infestation consisting of a few plants? Is it an established, but stable, population? Is it an established population or starting to approach problematic thresholds?
- **Plant location** – Is the infestation in an isolated location? Is the location conducive to spreading the pest plant by fragmentation, flow, etc. Are there important nearby water bodies that are prone to becoming infested?
- **Plant biology** – Is there a likelihood of a rapid population expansion? Would "no control" permit the plant to produce viable seed or vegetative propagules that could make later control efforts more difficult and expensive?
- **Exploitation** – Is the plant species providing an ecological service (e.g. nutrient uptake, food source for waterfowl, habitat for fisheries, etc.)
- **Managerial will** – Managers may be under pressure to not control a plant because it provides benefits (perceived or real) to a user group. Stakeholders may oppose control because they are not familiar with proposed methods.
- **Managerial experience** – Inexperienced resource managers are often uncomfortable with making aquatic plant management decisions (especially on a large-scale). Until a manager understands the issues and situation, the "no control" option may be viewed as the safest and least controversial.

The consideration of these factors and others may justify a "no control" decision. There are consequences associated with all management decisions and "no control" is not exempt. As previously addressed, plant reductions related to environmental factors could be included within the realm of the "no control" option. While environmental events such as floods, droughts, freezes, or severe algae blooms can be quite effective in controlling aquatic plants, these events are not typically predictable and they are not initiated by managers. Nonetheless, the fact that some managers tend to rely on seasonal or weather events to provide effective control suggests the term "no control" may be a misnomer in these situations.

Eradication

Much like defining control, eradication has proven to have numerous meanings to various managers, researchers, and stakeholders. In a strict sense, eradication means the complete and permanent removal of all viable propagules of a plant population. This is confounded when a population is removed and then reintroduced at a later time. Some plants may be eradicated following single management efforts (e.g. removal of water hyacinth (*Eichhornia crassipes*) plants prior to seed set) while others such as hydrilla (*Hydrilla verticillata*) may require years of intense surveillance and management. Eradication efforts are typically employed when a region, state, or watershed is threatened with a new introduction of an invasive species that has potential for significant economic or environmental impact. Based on efforts by various resource management agencies to date, aquatic plant eradication programs are characterized by:

- Sustained and multi-year efforts to insure elimination of the plant population;
- Small-scale efforts to control relatively few plants:
- Control costs on a per acre basis can be quite high;
- The overall impact of repeated control efforts on the infested water body is continually weighed against the regional threat posed by the invasive plant;
- Control efforts may eventually be reduced; however, vigilant monitoring remains a key to success.

Temporary Control

Outside the realm of eradication, all other control efforts are temporary. Temporary control is essentially an acknowledgement that one hundred percent control is either not an economically viable management objective or is not physically achievable. Temporary control is a continuum that can be represented by the short-term reduction of target plants following mechanical harvesting or spot treatments with contact herbicides, to many years of control that may result from grass carp (*Ctenopharyngodon idella*) stocking for submersed plants, or decades of suppression of alligatorweed (*Alternanthera philoxeroides*) by the alligatorweed flea beetle (*Agasicles hygrophila*). Thus, temporary control results when the aquatic plant manager has made the decision that eradication is not a viable endpoint and some level of target plant persistence is acceptable in the management strategy for a given water body.

Temporary control is achievable using a variety of methods. Managers should evaluate each proposed method and the integration of various methods in terms of meeting specific control objectives.

Maintenance Control
Maintenance control is applied on a lake-wide or regional scale over time, usually to reduce and contain invasive species. Once established, invasive aquatic plants can be extremely difficult, if not impossible, to eradicate. However, managing invasive plants at some prescribed level that does not impair the uses and functions of the water body can reduce environmental and economic impacts. As the term implies, maintenance control indicates that a conscious decision has been made to actively control an aquatic plant problem with the added understanding that a long-term commitment to management rather than eradication is the goal. Simply stated, maintenance control involves routine, recurring control efforts to suppress a problem aquatic plant population at an acceptable level.

Maintenance control encompasses a continuum of control objectives. On one extreme, the goal of maintenance control may be to reduce and sustain a plant population at the lowest feasible level that technology, finances, and conditions will allow. This strategy has proven effective in managing established populations of highly invasive aquatic plants. By managing water hyacinth at low levels through frequent small-scale control operations, there is a corresponding reduction in the overall management effort, especially herbicide use and management costs. There also are environmental gains, such as reductions in sedimentation, and dissolved oxygen depressions. At the other end of the spectrum, maintenance control operations can be applied just prior to plant populations impairing the uses or functions of the water body. This strategy entails allowing plants to grow to the brink of problem levels, and therefore may be best employed in controlling slow growing or otherwise non-invasive plants.

Paradoxically, there is often more stakeholder support for crisis management (allowing plants to reach some problem or impairment level) than maintaining invasive species at low levels. This may be related to stakeholders being unaware of invasive plant growth potential. It also may be related to the public's perceptions of control methods – for example, not understanding that less herbicide may be needed to maintain plants at low levels rather than waiting for an obvious problem to develop.

While the examples of grass carp and alligatorweed flea beetle describe multi-season impacts, it must be recognized that the basis for this extended control is the continued presence of adequate populations of the management tool (i.e. the carp or the beetle). If the carp numbers are reduced below a certain threshold (by predation, sportfishing, flooding, escape from the system), the target plant will generally re-colonize the aquatic system. Likewise, a severe winter can have adverse impacts on biological control organisms, and this may allow the target plant population to grow back to nuisance levels. The principle of maintaining a continuous pressure on the target plant is an important concept that is often not discussed when describing maintenance control provided by grass carp or biocontrol organisms. Maintenance control is often used to describe only ongoing herbicide programs, yet it is the integrated use and continuous pressure provided by grass carp biocontrol organisms, and chemical control tools that best describe a maintenance control approach.

Adaptive management –
Since maintenance control represents a long-term commitment, it must also encompass a strategy known as adaptive management. Uses and functions of water bodies change through time, as do conditions within water bodies and among plant populations. Examples include target and non-target plant growth stages, water temperature, depth, clarity, and flow. All factors may change several times during the year and could require different control strategies or different expectations for control outcomes. Therefore, integrated management plans for each aquatic plant control operation must account for and adapt to these changes.

Communicating Control Expectations to User Groups
Many stakeholders view aquatic plant management endeavors as a one-time control effort with no further need for additional management. This does not reflect the reality of the discipline of aquatic plant management. The vast majority of management programs require a sustained effort over multiple years to keep unwanted vegetation under control. For example, while grass carp can provide long-term control of hydrilla, this result is due to their continuous presence and feeding on existing biomass and propagules. Carp can sustain control for many years, yet removal of the carp due to natural losses or on purpose will typically result in the recovery of the target plant. Likewise, a single treatment with fluridone herbicide may remove or reduce a target invasive plant such as Eurasian watermilfoil (*Myriophyllum spicatum*) within a system for one to several years. Upon discovery of new plants, many stakeholders are dismayed that the treatment did not eradicate the problem. In some cases these plants may have recovered from dormant seed or they may have been introduced from a nearby system that was not managed. Aside from the use of an effective classical biological control organism (highly selective) or high stocking rates of grass carp (non-selective), user groups must be informed about the importance of maintaining continuity in an aquatic plant management program. Single small-scale efforts that don't address the problem at an adequate scale often lead to claims that "we tried that and it didn't work." A lake full of hydrilla or Eurasian watermilfoil may require whole-lake management efforts. The control may last one or two seasons or even longer, but experience suggests that these invasive plants will ultimately return at some level.

One of the bigger challenges facing aquatic resource managers relates to the promotion of unproven and often costly technologies that are packaged as environmentally friendly approaches to aquatic plant management. As noted earlier, claims of a product or device providing "control" should be supported by published or ongoing research, or by another reputable resource manager who has successfully applied that technique or strategy and met similar control objectives.

APPENDIX A

Parameters that Influence Aquatic Plant Control Decisions and Outcomes

Aquatic plant management is a complex discipline that blends predictable sciences of chemistry and hydrology with variable parameters of biology and meteorology for application in venues with boundaries defined by human values and economics. Before aquatic plant control activities are initiated, one of the first and most important steps is to identify the various uses and functions of the water body. Identifying uses clarifies environmental and economic values of the water body that may be at risk. It also helps in selecting management tools and strategies that are compatible with, and will help to conserve, the various uses and functions of the water body.

After the uses and functions are identified, a management objective must be developed for the water body that considers these uses as well as concerns of the various stakeholders with interests in the water body. Management objectives are fairly straight forward for waters with relatively few uses or an emergency plant problem. Conflicts in developing objectives arise more frequently when there are many shared uses, multiple stakeholder groups, and an unclear vision if plants, that currently may be enhancing an identified use, may in time impair this or other uses. After management objectives are developed, managers must list all of the potential control tools and select the best tool or combinations that will achieve the stated objective.

There are direct and indirect environmental and economic costs associated with aquatic plant management activities. Responsible resource managers must understand these consequences and choose options that are proven effective and compatible with the current conditions at the site of interest. This information can be obtained through peer-reviewed literature, from direct experience, or through consulting with reliable sources with successful experiences controlling similar plant problems under similar conditions. Table 1 lists various parameters to consider in developing an aquatic plant control program. Many of these considerations or constraints may influence both the scope of the program and the level of control achieved. While immediate and complete removal of a plant problem may be a desired goal or outcome, in practice, the control process may take months and may be temporary in nature and consequently will need to be repeated on a routine basis. Water body and plant conditions are constantly changing as are tools available to manage plants. Rarely can one person keep track of all of these changes or become an expert in each control tool; therefore, except for the most basic control situations, aquatic plant management experts should be consulted and stakeholders informed about impending aquatic plant control operations. Paramount in this communication is conveying to the non-technical stakeholder why particular methods were chosen and what are the anticipated or expected outcomes of selected (and perhaps rejected) control options, and a receptiveness of stakeholders to respect the multiple uses and functions that may be associated with each water body and to review control tools and options based on their potential for achieving management objectives rather than from a personal preference or bias.

TABLE 1 – Parameters to Consider

Parameter	Consideration/Constraint	Influence	Plant type
Water uses and functions	**Identify uses, values or functions of each water body to determine which if any may be at risk from invasive aquatic plants or nuisance growths of native and non-native plants – control tools and management strategies must be compatible with water body uses – water uses and conditions change and must be considered during the planning for each control operation**	**The uses of each water body must be identified and prioritized in order to develop management objectives – management objectives and water uses influence the tools and strategies best suited for aquatic plant control which in turn influence the spatial extent and duration of control**	**E = emergent S = submersed F = floating Plant types are listed if their control is a primary consideration or influenced by this control consideration**
Navigation and access	river channels or boat ramps blocked, areas of lakes inaccessible	frequent inspections and rapid response are necessary to sustain commercial navigation in rivers and canals – frequent inspections and control as necessary to conserve recreational access and navigation	E, S, F
Transportation	floating plant masses jam against bridges and may cause structural damage or erosion around pilings	frequent inspections and rapid response are necessary to prevent damage associated with aquatic vegetation, especially tussocks and floating islands	E, S, F
Flood control	plant masses can block or impede water flow in river channels, canals, lake outfalls, or flood control structures	frequent inspections and control of invasive plants that may impact flood control to the lowest feasible level – control native and non-invasive plants as necessary to conserve flood control	E, S, F

Parameter	Consideration/Constraint	Influence	Plant type
Water uses and functions	**Identify uses, values or functions of each water body to determine which if any may be at risk from invasive aquatic plants or nuisance growths of native and non-native plants – control tools and management strategies must be compatible with water body uses – water uses and conditions change and must be considered during the planning for each control operation**	**The uses of each water body must be identified and prioritized in order to develop management objectives – management objectives and water uses influence the tools and strategies best suited for aquatic plant control which in turn influence the spatial extent and duration of control**	**E = emergent S = submersed F = floating Plant types are listed if their control is a primary consideration or influenced by this control consideration**
Potable water	plants clog water intakes	frequent inspections and control of plants as necessary to prevent disruption of water supply – herbicides must have potable water tolerance, set-back distance, or concentration limit	S, F
Irrigation	plants clog water intakes, impede water flow in ditches, canals, and rivers	ensure herbicides are compatible with irrigated crops, may need to treat when crops not in field, find alternate irrigation supply	E, S, F
Livestock watering	plants do not usually impact ability for watering livestock from water bodies	if herbicides used, may need to remove livestock from water body shoreline, find alternate watering source	E, S, F
Downstream uses and needs	plant masses prevent water releases for downstream uses like drinking, irrigation, wetland restoration, estuaries	control plants to provide downstream water – herbicides must be compatible with downstream uses – coordinate control with water releases – frequent releases may dilute or draw off herbicide concentrations	E, S, F

Parameter	Consideration/Constraint	Influence	Plant type
Water uses and functions	**Identify uses, values or functions of each water body to determine which if any may be at risk from invasive aquatic plants or nuisance growths of native and non-native plants – control tools and management strategies must be compatible with water body uses – water uses and conditions change and must be considered during the planning for each control operation**	**The uses of each water body must be identified and prioritized in order to develop management objectives – management objectives and water uses influence the tools and strategies best suited for aquatic plant control which in turn influence the spatial extent and duration of control**	**E = emergent S = submersed F = floating Plant types are listed if their control is a primary consideration or influenced by this control consideration**
Recreation	identify and assess recreational uses within the system	aquatic plants may enhance or hinder recreational activities within a water body that may be seasonal or year-round	
Boating	plants can restrict access and boating activities	select control methods and frequency to accommodate types and amounts of boating – inboard/outboard motor, sailing, canoe/kayak, rowing shell, etc.	E, S, F
Fishing	plants can block access to fishing areas – plants provide habitat to support fisheries and at high densities and cover can impair fish and wildlife habitat	manage invasive plants to conserve or enhance native plants – select herbicides that are compatible with fishery – try to time control to minimize impacts with bedding and increased activities like tournaments, weekends, holidays, etc.	E, S, F
Hunting	plants can block access to hunting areas – plants provide habitat and food source, especially for some waterfowl	manage invasive plants to conserve or enhance native plant habitat – plan control to minimize impacts with hunting	E, S, F
Swimming	plants can cover swimming areas, increase danger of	select control method compatible with swimming or control during low or no	E, S, F

Parameter	Consideration/Constraint	Influence	Plant type
Water uses and functions	**Identify uses, values or functions of each water body to determine which if any may be at risk from invasive aquatic plants or nuisance growths of native and non-native plants – control tools and management strategies must be compatible with water body uses – water uses and conditions change and must be considered during the planning for each control operation**	**The uses of each water body must be identified and prioritized in order to develop management objectives – management objectives and water uses influence the tools and strategies best suited for aquatic plant control which in turn influence the spatial extent and duration of control**	**E = emergent S = submersed F = floating Plant types are listed if their control is a primary consideration or influenced by this control consideration**
	entanglement and drowning	swimming periods	
Skiing	plants can impede boat operation and increase danger of entanglement and drowning	keep designated ski / boating areas free of aquatic plants	E, S, F
Wildlife viewing	plants can block access to wildlife viewing areas and view of wildlife	work with wildlife management agencies to ensure access to wildlife areas is acceptable – keep designated areas open for boat access	E, S, F
Fish and wildlife management	identify and assess wildlife uses and needs within the system – while moderate levels of plants may provide essential habitat or forage, too many plants may cover nesting, bedding and forage areas	aquatic plants and control operations may enhance or hinder wildlife management activities within a water body that may be seasonal or year round	
Endangered species, including habitat and forage/prey	plants may provide essential habitat for endangered species – conversely, plants can cover nesting, bedding and forage sites as well as impair habitat for forage animals – ex: in Florida, water hyacinth may outcompete native plants essential for Everglades Kite	understand types and seasonality of endangered species as well as forage/prey habitat requirements, select control tools and timing compatible with endangered species	E, S, F

Parameter	Consideration/Constraint	Influence	Plant type
Water uses and functions	**Identify uses, values or functions of each water body to determine which if any may be at risk from invasive aquatic plants or nuisance growths of native and non-native plants – control tools and management strategies must be compatible with water body uses – water uses and conditions change and must be considered during the planning for each control operation**	**The uses of each water body must be identified and prioritized in order to develop management objectives – management objectives and water uses influence the tools and strategies best suited for aquatic plant control which in turn influence the spatial extent and duration of control**	**E = emergent S = submersed F = floating Plant types are listed if their control is a primary consideration or influenced by this control consideration**
	nesting as well as cover their prey (apple snails) causing them to abandon nests		
Fishery	moderate levels of diverse plant communities are generally viewed as favorable for many sport fish populations – monocultures of nuisance or invasive plants can crowd out beneficial native plants, cover bedding sites, stunt or eliminate some fish populations, reduce dissolved oxygen leading to fish kills	select control methods compatible with fish management objectives for water body – ex: do not drawdown during spawn; repeated harvesting may reduce young of year sport fish, ensure herbicide is compatible with primary fish management objective, avoid formation of extensive surface mats of submersed or floating plants and large submersed plant treatments with contact-type herbicides during hot water/low oxygen periods	E, S, F
Waterfowl hunting	plant monocultures can crowd out or cover beneficial native plants	if possible, control plants well in advance of or after hunting season	E, S, F
Non-game wildlife	plant monocultures can crowd out or cover beneficial native plants or cover nesting and foraging sites	identify areas or species of concern with wildlife management agency and select control tools and timing compatible with non-game species managed in the water body	E, S, F

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Water uses and functions	**Identify uses, values or functions of each water body to determine which if any may be at risk from invasive aquatic plants or nuisance growths of native and non-native plants – control tools and management strategies must be compatible with water body uses – water uses and conditions change and must be considered during the planning for each control operation**	**The uses of each water body must be identified and prioritized in order to develop management objectives – management objectives and water uses influence the tools and strategies best suited for aquatic plant control which in turn influence the spatial extent and duration of control**	**E = emergent S = submersed F = floating Plant types are listed if their control is a primary consideration or influenced by this control consideration**
Habitat	plant monocultures can crowd out or cover beneficial native plants	control invasive or nuisance plant populations to conserve or enhance diverse beneficial native plant assemblages	E, S, F
Nesting / foraging	plant monocultures can cover fish bedding sites, interfere with rookeries, cover or exclude prey or forage animals and plants	control invasive or nuisance plant populations to conserve nesting and foraging sites, ensure control tools are compatible with important forage plants and animals	E, S, F
Vegetation planting project	invasive and nuisance plant growth can cover or crowd out newly planted vegetation	prevent invasive or nuisance plants from covering revegetation projects, select control tools and timing that are compatible with planted species	E, S, F
Mosquito control	invasive floating plants and surface mats of submersed plants are ideal mosquito breeding sites	control invasive and nuisance plant mats, especially in quiescent waters in urban areas to reduce mosquito habitat	S, F
Parameter	**Consideration/Constraint**	**Influence**	**Plant type**

Control feasibility	**various parameters influence whether or not a plant can be effectively controlled including; available tools, water body physical and chemical conditions, and plant susceptibility and growth stage**	**list and consider all control tools that have been proven successful in the water body in question or in similar waters and conditions – integrate the best tool or tools compatible with water body uses, functions, and conditions, that meet management objectives into the control program**	**E = emergent S = submersed F = floating**
Available methods	list all plant control tools that have been demonstrated effective in controlling plant(s) in question – demonstrated through documentation, contact with experienced managers that have effectively applied that control strategy	integrate tools into control plan that have been demonstrated to be effective – if tool is new, unproven, experimental, etc., approach implementation as operational research and convey to stakeholders the level of control anticipated and level of confidence in achieving control	E, S, F
Biological	usually refers to releasing an animal species including fish, arthropods, or pathogens to suppress or control target aquatic plants to some extent	effectiveness may vary from suppression to complete control so target plant susceptibility and management objectives must be clearly evaluated and conveyed to stakeholders	E, S, F
Fish – grass carp	generalist feeder that may control target and non-target plants – prefer some plant species over others – sterile, triploid chromosome variety available – mobile river fish that may need to be contained with physical or electric barrier – may control plants for up to a decade – may require permit from fish and game agency – extremely difficult to remove and determine population size in system after stocked(easier to add more if needed than to remove after stocking)	test to ensure that only sterile triploid grass carp are released – ensure target plant is susceptible to grass carp, stock at the lowest feasible level – consider controlling target plants with other methods first to reduce biomass – install containment strategy – identify non-target susceptible plants – develop integrated strategy to augment control – stock 10”-12” fish in cooler months to reduce losses from predation, heat stress, and low dissolved oxygen – stocking rate can change significantly, ex: if water levels increase or decrease after stocking or	S, F

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Water uses and functions	**Identify uses, values or functions of each water body to determine which if any may be at risk from invasive aquatic plants or nuisance growths of native and non-native plants – control tools and management strategies must be compatible with water body uses – water uses and conditions change and must be considered during the planning for each control operation**	**The uses of each water body must be identified and prioritized in order to develop management objectives – management objectives and water uses influence the tools and strategies best suited for aquatic plant control which in turn influence the spatial extent and duration of control**	**E = emergent S = submersed F = floating Plant types are listed if their control is a primary consideration or influenced by this control consideration**
		sudden natural declines in vegetation (shading, etc.) can cause "overstocked" situation	
Arthropods	most classical biological control is conducted with insects – agents must be approved by the USDA as well as state regulatory agencies prior to release to ensure host specificity – agents may reproduce in self-sustaining populations or may need additional releases to sustain sufficient levels to suppress or control plants	impacts from insects may range from no observable control to decimation of target plant depending on insect species, plant type and climate at release site – predation from native animals (birds, fish, wasps, etc.) may influence the biocontrol population size and therefore the level of stress, suppression, or control achieved	E, S, F
Pathogens	some plant pathogens, especially fungi can stress aquatic plants – commercially available pathogens(bioherbicides) are under research evaluation	naturally occurring outbreaks may increase efficacy of herbicide treatments, ex: water hyacinth control in some Florida waters	E, S, F
Chemical Herbicides	chemical herbicides must be registered for aquatic use by the USEPA and state regulatory agency – permits may be required from state or local governments before using registered herbicides	sites and maximum rates are regulated by the federal and state label – susceptible plant species and lower than maximum use rates are determined through laboratory and operational research	E, S, F

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Contact/systemic	herbicides fall into two general categories, faster acting contact type herbicides that the kill the portion of the plant to which they are applied, and slower acting systemic type herbicides that translocate within the plant killing the entire plant including the roots	faster acting or contact type herbicides may be more conducive to controlling submersed plants in flowing waters – slower systemic herbicides may be more suited to large-scale treatments to minimize oxygen consumption during plant decomposition	E, S, F
Liquid/pellet formulation	herbicide formulations fall into two basic formulations; liquid or aqueous, and solid pellets, flakes, wettable powders, or granules	liquid formulations are usually less expensive and are a better choice in waters with thick soft sediments where pellets can sink, diminishing effectiveness – pellets applied in slow flowing waters with firm substrates sustain prescribed concentrations for longer periods	E, S, F
Plant growth regulators	PGRs do not kill, but rather suppress growth of target aquatic plant	herbicides at low rates may provide some plant growth regulation – may lead to increased resistance in plants if not killed – application of this control strategy not well developed	S
Mechanical			

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Water uses and functions	**Identify uses, values or functions of each water body to determine which if any may be at risk from invasive aquatic plants or nuisance growths of native and non-native plants – control tools and management strategies must be compatible with water body uses – water uses and conditions change and must be considered during the planning for each control operation**	**The uses of each water body must be identified and prioritized in order to develop management objectives – management objectives and water uses influence the tools and strategies best suited for aquatic plant control which in turn influence the spatial extent and duration of control**	**E = emergent S = submersed F = floating Plant types are listed if their control is a primary consideration or influenced by this control consideration**
Harvester	removal of plant mass from water body – may control non-target plants and animals – various designs, sizes, and hauling capacity available – may provide immediate control of small scale plant problems	may fragment and spread target plant – must find disposal sites – removes target and non-target plants and animals – more efficient harvesters may harvest larger fish and wildlife that cannot escape path – efficiency may be increased with barges to shuttle plants to disposal site – may create turbidity in shallow waters	E, S, F
Barge mounted hoe/dragline	removal of dense mats of plants and floating islands	removes dense masses of vegetation and other material from canals and river channels as well as bridges and flood control structures – may fragment and spread target plant – must find disposal sites – may remove target and non-target plants and animals	E, S, F
Shredder	various designs are available to shred floating masses of herbaceous and woody plants and floating masses or islands of sediments	used for emergency restoration of access, navigation, or flood control attributes as well as around bridges – generates fragments that may spread invasive plants – controls all plants and animals in control area – may require additional shredding or harvesting of materials that float back to the surface – may generate	E, S, F

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		extensive turbidity – drops mater on bottom – not advisable for repeated use at boat ramps, navigation channels, residential shorelines, etc.	
Rotovator	underwater apparatus or arm extending from barge with rotating tines to tear plants from sediments	generates fragments and may spread invasive plant infestation – may need to harvest uprooted plants – disturbs sediments and may generate extensive turbidity	E, S
Cultural/Physical			
Barriers	passive devises to cover target plants, or to contain plant fragments, turbidity, herbicide-treated water – may be highly labor intensive to install/remove	may be used in small areas where other options are less practical	E, S
Benthic	fabric laid over plants on substrate – must anchor to bottom – place over live plants or control plants to substrate and place barrier to control re-growth	evaluate potential impacts to target and non-target plants and animals – may need to clean barrier to prevent plant growth on top	E, S

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Curtains	vertical barrier in the water column to minimize water exchange from one site to another – can either be manufactured curtain to prevent water exchange to contain herbicides, or a strip of plants left on the edge of harvest or shredding sites to contain fragments or turbidity	prevent or reduce herbicide dilution and turbidity in flowing or open waters	E, S
Benthic rollers	devise usually anchored to a piling or dock to roll over plants and sediments	may be effective on small scale – needs power source and frequent monitoring	E, S
Drawdown	water control structure must be available – reducing water levels to accommodate aquatic plant control must be compatible with other uses and functions of the water body – consider ability to refill water body after drawdown	drawdowns need to last for several months – must be complete to desiccate plants – best applied in winter to include impacts from freezing – compatible with prescribed fire for emergent plant control – try to avoid during fish spawn, waterfowl hunting, endangered species nesting foraging – partial drawdowns during growing season may allow invasive or nuisance submersed plants to colonize into deeper waters expanding the problem – incomplete drawdowns may allow wetland plants like cattail or willow to reach	E, S, F

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		nuisance levels	
Desiccation	extreme drawdown must be of sufficient duration to dry target plants and preferably sediments – not appropriate during wet or growing season	plants that produce underground tubers (hydrilla) or extensive seed bank (water hyacinth) are not well suited to control by drawdown – in some areas floating islands may develop upon re-flooding and may need to be controlled	E, S, F
Freezing	freezing enhances desiccation and amount of control	drawdown needs to expose sediment to reducing insulating effect from water – conversely, summer drawdowns can increase spread of invasive (torpedograss) or native plants (willow) can expand to nuisance levels	E, S, F
Prescribed fire	planned burning of emergent vegetation to reduce standing crop – burning must be compatible with surrounding land use	reduces standing crop and stimulates re-growth in some species – be prepared to follow up with other methods including herbicides upon re-flooding – may not be practical in urban areas or near high traffic highways	E

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Flooding	flush floating plants or mats of plants out of system or into uplands, – increase water level to shade and stress submersed plants	raising the water level to flush and strand floating plants or mats of plants into uplands is an option in waters with flood control structure and few to no houses or structures along shoreline – other flooding methods include lowering water levels to treat submersed plants, then re-flooding to reduce light and further stress plants – some emergent plants (torpedograss) can be controlled by dewatering, burning, and re-flooding to suppress re-growth	E, S, F
Dredge – barge mounted	large-scale dredging operation that removes rooted plants and sediments – sediments returned to water column or pumped to settling basin	may miss plants – may fragment and spread plants – may increase turbidity	S
Dredge – diver assisted	hand-held suction devise controlled by underwater diver using snorkel or SCUBA – dislodge plants by hand and place into suction lift to screen plants onshore or on attending barge	labor intensive – effective in small areas where other methods are not practical – may cause or may be impeded by siltation / turbidity	S

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Dyes	artificial dyes like natural tannins color water, reducing light penetration to control or suppress submersed plant growth	may provide submersed plant and algae suppression in small areas where water flow, volume, and exchange are low	S
Hand pulling	removing plants by hand – includes tossing rakes or hand-held cutting blades to sheer plants	immediate control – labor intensive – may be suitable for new infestations around boat ramps, docks, trash rakes at water intakes, pumps, etc. – may use rakes and cutting blades to clear small areas of plant material – creates fragments that may spread plants to other areas	E, S, F
Shearing – chains, etc.	includes any of a number of devises that are dragged through rooted stands of plants including chains pulled by hand or steel bars towed by boat or barge	labor intensive – disturbs sediments – creates fragments and turbidity – may need to clear obstructions – used in some canal systems where most plants may be considered undesirable and substrate habitat is a low concern	E, S
Waterbody parameters			
Hydrology			

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Water uses and functions	**Identify uses, values or functions of each water body to determine which if any may be at risk from invasive aquatic plants or nuisance growths of native and non-native plants – control tools and management strategies must be compatible with water body uses – water uses and conditions change and must be considered during the planning for each control operation**	**The uses of each water body must be identified and prioritized in order to develop management objectives – management objectives and water uses influence the tools and strategies best suited for aquatic plant control which in turn influence the spatial extent and duration of control**	**E = emergent S = submersed F = floating Plant types are listed if their control is a primary consideration or influenced by this control consideration**
Water depth	water depth can influence the cost and duration of control – water control structures can give the flexibility of reducing and increasing water depths to accommodate control	re-growth of submersed plants to the surface is faster in shallow waters – do control costs, methods, etc. warrant short term control? – control of submersed plants with herbicides requires treating much or all of the water column – shallow water should be less costly to treat than deep water – increasing the water depth after a submersed plant herbicide treatment reduces light penetration enhancing the amount and duration of control	E, S
Water volume	important for herbicide control since effectiveness of many herbicides is dependent upon sustaining a prescribed concentration	reducing water volumes before herbicide treatments for submersed plant control can save money and increase efficacy – increasing water volume before use of herbicides to control submersed plants can dilute concentration and reduce or negate control efficacy	S
Water flow	static vs. moving water can play an important role in selecting control methods	important in determining pelletized vs. liquid formulation herbicides – dilution from flow may be too great to apply herbicides, especially slow acting systemic compounds – flow	E, S, F

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		may dictate urgency of control, ex: to keep floating plants from clogging flood control structures or jamming against bridges – keeping flow unimpeded may impact ability to contain grass carp with conventional physical barrier	
Springs / sinkholes	related to flow	groundwater may dilute or dissipate herbicides	S
Tidal influence	tides can raise or lower water levels and volumes, can flush herbicides, and regulate plant growth	may dilute herbicide concentrations by adding water volume at high tide or flush herbicides out of treatment area as tide recedes – depending on salt content, may preclude use of some herbicides not registered for use in brackish or marine waters – may restrict access for herbicide spray boats, harvesters, barges, etc. due to low (grounding) or high (bridge clearance) water level – invasive plants may not reach problem level if salt content sufficiently high – ex: hydrilla in brackish water – may favor invasive species tolerant to low salinities – ex: Eurasian watermilfoil	S

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Water chemistry			
Dissolved oxygen	oxygen is needed to sustain aquatic life and decompose organic sediments and detritus – warmer water holds less dissolved oxygen than cooler water	check oxygen level prior to herbicide use – slow acting or systemic herbicides or treating smaller areas with contact type herbicides can reduce amount of plant decomposition and demand on oxygen to avoid stressing or killing fish – try to conduct large-scale plant management in cooler months before plants reach peak biomass (more oxygen / less decomposition)	S, F
pH, alkalinity, and hardness	these parameters may be important in determining invasiveness of plants in certain waters – ex: water hyacinth and hydrilla do not grow as well in low pH waters – pH, alkalinity, and hardness modify performance of certain herbicides	low alkalinity and pH increase copper toxicity to fish – high pH decreases efficacy of flumioxazin herbicide for submersed plant control – hard water binds with glyphosate and reduces efficacy	S
Nutrient content	nutrient content in aquatic macrophytes and in the sediments may be re-suspended in the water column after controlling aquatic plants – nutrients are released from decomposing	nutrient content may be a concern when planning large-scale management – some nutrients are released by decomposing plants – removing plants from the system to remove nutrients	S, F

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	plants and in shallow waters, sediments may be stirred by wave and water currents	may not be cost-effective since aquatic plants are mostly water – sediment nutrient re-suspension may be significant after the calming effects of plant cover is removed	
Water transparency	water transparency affects the amount of and depth to which light penetrates the water column to stimulate submersed plant growth and growth of new emergent plant shoots	generally, submersed plants grow faster in waters with higher transparency with all other factors being equal – conversely, lower transparency can retard growth of submersed plant shoots	S
Color / tannic content	highly colored or tannic water limits light penetration and can suppress submersed plant growth	submersed plant recovery after control can be retarded in highly colored or tannic waters – anticipate increased submersed plant control duration	S
Turbidity / suspended particles	turbid water limits light and suppresses submersed plant growth	submersed plant recovery after control may be retarded in highly turbid waters – suspended clays and organics can neutralize diquat and fluridone herbicides	S

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Algal type and concentration	some algal blooms can suppress submersed plant growth either through light attenuation or perhaps allelopathy with blue-green blooms	treating large areas of submersed plants during a planktonic algae bloom may perpetuate or enhance the bloom	S
Sediment characteristics			
Composition – sand, clay, organics	sediment type plays an important role in plant growth as well as control, especially chemical options	clay sediments inactivate diquat herbicide, high levels of organic sediments can adsorb fluridone herbicide	S
Sediment depth / location	check sediment type and thickness prior to herbicide treatments	thick soft sediment layers can reduce or negate pelletized herbicide formulation efficacy – harvesting in shallow waters above flocculent sediments may result in turbidity problems	S
Potential for re-suspension	extensive plant cover, especially submersed plants, can retard organic sediment decomposition or allow suspended particles to settle out of flowing water forming thick flocculent layer	diquat herbicide is inactivated by suspended clay particles – high suspended organic particle content can reduce fluridone herbicide efficacy – removing calming effect of plants (after control) may allow water flow or waves to agitate sediments, especially in shallow waters, re-	S

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		suspending sediments and associated nutrients – result may be increased turbidity or algae bloom – agitation from harvester paddle wheels can increase turbidity in shallow waters with flocculent sediments	
Plant physiology			
Plant origin/growth characteristics	problem plants in a proposed control area should be characterized as native or exotic, and if exotic, they should be characterized as either a nuisance under the conditions present in the water body, or an invasive species in that region	the invasiveness and extent of the plant in the region influences the intensity of control – ex: a newly discovered plant that may be invasive in waters across the region may trigger eradication efforts – a native plant that interferes with boat ramp access may be beneficial throughout the rest of the water body triggering only local control	E, S, F
Native plant	a plant species that evolved in the general region where it is now found	a diverse assemblage of native plants is generally viewed as favorable – native plants do not generally impair natural waters, they may present problems to various uses and functions of the water body on a local scale – problems associated with	E, S, F

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		native plants are often generated by watershed alterations including stabilized water levels and increased nutrient content – plants native to a region can cause problems in man-made waters like shallow canals or aqueducts where presence of any plant species may be considered undesirable or problematic	
Exotic / alien	a plant that has been transported to a region in which it did not evolve	exotic plants do not necessarily cause problems in the ecosystems in which they have been introduced – causes of problems may be similar to those associated with native plants and therefore may be localized	E, S, F
Invasive	a plant that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health – even if an invasive plant species does not cause problems in one waterbody, it may serve as a contamination source for adjacent waters that may be	newly discovered populations of invasive plants should be considered for eradication or containment – delays may allow spread within infested waters or to additional waters – invasive plants may not be invasive in all cases – ex: water milfoil may cause problems in clear, shallow, stabilized waters, but may not be problematic in deep or turbid lakes or reservoirs with widely fluctuating water	E, S, F

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	more conducive to invasion	levels	
Plant growth stage	plants are susceptible to various control methods based on current weather and growth conditions	most herbicides need actively growing plants to be effective – new growth is generally easier to control with herbicides than mature plants with high starch reserves and larger rhizome / root mass	E, S, F
Target plant / non-target	it is important to understand the growth stage of target plants as well as commingled non-target plants	consider controlling target plant while non-target plants are dormant or after they have produced seeds and are senescing – control target plant while infestation is still low to minimize effects on desirable comingled native plant species	E, S, F
Plant susceptibility	plants must be susceptible to control tools to avoid wasting valuable time and money	evaluate effectiveness of control tools through literature reviews or contact with managers with similar problems and conditions – plant susceptibility may change from one control event to the next related to such parameters as plant growth stage or water conditions	E, S, F

Parameter	Consideration/Constraint	Influence	Plant type
Water uses and functions	**Identify uses, values or functions of each water body to determine which if any may be at risk from invasive aquatic plants or nuisance growths of native and non-native plants – control tools and management strategies must be compatible with water body uses – water uses and conditions change and must be considered during the planning for each control operation**	**The uses of each water body must be identified and prioritized in order to develop management objectives – management objectives and water uses influence the tools and strategies best suited for aquatic plant control which in turn influence the spatial extent and duration of control**	**E = emergent S = submersed F = floating Plant types are listed if their control is a primary consideration or influenced by this control consideration**
Target plant / non-target	prior to initiating aquatic plant control in systems where a diverse native plant community is desired, it is important to identify non-target plants to develop control programs that conserve or enhance these species	impacts to non-target plants can be reduced through selection of control methods, timing of control, using lowest feasible herbicide rates, and controlling target plants, especially invasive plants, before they become widespread and require large-scale control efforts – ex: stocking sterile grass carp early after an infestation of susceptible plants or reducing plant biomass prior to stocking allows the lowest number of fish to be released lessening non-target plant control	E, S ,F
Potential for re-growth			E, S, F
Target / non-target	control operations may be expensive – evaluate the potential for re-growth for proposed control methods or strategies	consider cost-effective control measures that selectively control target plants while conserving or enhancing non-target species – evaluate cost-effectiveness of proposed control – ex: controlling a new infestation of hydrilla or Eurasian watermilfoil in two feet of water in an attempt to eradicate may be cost-effective – controlling widely dispersed and established	E, S, F

Parameter	Consideration/Constraint	Influence	Plant type
Water uses and functions	**Identify uses, values or functions of each water body to determine which if any may be at risk from invasive aquatic plants or nuisance growths of native and non-native plants – control tools and management strategies must be compatible with water body uses – water uses and conditions change and must be considered during the planning for each control operation**	**The uses of each water body must be identified and prioritized in order to develop management objectives – management objectives and water uses influence the tools and strategies best suited for aquatic plant control which in turn influence the spatial extent and duration of control**	**E = emergent S = submersed F = floating Plant types are listed if their control is a primary consideration or influenced by this control consideration**
		hydrilla or EWM in two feet of water where re-growth to the surface may take 1-2 months may not be cost-effective management	
Climate			
Weather	daily weather conditions seasonal weather conditions	rain may wash off herbicides before they are effective – treat early in day during summer months in thunderstorm prone areas – check weather report prior to herbicide applications for wind and rain forecast – several cloudy or rainy days after a large submersed plant treatment with contact herbicides may result in substantial dissolved oxygen reductions use caution applying systemic herbicides requiring 2-3 months of contact in areas impacted by tropical or seasonal monsoonal weather – take advantage of winter dieback by controlling plants before they become a problem in spring or summer	E, F, S
Light intensity	an important plant growth	some herbicides' primary breakdown pathway is via	S

Parameter	Consideration/Constraint	Influence	Plant type
Water uses and functions	**Identify uses, values or functions of each water body to determine which if any may be at risk from invasive aquatic plants or nuisance growths of native and non-native plants – control tools and management strategies must be compatible with water body uses – water uses and conditions change and must be considered during the planning for each control operation**	**The uses of each water body must be identified and prioritized in order to develop management objectives – management objectives and water uses influence the tools and strategies best suited for aquatic plant control which in turn influence the spatial extent and duration of control**	**E = emergent S = submersed F = floating Plant types are listed if their control is a primary consideration or influenced by this control consideration**
	factor along with temperature	photolysis; efficacy may be reduced in the summer or in shallow clear waters – consider with water transparency for predicting submersed plant growth along with herbicide selection and treatment timing – light intensity triggers tuber production in hydrilla	
Water temperature	temperature influences plant growth and the amount of dissolved oxygen in the water column as well as microbial activity important for decomposing plant material and degrading some herbicide compounds	warming winter and spring temperatures can trigger plant growth, important for herbicide uptake especially in submersed plants – warmer water holds less dissolved oxygen than cooler; important for planning size of herbicide treatment and mode of action (fast acting contact vs. slower systemic)	S, F
Parameter	**Consideration/Constraint**	**Influence**	**Plant type**

Other considerations	in addition to physical parameters, there are human values to consider when deciding the level of aquatic plant control to attempt on a water body	these influences do not necessarily reflect the level of control that may be achieved, but rather the will of stakeholders to commit to attempting some level of control effort	E = emergent S = submersed F = floating
Cost	value judgment – does the anticipated outcome of controlling or not controlling plants justify expenditure?	the benefits of control must justify control expenditures – control must meet reasonable management objectives, including duration of control, restore or conserve uses and functions of water body, protect public health and safety, etc.	E, S, F
Anticipated amount of control	aquatic plant control is complex and many stakeholders have a rudimentary understanding of available tools and realistic control expectations – the public usually expects control to resolve impaired uses or functions of water bodies – responsible aquatic plant managers and researchers must clearly convey to stakeholders why they select or support control options as well as the anticipated amount and duration of control	management objectives should address anticipated extent of control – control includes the level of impact to the standing crop as well as underground roots, rhizomes, tubers etc. that influence ability of the plant to recover; therefore, control also includes the degree of impact to the problem-causing plant, the time to alleviate impaired uses, and the expected amount of time control will last; i.e. time until water uses may again be impaired	
Spatial – acres, % of water column	control area includes the coverage of plants to be controlled, expressed in acreage, square meters, etc. – also includes the percent of the water column in which plants are controlled, expressed as percent volume infested – can also include the below ground portion controlled (runners, roots, corms, tubers, etc.)	control using different tools or applied to different plant species provides variable results – managers must select tools that provide a level of control that satisfies management objectives and convey this reasoning or expectations to stakeholders	E, S, F

Parameter	Consideration/Constraint	Influence	Plant type
Other considerations	**in addition to physical parameters, there are human values to consider when deciding the level of aquatic plant control to attempt on a water body**	**these influences do not necessarily reflect the level of control that may be achieved, but rather the will of stakeholders to commit to attempting some level of control effort**	**E = emergent S = submersed F = floating**
Duration			
Time to achieve control	depending on the method(s), the amount of time to achieve control may be immediate or may take months or longer, if achieved at all	control methods may provide immediate relief of a problem (ex: harvesting adjacent to flood control structures or bridge pilings) or take months (ex: systemic herbicides, biological controls)	E, S, F
Length of control in time	the applied control method(s) as well as environmental parameters impact the duration of control achieved – ex: control may be achieved in a matter of a few days to a few weeks, but plants may re-grow to problem levels within a month	control may last a few days to several years depending on method and water body conditions – ex: a summer contact type herbicide treatment of hydrilla or torpedograss growing in 1-2ft of water may only last a few weeks before plants refill the water column while a winter fluridone treatment in 12-15 feet of water may prevent hydrilla from growing back to the water surface for 18-24 months	E, S, F
Suppression	includes reducing plant vigor as well as flowering, seed production	many biological controls as well as plant growth regulators stress plants but by themselves may not provide a level of control that meets management objectives or stakeholder expectations	E, S, F
Water body values at	assess various uses of water bodies and estimate economic	assists in establishing management objectives as	E, S, F

Parameter	Consideration/Constraint	Influence	Plant type
Other considerations	**in addition to physical parameters, there are human values to consider when deciding the level of aquatic plant control to attempt on a water body**	**these influences do not necessarily reflect the level of control that may be achieved, but rather the will of stakeholders to commit to attempting some level of control effort**	**E = emergent S = submersed F = floating**
risk	and environmental costs as well as impacts to human health if plants are controlled or not controlled	well as level of control and choosing control options	
Alternative water body	if plant control cannot be achieved in a water body, identify any alternative waters to serve the uses and functions	this is a temporary solution while eradication or management efforts are being devised or applied in a water body – access to the infested water body may be closed during eradication efforts or control delayed in infested waters while higher priority waters are managed, especially if other nearby waters are available – efforts should be made to resume use of water body as soon as possible	E, S, F
Contractor / equipment availability	ensure availability of contractor and equipment to address all anticipated control possibilities	have back-up labor and equipment contractors available – securing contracts can take time which may be critical for eradication or in emergency situations – large-scale control operations or operations in waters with multiple uses and functions may have very narrow windows of opportunity to implement	E, S, F
Control history in similar waters	apply control tools or management strategies with proven or demonstrated	monitor efficacy of each control event – determine causes of poor or no control	E, S, F

Parameter	Consideration/Constraint	Influence	Plant type
Other considerations	**in addition to physical parameters, there are human values to consider when deciding the level of aquatic plant control to attempt on a water body**	**these influences do not necessarily reflect the level of control that may be achieved, but rather the will of stakeholders to commit to attempting some level of control effort**	**E = emergent S = submersed F = floating**
	effectiveness and compatibility with uses and functions of system	and avoid repeating – for new infestations look to successes or failures with various control options in waters as similar as possible to proposed control site	
Coordinate with stakeholders	control operations should be developed with stakeholders that have expressed interest in understanding the intricacies of aquatic plant control – the public should be notified through some means of any use restriction of impending herbicide control operations	stakeholders may view aquatic plant control and control tools from a single or less than holistic perspective – education and outreach efforts are important in addressing public concerns	E, S, F
Support – verbal, financial, in-kind	important tiebreaker for waters of equal importance when factors such as funding, technology, contractor availability, or cost/benefit ratios are insufficient to implement control projects in all water bodies – especially for lower priority uses or waters	work with all stakeholders to clarify management objectives – in low priority management waters, if support is high, then elevate to higher priority than equal priority waters where support is low or stakeholders oppose control	E, S, F
Public	level of verbal support from homeowner or public or private stakeholders or associations	for equally ranked control project priorities, public support may elevate control projects, especially above projects where there is no support or open stakeholder opposition to control	E, S, F

Parameter	Consideration/Constraint	Influence	Plant type
Other considerations	**in addition to physical parameters, there are human values to consider when deciding the level of aquatic plant control to attempt on a water body**	**these influences do not necessarily reflect the level of control that may be achieved, but rather the will of stakeholders to commit to attempting some level of control effort**	**E = emergent S = submersed F = floating**
Agency – federal, state, local	level of verbal, financial, or in-kind service support for controlling aquatic plants	external funding or services may elevate a control project to a higher priority above otherwise equally evaluated projects with no external assistance	E, S, F

This paper was written by Michael D. Netherland and Jeffrey D. Schardt for the Aquatic Plant Management Society. It was first published in Aquatics magazine, Vol. 31(1):6, 9-19 (2009), and subsequently published by the Aquatic Ecosystem Restoration Foundation (AERF) in Biology and Control of Aquatic Plants – A Best Management Practices Handbook edited by Lyn A. Gettys, William T. Haller and Marc Bellaud (2009).

Defining Nuisance

A. Regulatory Definitions

IDAPA 58.01.02.010.67 - Nuisance. Anything which is injurious to the public health or an obstruction to the free use, in the customary manner, of any waters of the state.
IDAPA 58.01.02.010.04 - Aquatic Species. Any plant or animal that lives at least part of its life in the water column or benthic portion of waters of the state.

B. IPC Trend Monitoring on Mid-Snake River

IPC WQ Trend Monitoring of Mid-Snake River (10/10/2013 – 09/23/2014; WY 2014)

DATE	KING HILL WY 2014	BUHL WY 2014	MILNER WY 2014	
		µg/L		
10/10/2013	0.9	5.3	2.9	
10/24/2013	22.0	19.0	58.0	
11/05/2013		1.1	71.0	
11/21/2013	3.2	5.9	82.0	
12/05/2013	2.7		57.0	
12/18/2013	10.0	20.0	76.0	
01/02/2014	1.6	11.0	54.0	
01/15/2014		13.0	50.0	
01/30/2014	1.9	9.5	48.0	
02/13/2014	4.3	5.6	35.0	
02/25/2014			72.0	
03/11/2014	7.7	21.0	80.0	
03/27/2014	33.0	64.0	85.0	
04/10/2014	52.0	58.0	38.0	
04/24/2014	49.0	35.0	6.4	
05/08/2014	37.0	25.0	11.0	
05/21/2014	110.0	41.0	9.6	
06/05/2014	19.0	15.0	12.0	
06/17/2014	8.9	6.2	6.9	
07/02/2014	15.0	12.0	5.3	
07/17/2014	30.0	21.0	21.0	
07/31/2014	22.0	25.0	38.0	
08/13/2014	20.0	21.0	59.0	
08/27/2014		9.9	41.0	
09/11/2014	6.5	5.1	50.0	
09/23/2014	6.1	9.9	49.0	
N	22	24	26	
Minimum	0.9	1.1	2.9	
Mean	21.0	19.1	43.0	
Median	12.5	14.0	48.5	
Maximum	110.0	64.0	85.0	

Source: Middle Snake River Water-Quality Monitoring Annual Report – Water Year 2014 – Compliance Report by Jim Younk & Brian Hoelscher, January 2015, IPC: Boise, Idaho.
King Hill WY 2014 – See Appendix 1
Buhl WY 2014 – See Appendix 3

Milner WY 2014 – See Appendix 5. Milner values that are underlined are ½ MDL.

C. New Hampshire's Description of "Nuisance" Levels

One method used to describe nuisance based on chlorophyll-a according to the New Hampshire Department of Environmental Services:

< 3 µg/L	Excellent
3-7 µg/L	Good
7-15 µg/L	Less than desirable
>15 µg/L	Nuisance

Source: https://www.des.nh.gov/organization/divisions/water/wmb/vrap/documents/wq-resultsinfo.pdf

D. Comparison of Nuisance to Other States & South Africa

Table 2. Chlorophyll a concentrations applied for the protection of national waters.

Location	Chlorophyll a Concentration and Application	
Oregon (OAR 340-041 n.d.)	10 µg/L impairment guidance value for stratified lakes	15 µg/L impairment guidance value for other lakes and reservoirs
Southeastern US (Rashke 1994)	15 µg/L proposed mean growing season limit for water supply	25 µg/L proposed mean growing season limit for other uses
South Africa (Walmsey 1984)	10-20 µg/L for evident algal scums	20-30 µg/L for nuisance algal bloom condition
North Carolina (NALMS 1992)	15 µg/L standard for trout waters	40 µg/L standard for non trout waters
Lake Pepin (Heiskary and Walker 1995)	30 µg/L mean summer limit for aesthetics and recreation	> 40 µg/L mean summer limit for nuisance algal bloom condition

Source: https://www.deq.idaho.gov/media/899754-evaluation-of-chlorophylla-nuisance-thresholds-targets-southwest-snake-river-brownlee-reservoir-2002.pdf

E. Colorado's Chlorophyll Thresholds

Chlorophyll Threshold for Protection of the Recreation Use (Power Point) August 2011) – State of Colorado

Chlorophyll Threshold

For Protection of the Recreation Use

Nutrient Workgroup
August 29, 2011

Algal Abundance

- In Colorado, algae in streams is found mostly on the substrate ("periphyton") rather than suspended ("phytoplankton")
- Abundance is generally measured as chlorophyll per unit area (mg/m^2)
- Nutrients in the stream affect the abundance of algae on the substrate

WQCD Collection Method

- WQCD Periphyton Method:
  - Collect 15 rocks (3 rocks along 5 equidistant transects)
  - Scrape an area of 0.785 in^2 per rock
  - Filter ~25-40 ml of scrapings/water mixture
  - Preserve chlorophyll molecule by freezing
- Chl-a Lab Method:
  - Spectrophotometric measurement

How Much Is Too Much?

- Over-abundance of algae can be detrimental to:
  - Other aquatic life and recreation use
- Several algal abundance thresholds have been proposed in literature
  - Typical range of 100-200 mg/m^2 as max
  - Table of thresholds presented in a later slide

Colorado Proposal

- The Division proposes a chlorophyll threshold of <u>150 mg/m^2</u> to protect the recreation use in rivers/streams
- Supported by Montana DEQ study [1]
- Corroborated by evidence from other studies

[1] Suplee et al. 2009.

MT DEQ Public Opinion Survey

- Surveyed public's perception of stream bottom algae levels in Montana's wadeable rivers and streams[1]
- Identify what level of algae is undesirable for recreation
- Targeted two public groups
  - On-River survey (anglers, kayakers, visitors)
  - By-Mail survey (Montana registered voters)

[1] http://www.umt.edu/watershedclinic/algaesurveypix.htm

Survey Methods

- Surveys used same randomly ordered photographs
  - Each photo depicted a different algae level
  - Range of 40 to 1280 mg/m^2
- Survey participants asked if algae level in ea. photo was "desirable" or "undesirable"
- A "pretest" refined photo sequencing and form design – reduced study bias

By-Mail Survey

- Sent to 2,000 randomly selected MT voters
- Three phase process
  - Introduction letter
  - Survey form
  - Follow-up postcards encouraging return of surveys
- Received 389 completed surveys
- High non-response rate

On-River Survey

- 44 survey trips randomly scheduled across state
- Selection of sites based on angler use patterns
  - Avoided non-wadeable rivers
  - Wanted opinion of recreators using stream reaches similar to those in photos
- Conducted Jun-Aug; set time intervals (am/pm)
- 563 interviews completed; variety of recreators

Results

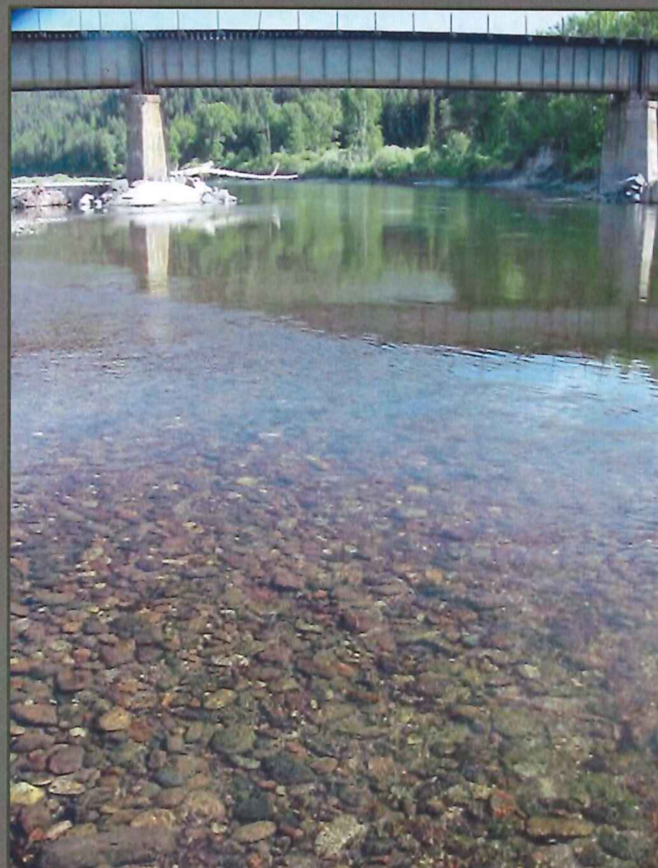
- Survey showed a high degree of consistency across public users
- There was no significant difference of opinion between:
  - On-river and mail-in respondents
  - Montana residents vs. out-of-state visitors
  - Urban vs. rural residents

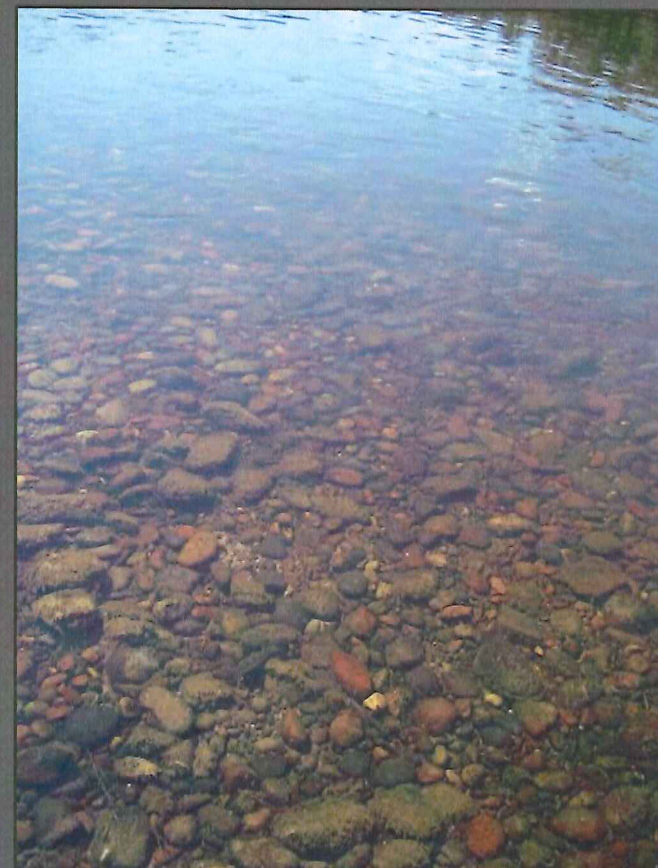
Results

- Chl levels at or below 150 mg/m^2 were determined to be "desirable" by the majority of survey respondents
- Chl levels at or above 200 mg/m^2 were determined to be "undesirable" for recreation

http://onlinelibrary.wiley.com/doi/10.1111/j.1752-1688.2008.00265.x/pdf

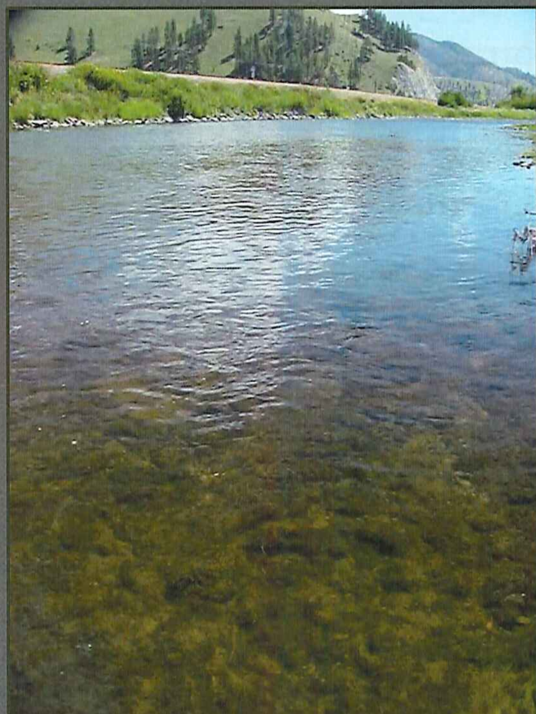
Examples of Desirable Chl Levels (MT)

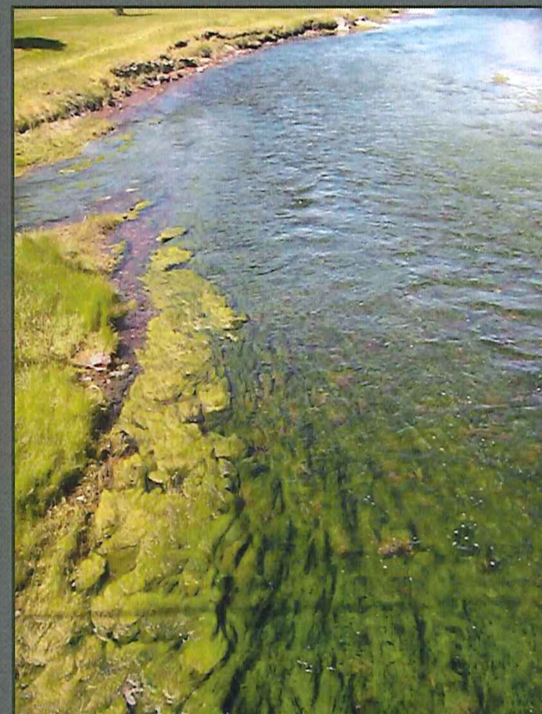


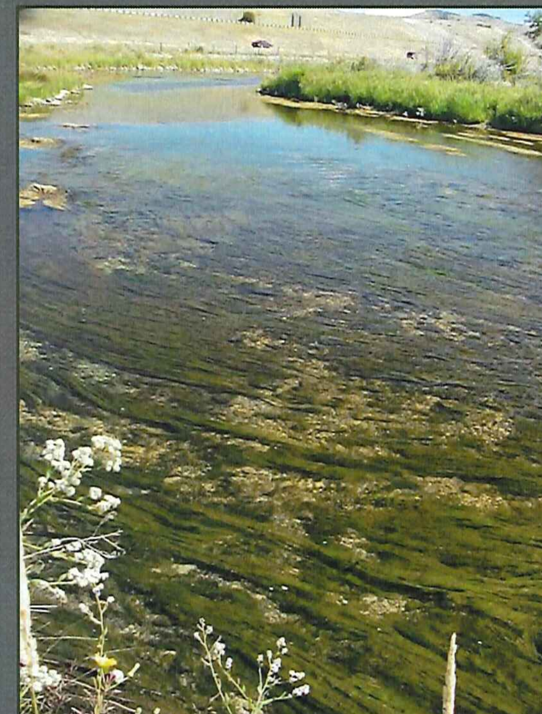


Chlorophyll levels at or less than 150 mg/m^2

Examples of Undesirable Chl Levels (MT)







Chlorophyll levels at or above 200 mg/m^2

Corroborating Evidence

- Some thresholds proposed in the literature by various agencies and researchers

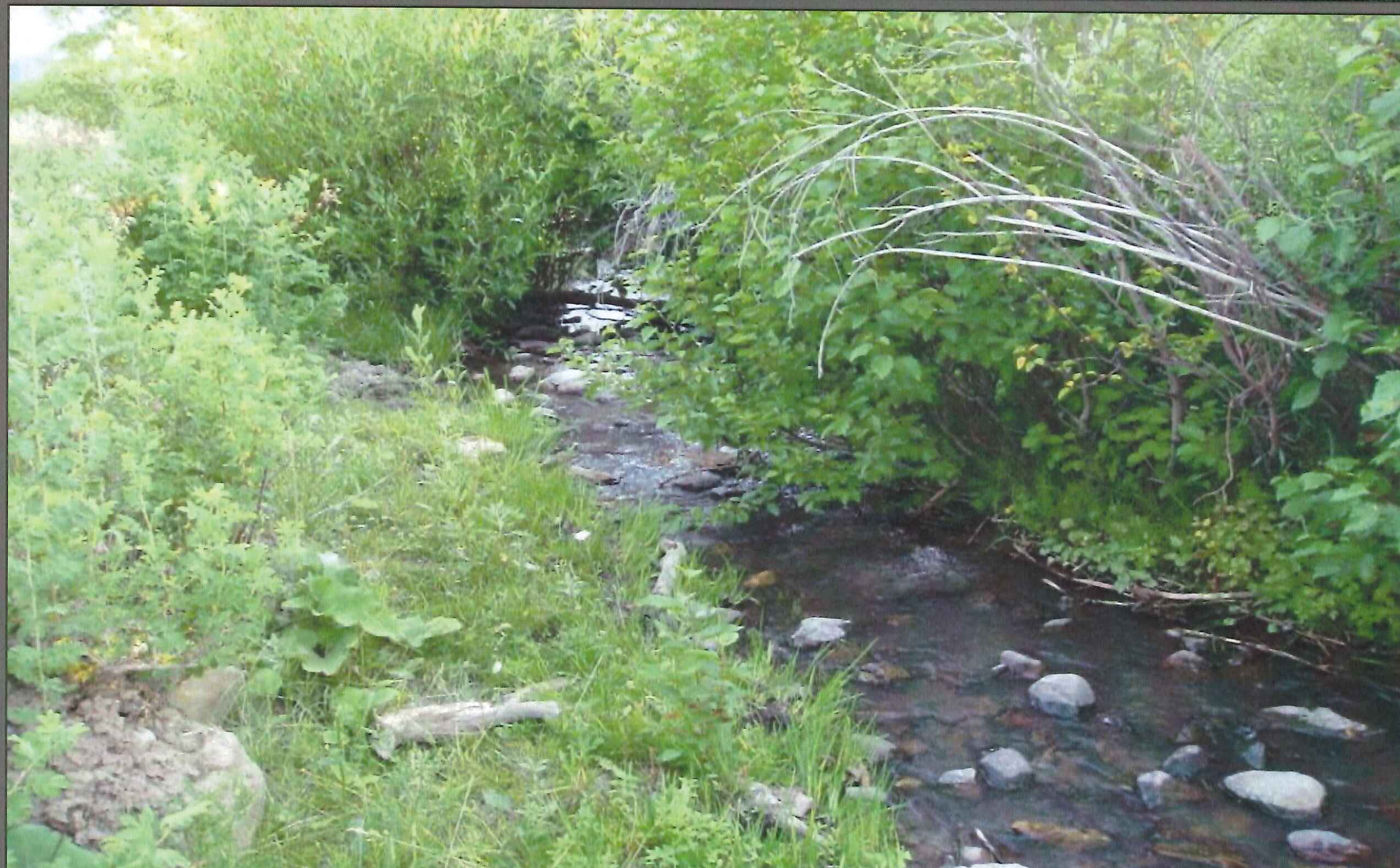
Chl mg/m^2 max	Impairment Risk	Source
200	Aesthetic nuisance level	Welch et al. 1988
200	Nuisance growth	Biggs 2000
182	Aquatic life (management)	Miltner 2010
150	Nuisance growth	Watson and Gestring 1996
100	Contact recreation	Quinn 1991
100	Nuisance growth	Nordin 1985

Colorado Examples

- Montana DEQ photo selection process was very intensive
- Colorado WQCD photos are from routine biological monitoring sites
  - Upstream and downstream photos taken w/ common digital cameras
- Similar range of algae levels used

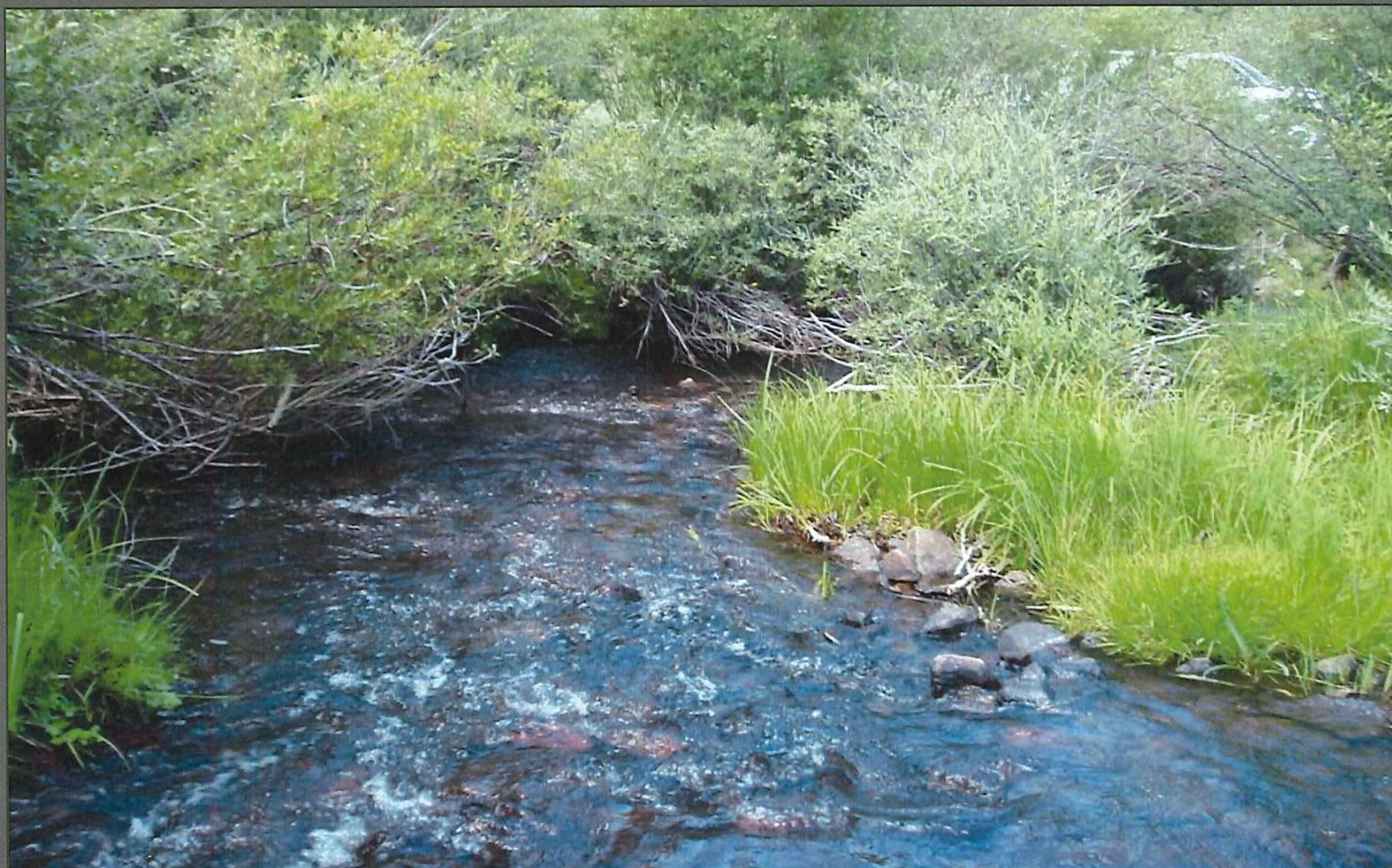
Examples of Desirable Chl Levels (CO)

Billy Creek – 3.7 mg/m^2



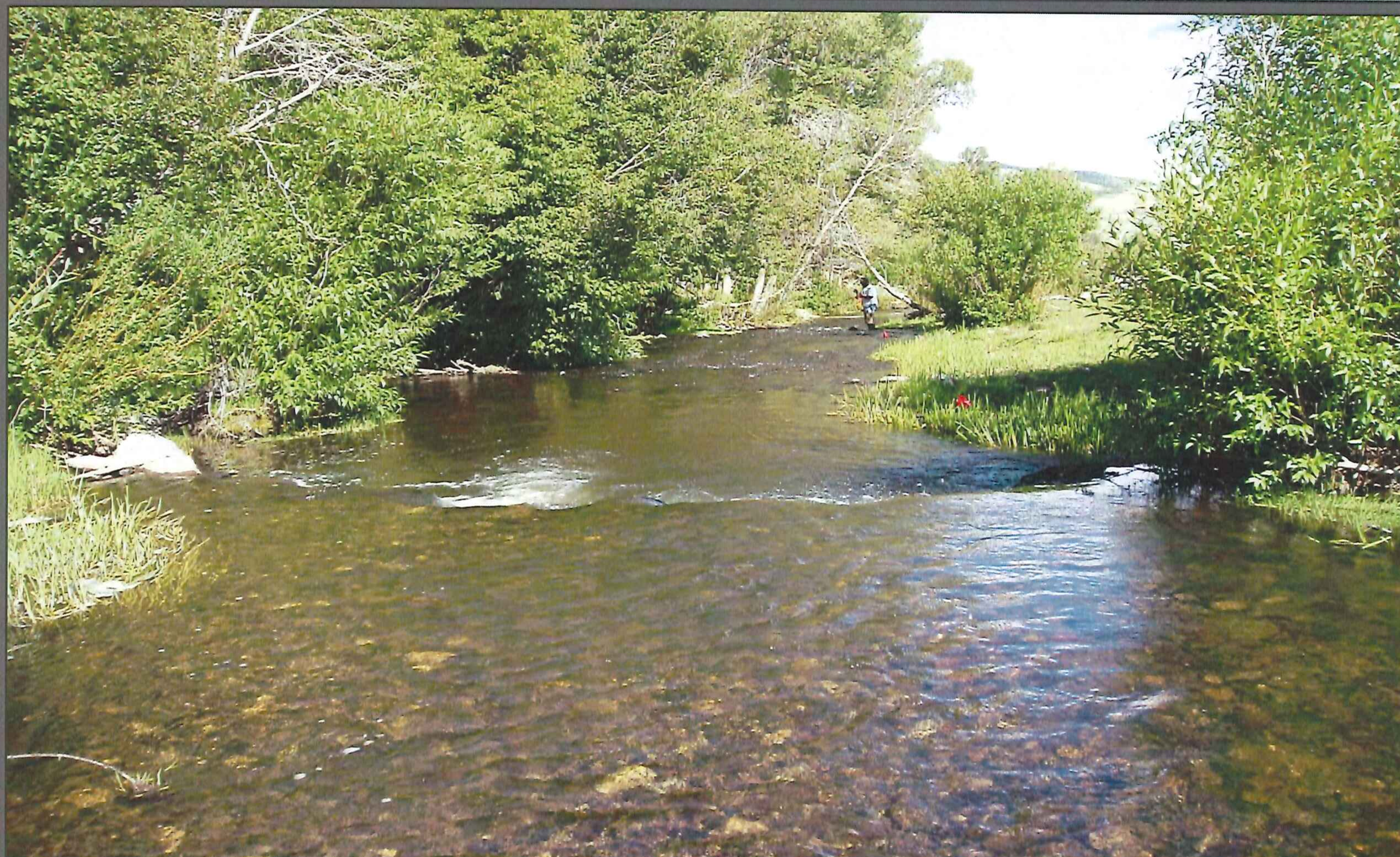
Examples of Desirable Chl Levels (CO)

Lime Creek – 36.7 mg/m^2



Examples of Desirable Chl Levels (CO)

Sheephorn Creek – 81.8 mg/m^2

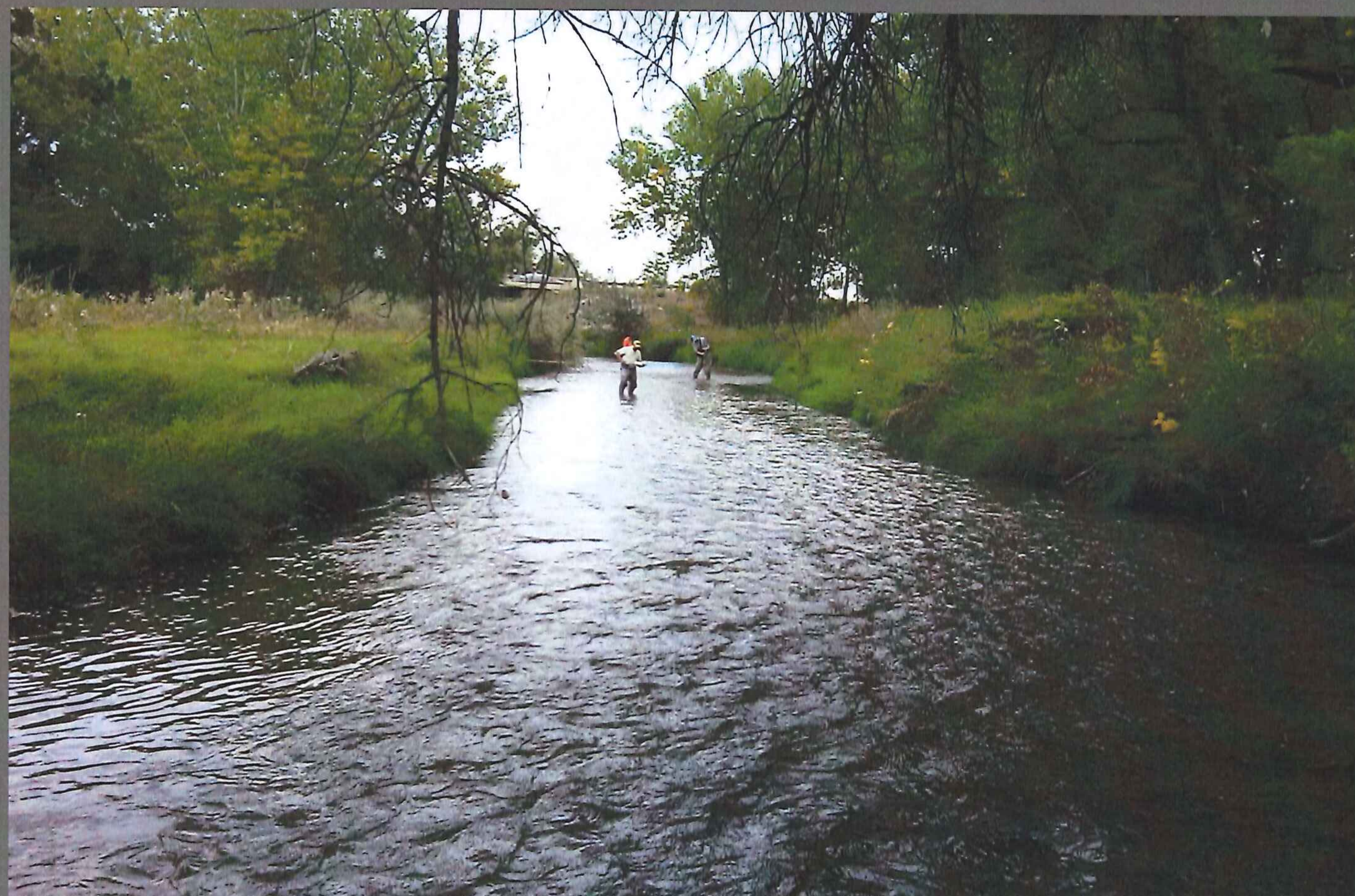


Examples of Desirable Chl Levels (CO)

Garfield Creek – 144.2 mg/m^2

Examples of Chl Levels (CO)

Big Thompson River – at I-25 – 150.0 mg/m^2



Examples of Undesirable Chl Levels (CO)

Boulder Creek – at mouth – 217.1 mg/m^2

Examples of Undesirable Chl Levels (CO)

St. Charles River – above mouth – 362.4 mg/m^2

Colorado Proposal

- The Division proposes a chlorophyll threshold of <u>150 mg/m^2</u>
- Proposed standard is "not-to-exceed"
- Why?
  - Enduring conditions – no risk of false positive
  - Statistical uncertainty in selecting an "average" value
  - A "not-to-exceed" value protects the recreation use every day

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IV. Exploring the Extent of Opening the TMDL as Components to Review

Flow & Seasonality

Source: https://pubs.usgs.gov/sir/2005/5177/pdf/sir2005-5177.pdf

An Analysis of Statistical Methods for Seasonal Flow Forecasting in the Upper Klamath River Basin of Oregon and California

By John C. Risley and Marshall W. Gannett, U.S. Geological Survey,
Jolyne K. Lea, Natural Resources Conservation Service, and
Edwin A. Roehl Jr., Advanced Data Mining Services, LLC

Approach: Water managers in the upper Klamath Basin, located in south-central Oregon and northeastern California, use forecasts of spring and summer streamflow to optimally allocate increasingly limited water supplies for various demands that include irrigation for agriculture, habitat for endangered fishes, and hydropower production. Flow forecasts are made by the Natural Resources Conservation Service using statistical models that use current snow and precipitation data collected at nearby monitoring sites as input. The forecasts for five upper Klamath Basin sites (Williamson River, Sprague River, Upper Klamath Lake, Gerber Reservoir, and Clear Lake Reservoir) are made at the beginning of each month from January through June.

Issue: In water year 2001, the upper Klamath Basin experienced one of the worst droughts on record. In January and February 2001, basinwide snowpack and cumulative precipitation were only 50 percent of average. The January median forecasts (50 percent exceedance probability) for the five sites ranged from 54 to 70 percent of average. By April, the median forecasts dropped to 6 to 39 percent of average because of the continued lack of precipitation during the early spring. Typically, by early April and prior to planting crops, farmers want to know if and how much irrigation water will be delivered to them during the coming summer. Because of the combination of well-below-average volume forecasts and legal obligations under the Endangered Species Act to protect suckers and Chinook and coho salmon, the BOR ceased irrigation water deliveries to 75 percent of the Klamath Project (approximately 150,000 acres) in early April 2001.

In 2003, the USGS, NRCS, and BOR began a collaborative study to determine how some of the uncertainty and errors in seasonal flow forecasting in the upper Klamath Basin could be reduced. Uncertainty will exist in any seasonal flow forecasting method because of limitations in predicting the weather several months into the future, data network deficiencies, and processes not well represented in forecast models.

Data Networks: Snow-water equivalent, precipitation, air temperature, streamflow, net reservoir inflow data, and climate-trend variables (well-water elevation data, precipitation records, and ocean climate indicators) were used to create both the dependent and independent variables of the models presented in this report). The USGS, NRCS, BOR, and NWS maintain long-term data monitoring networks for these data in the study area. The data period of record used for many of the models in the study ranged from 1960 to the present.

Models: Three different sets of models used to forecast spring and summer flows at five upper Klamath Basin forecast sites are presented.

- The first model set was developed by NRCS and uses principal components regression. Current or recent monthly SWE and precipitation from climate sites near the forecast sites were used as input data.

- The second set of models, developed by the USGS, also used current or recent monthly SWE and precipitation as input data, except these models were created from artificial neural networks.

- The third set of models, developed by Advanced Data Mining LLC, Greenville, South Carolina, was also created from artificial neural networks. However, these models are autoregressive and use model input variables that are derived from components of the flow time series of the forecast site.

Aquaculture – Flow & Seasonality

Water sources:

- Snake River water
- Tributary water to the Snake River
- Spring water (Eastern Snake River Plain Aquifer; other aquifers)
- Seep Tunnel water
- Irrigation water
- Cold/Cool water wells
- Geothermal wells

Facility Types (broad spectrum)

- Fish processors
- Production Hatcheries (cold water type)
    1. Spring-fed hatcheries
    2. Combination of spring-fed & irrigation-fed hatcheries
    3. Irrigation-fed hatcheries
- Production Hatcheries (warm water type)
- Conservation Hatcheries (IDFG, USFWS & CSI)
- Others?

POTWs / WWTPs

Facility Types (broad spectrum)

- Facilities ≥ 1 mgd ("major")
- Facilities < 1 mgd ("minor")

There are 4 flow conditions (per the Minnesota Pollution Control Agency) that are critical to the design and operation of WWTPs (https://www.pca.state.mn.us/sites/default/files/wq-wwtp5-20.pdf):

- Average dry weather (ADW) - The ADW flow is the daily average flow when the ground water is at or near normal and a runoff condition is not occurring.
- Average wet weather (AWW) – The AWW or peak month flow is the daily average flow for the wettest 30 consecutive days for mechanical plants or for the wettest 180 consecutive days for controlled discharge pond systems. The 180 consecutive days for pond systems should be based on either the storage period from approximately November 15 through May 15 or the storage period from approximately May 15 through November 15.
- Peak hourly wet weather (PHWW) - The PHWW flow is the peak flow during the peak hour of the day at a time when the ground water is high and a five-year one-hour storm event is occurring.
- Peak instantaneous wet weather (PIWW) - The PIWW flow is the peak instantaneous flow during the day at a time when the ground water is high and a twenty-five year one-hour storm event is occurring.

Design Conditions Summary for "major" and possibly "minor" facilities:

1 – Collection System (must be capable of transporting all flow to the treatment facility without bypassing)
2 – Lift Station (must be capable of transporting all flow to the treatment facility without bypassing)
3 – Organic Loading (Minimum BOD and TSS requirements)
4 – PHWW (for residential, commercial & industrial flows)
5 – PIWW (for residential, commercial & industrial flows)
6 – Flow Equalization Basin (If PHWW/ADW ≥ 3, flow equalization must be considered; if PHWW/AWW ≥ 3, flow equalization must be considered).
7 – Facility Piping & Pumping (PIWW)
8 – Preliminary Treatment Unit (screens, grit removal, influent filters, etc.; PIWW)
9 – Clarifiers (surface settling rate and weir loading rate; PHWW + recirculation flow)
10 – Disinfection (detention time; PHWW)

Critical Issue = Infiltration and Inflow (I/I)
Inflow means water other than wastewater that enters a sewer system from sources such as roof leaders, foundation drains, yard drains, manhole covers, cross connections between storm sewers and sanitary sewers, catch basins, storm water runoff and other drainage structures. Infiltration means water other than wastewater that enters the

sewer system from the ground through defective pipe, pipe joints, and manholes. I/I is a part of every collection system and must be taken into account in the determination of an appropriate design flow.

Industrial-type Facilities + Hydropower
Facility Types (broad spectrum)

Industrial withdrawals provide water for such purposes as fabricating, processing, washing, diluting, cooling, or transporting a product; incorporating water into a product; or for sanitation needs within the manufacturing facility. (https://water.usgs.gov/watuse/wuin.html)

"Q&A: The State of Industrial Water" (http://www.watertechonline.com/qa-the-state-of-industrial-water/)

- Hydropower. The electrical power generation sector has the highest water use and faces the largest challenges over time. The use of gray water is significantly increasing in this market, and regulation of discharge of waters from ash ponds, etc., is having an immediate effect on coal-fired plants.
- Industrials. In general, surface waters remain a prominent source water for industrial facilities. Since 1950, the U.S. Geological Survey (see https://pubs.usgs.gov/fs/2014/3109/pdf/fs2014-3109.pdf) has been capturing water withdrawal trends at five-year intervals. In its last report in 2010, [it] found that surface waters continue to be 78 percent of all withdrawals. This trend has not shifted much. However, what we are seeing is that recycled wastewater [use] is a growing trend. This evolving trend is driven both by increasing competition for available water as well as discharge regulations, which have become stricter in many parts of the world.
- Gray Water. One of the most common impaired water sources today is municipally treated wastewater, often called gray water (other impaired waters are also generically labeled as gray water). This low-cost, or sometimes free, water source is abundant and does not strain local water sources. Gray water makeup can vary from hour to hour or day to day and is rich in nutrients. If left untreated, gray water can lead to scale formation or other biological concerns on treatment equipment. However, innovative engineering and treatment technologies can treat common issues surrounding gray water use.
- Process Water. Process water is not considered drinkable (not drinking water) and is basically used in relation to industrial plants, industrial processes and production facilities. Process water is subjected to a substantial water treatment and includes:: ion removed water, purified water, ultra-pure water, cooling water, rinse and wash water, softened water, brewing water, media-filtered water and desalination water using RO.

- Cheese Manufacturing. (http://www.dairyfoods.com/articles/85094-concern-about-water-quality-impacts-cheese-making-facility (November 28, 2009)) New laws affecting a major Northwestern river basin threatened to cripple a major area cheese producer with BOD limits below 3 mg/L, total nitrogen limits below 1 mg/L and total phosphorus limits below 0.07 mg/L -- all exceptionally low levels and levels that are difficult to achieve with most in-place wastewater treatment technologies.

Agriculture and Ranching

(Source: http://www.tucson.ars.ag.gov/icrw/Proceedings/Van%20Liew.pdf)
Seasonal variations in streamflow, coupled with increased and competing demands for water by a growing population, place considerable pressure upon efficient management of available water resources. This is especially true for management of reservoir storage and water releases during and at the end of the dry season when water demand is highest and streamflow supply is lowest.

How would seasonality work under agriculture and ranching?

- Irrigation season versus non-irrigation season

TP as a limiting nutrient

Source:
http://www.epa.ie/pubs/reports/research/water/EPA_patters_effects_phosphorous.pdf

Phosphorus is considered to be the main limiting nutrient for primary production in most freshwater systems. Long-term increases in the concentration of phosphorus have occurred in many rivers and lakes in recent decades. External supplies of nutrients to surface waters can originate from point sources, which are localized and more readily monitored and controlled, and non-point sources, which are diffuse and much more difficult to monitor and regulate. Reductions in phosphorus inputs from point sources do not always reduce phosphorus concentrations in surface waters. While internal loading from sediments may be a factor in the maintenance of phosphorus availability in these systems, diffuse losses from agricultural sources are considered the major cause.

Phosphorus in water may exist in one of four broadly defined states: dissolved as an inorganic molecule readily available for biotic uptake, incorporated through sorption onto solids, incorporated within biological material, or dissolved within organic molecules of varying complexity, which may or may not be readily available for biotic use. Phosphorus exists as orthophosphate ($PO4^{3-}$) in all its biologically active fractions (Reynolds and Davies, 2001). The relative proportions of its anions vary with pH. The hydrogen radicals, however, are all replaceable by metals. While orthophosphate itself is freely soluble in water, orthophosphates of the alkaline earth and transition metals are particularly insoluble. The bioavailability of phosphorus refers to 'those fractions that are readily assimilated by organisms, or can be made assimilable through the activities of organisms, and that portion which has already been assimilated' (Reynolds and Davies, 2001). The bioavailability of phosphate is reduced by adsorption on the surfaces of metal oxides. The sorption–desorption reactions with redox-sensitive metals such as iron and manganese are particularly important in aquatic systems. Phosphorus is a highly particle-reactive element and will often be involved in a series of sequential sorption / desorption reactions with particulate material suspended in the water column (Froelich, 1988). Where a stream or river carries a high particulate load, the balance between dissolved and particulate phosphorus pools changes continuously. Froelich (1988) described phosphate ions as 'playing hide and seek with both plankton and experimentalists'. The 'phosphate buffer mechanism' is the name given to this dynamic equilibrium (Froelich, 1988).

Source: https://oup.silverchair-cdn.com/oup/backfile/Content_public/Journal/ps/78/5/10.1093/ps/78.5.674/2/poultrysci78-0674.pdf?Expires=1499643930&Signature=PL0PCBoW2UCZ5cGiiI5S1YvrxqcOyXuVDtx6Q7OF4--ZvTPIDBoYtULBGje~5BuqgaAye0Wikrxpca0DpW~Oo3BARTaGNya4vIB4smxbT-TuAN~y-UFD7BsQmwOBsqHfy6dmkjSZqxJqR3meTFYq7J26YwqTTQaLf5B49jIep18XaAIaMtrdRFy-tia8XG-gX4bdtVK5BDdAFPatGfgaAWb24E-OwA6cGZ3jv22FGMpNxwF1r5B1HGtFKh64NbYbOJV-i2dLZsJus97uOS28zD3mZZrXRtJDgs0~SuZvjWo840iIWTxMMgLr3ypGfBtNOpbh2hLJRL9xcla~QOGuvQ__&Key-Pair-Id=APKAIUCZBIA4LVPAVW3Q

Phosphorus: A Rate Limiting Nutrient in Surface Waters
By D. L. Correll, Smithsonian Environmental Research Center, 1999

Phosphorus is an essential element for all life forms. It is a mineral nutrient. Orthophosphate is the only form of P that autotrophs can assimilate. Extracellular enzymes hydrolyze organic forms of P to phosphate. Eutrophication is the over-enrichment of surface waters with mineral nutrients. The results are excessive production of autotrophs, especially algae and cyanobacteria. This high productivity leads to high bacterial populations and high respiration rates, leading to hypoxia or anoxia in poorly mixed bottom waters and at night in surface waters during calm, warm conditions. Low dissolved oxygen causes the loss of aquatic animals and the release of many materials normally bound to bottom sediments, including various forms of P. This release of P reinforces the eutrophication. Excessive concentrations of P is the most common cause of eutrophication in freshwater lakes, reservoirs, streams, and in the headwaters of estuarine systems.

Lakes are primarily P limited.
Oceans are primarily N limited.
Estuaries are transition zones.
Streams, rivers, and reservoirs behave somewhat like lakes. However, they would have to be highly enriched with nutrients to undergo anaerobic periods, and thus are unlikely to release high concentrations of phosphate from bottom sediments.

Streams and rivers, however, may have “spiraling” of P down the channel (Newbold et al., 1981; Elwood et al., 1983). Spiraling is the result of uptake of P by attached bacteria and algae (periphyton) and vascular plants and the binding of P compounds in bottom sediments. When these P compounds are released back into the water column, either from bottom sediments or attached biota, they move further down stream, before becoming attached again as the P is cycled among the system components. Each such P movement downstream in the water column is referred to as a “spiral”.

The Redfield Ratio Concept - A series of studies of laboratory cultures of algae and of natural marine phytoplankton populations in the period from the 1930s to the 1950s

(Redfield, 1958) led to a concept that algae, under reasonably good growth conditions, will have an elemental composition with relatively defined atomic ratios. These ratios have become known as the Redfield ratios. For N to P this ratio is about 15 to 16:1.

Upper Snake Rock TMDL (1999 Draft) – Appendix D, TSD, Section 4 (pp 304-447)

TN:TP Ratio:							
MONTH	MD	PF	CS	BC	GB	SB	KH
1	9	10	13	18	17	16	21
2	9	10	12	16	16	15	19
3	7	12	14	15	15	15	17
4	7	13	12	15	15	13	16
5	7	11	12	14	14	15	17
6	7	10	11	12	10	11	12
7	7	11	11	18	19	17	21
8	6	10	13	18	21	17	23
9	5	11	14	18	18	16	16
10	6	13	16	21	22	17	23
11	7	11	13	19	20	18	24
12	8	10	13	17	16	18	22
MEAN	7	11	13	17	17	16	19

TN:TP Ratio:							
WY	MD	PF	CS	BC	GB	SB	KH
1990	4	14	12	21	22	19	18
1991	5	14	17	21	19	19	16
1992	4	9	15	21	20	20	27
1993	7	9	9	20	19	18	23
1994	7	9	15	20	19	19	26
1995	7	12	13	17	18	17	23
1996	7	11	11	15	15	14	21
1997	9	10	10	12	12	12	13
1998	7	10	11	16	13	15	19
1990-1991	4	14	14	21	20	19	17
1990-1995	5	11	13	20	19	18	22
1996-1998	8	10	11	14	13	14	17

TN (Total Nitrogen) = TKN + NOx

TP (Total Phosphorus) = Total Dissolved P + Total Particulate P

Redfield Ratio Calculator

Tabel N:P ratio (Geldt alleen als C:N<15)												
Fosfaat	**Nitraat gehalte** (mg/ltr)											
(mg/ltr)	**0,0**	**1,0**	**2,0**	**3,0**	**4,0**	**5,0**	**7,5**	**10,0**	**15,0**	**20,0**	**25,0**	**50,0**
0,00	--	--	--	--	--	--	--	--	--	--	--	--
0,01	0	150	300	450	600	750	1125	1500	2250	3000	3750	7500
0,10	0	15	30	45	60	75	113	150	225	300	375	750
0,20	0	8	15	23	30	38	56	75	113	150	188	375
0,30	0	5	10	15	20	25	38	50	75	100	125	250
0,40	0	4	8	11	15	19	28	38	56	75	94	188
0,50	0	3	6	9	12	15	23	30	45	60	75	150
0,75	0	2	4	6	8	10	15	20	30	40	50	100
1,00	0	2	3	5	6	8	11	15	23	30	38	75
2,50	0	1	1	2	2	3	5	6	9	12	15	30
5,00	0	0	1	1	1	2	2	3	5	6	8	15

(white)	Minste kans op alg, gunstig gebied voor planten
(blue)	Gunstig gebied voor blauwe alg
(green)	Gunstig gebied voor groene alg

Dutch to English:
Title = Table N:P ratio (Only valid if C:N < 15)
Top Row = Nitrate content
Left Column = Phosphate

Minimal chance of alg, favorable area for plants (white portion of table)
Favorable area for blue algae (blue portion of table)
Favorable area for green algae (green portion of table)

TSS, TP & E. coli

Based on the April 2010 USR/Middle Snake TMDLs Five Year Review:

Table 19. Summary of DEQ WQ Data collected since 2000 on the Snake River

Descrip Stats	Milner Dam (MD)		Pillar Falls (PF)		Crystal Springs (CS)		Box Canyon (BC)		Gridley Bridge (GB)		Shoestring Bridge (SB)		King Hill (KH)	
TSS, mg/L --- Instream Target = < 52.0 mg/L														
Years	<2000	>2000	<2000	>2000	<2000	>2000	<2000	>2000	<2000	>2000	<2000	>2000	<2000	>2000
N	199	97	63	101	61	99	152	98	77	99	14	98	29	98
Min	0.2	0.3	2.0	0.5	< 0.0	0.1	2.0	0.5	0.5	0.5	18.0	0.5	3.0	0.5
Mean	15.1	11.4	18.7	10.6	27.0	9.8	26.1	7.8	25.0	6.4	40.7	8.0	43.9	76.0
Med	15.0	10.5	16.0	8.0	25.0	8.0	18.0	6.6	17.0	4.0	33.0	7.4	27.0	6.2
Max	77.0	35.0	50.0	79.0	65.0	56.0	134.0	54.0	109.0	130.0	156.0	32.0	305.0	30.0
TSS, tons/year – Point Sources & Nonpoint Sources														
PS-1990	-		1.3		177.7		3,456.3		83.3		786.4		0.0	
PS-2000	-		1.3		204.4		3,462.0		101.7		973.7		0.0	
	Net PS		0.0		+26.7		+5.7		+18.4		+187.8		0.0	
NPS-1990	-		24,064.2		40,073.0		76,133.8		40,286,6		42,462.3		93,524.9	
NPS-2000	-		20,373.8		54,208.8		74,519.4		10,028.2		90,659.3		7,202.3	
	Net NPS		-3,690.4		+14,135.8		-1,614.4		-30,258.4		+48,197.0		-86,322.6	
TP, mg/L --- Instream Target = < 0.075 mg/L														
N	199	97	95	99	94	99	207	98	131	99	14	98	29	98
Min	0.030	0.029	0.049	0.005	0.060	0.051	0.018	0.035	0.022	0.038	0.074	0.033	0.076	0.010
Mean	0.164	0.137	0.101	0.102	0.137	0.142	0.119	0.111	0.112	0.094	0.116	0.097	0.118	0.081
Med	0.100	0.117	0.090	0.077	0.135	0.122	0.111	0.107	0.100	0.088	0.104	0.083	0.100	0.078
Max	0.900	0.410	0.270	0.910	0.300	1.400	0.430	0.229	0.400	0.236	0.263	0.620	0.471	0.190
TP, lb /day – Point Sources & Nonpoint Sources														
PS-1990	-		5.1		177.7		3,456.3		83.3		786.4		0.0	
PS-2000	-		3.3		204.4		3,462.0		101.7		973.7		0.0	
	Net PS		-1.8		+26.7		+5.7		+18.4		+187.3		0.0	
NPS-1990	-		993.8		1,217.0		1,684.8		1,381.2		2,072.1		525.2	
NPS-2000	-		407.2		1,374.6		1,345.6		1,524.9		1,278.9		210.6	
	Net NPS		-586.6		+157.6		-339.2		+143.7		-793.2		-314.6	
E. coli, cfu/100 m L														
N	-	96	-	100	-	98	-	97	-	99	-	97	-	97
Min	-	0	-	1	-	1	-	1	-	1	-	1	-	1
Mean	-	3	-	15	-	14	-	25	-	21	-	7	-	7
Med	-	1	-	2	-	10	-	10	-	8	-	4	-	4
Max	-	50	-	980	-	80	-	500	-	687	-	110	-	52
Summary of Point Sources														
PSs	-		1 POTW 0 Aquac		1 POTW 10 Aquac		3 POTWs 46 Aquac		0 POTWs 7 Aquac		1 POTW 13 Aquac		0 POTWs 0 Aquac	

Descrip Stats = Descriptive Statistics. TSS = Total Suspended Solids. TP = Total Phosphorus. E. coli = Escherichia coli bacteria. Aquac = Aquaculture fish farm.
Values for TSS, TP and E. coli taken from USR Five Year Review (April 2010), Table 19, page 36.
PS-1990 = Point Sources Baseline Load 1990-1991.
PS 2000 = Point Sources WLA After 2000/2005
NPS-1990 = Nonpoint Sources Baseline Load 1990-1991.
NPS 2000 = Nonpoint Sources LA After 2000/2005
TSS, tons/year – Point Sources & Nonpoint Sources from USR Five Year Review, Table 4, p 12.
Net PS = PS-2000 – PS-1990; Net NPS = NPS-2000 – NPS-1990.
The 6 Snake River segments are offset to the right in the table. Thus, Segment 1 (MD-PF) would be shown as Net values

below the PF, and so on. Summary of Point Sources comes from Appendix B, USR Five Year Review (April 2010).

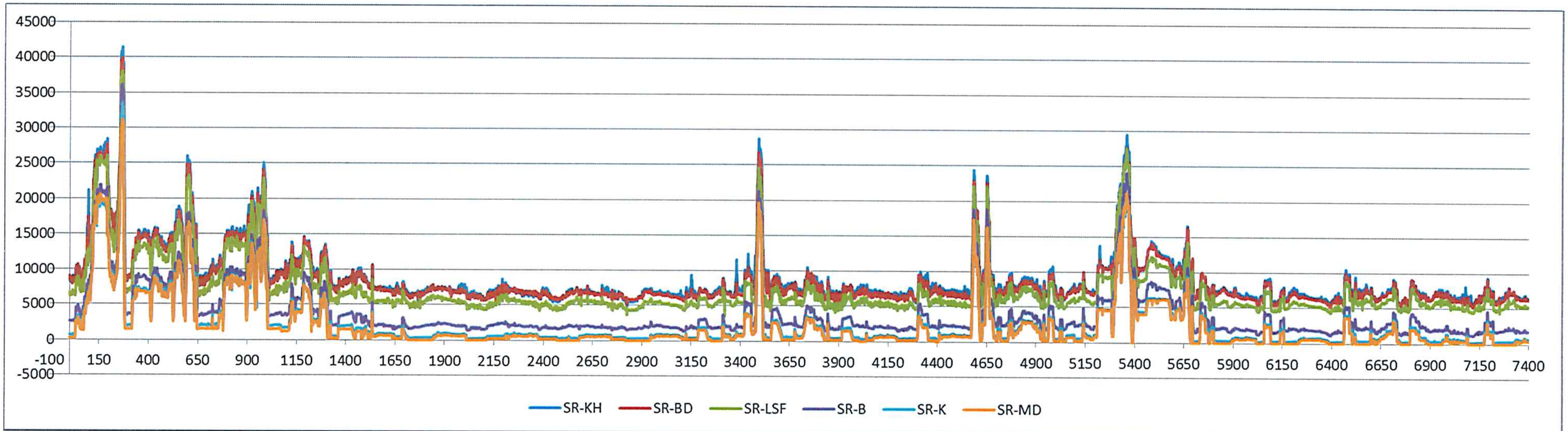
Other parameters:

- Temperature
- Nitrogen

V. Exploring the Scope of the Flow Data

IPC – USGS Flows – 10/01/1996 through 12/31/2016 – Daily Mean Flow

	13154500 SNAKE RIVER AT KING HILL ID	13153776 Snake Riv blw Bliss Dam nr Bliss	13135000 Snake Riv blw LwrSalmFls nr Hagerman	13094000 SNAKE RIVER NR BUHL ID	13090000 Snake Riv nr Kimberly	13088000 Snake Riv at Milner
N	7397	7396	7397	7397	7396	7397
Min	4870	4965	3500	1200	183	0
Mean	8962	8662	7331	3940	2520	2253
Median	7330	7043	5716	2220	871	635
Max	41400	39900	38000	36100	33500	31200



Count

1-92 = 1996	1188-1553 = 2000	2649-3014 = 2004	4110-4475 = 2008	5571-5936 = 2012	7032-7397 = 2016
93-457 = 1997	1554-1918 = 2001	3015-3379 = 2005	4476-4840 = 2009	5937-6301 = 2013	
458-822 = 1998	1919-2283 = 2002	3380-3744 = 2006	4841-5205 = 2010	6302-6666 = 2014	
823-1187 = 1999	2284-2648 = 2003	3745-4109 = 2007	5206-5570 = 2011	6667-7031 = 2015	

Components of Flow in the Mid-Snake River

1. USGS Flow for Mid-Snake River. USGS Flow information that characterizes the current flow conditions in the Mid-Snake River from Milner Dam to King Hill, Idaho. DEQ is looking for the USGS flow information on Gages 13154500 (River Mile 546.0; Snake River at King Hill), 13094000 (River Mile 594.4; Snake river near Buhl) and 13087995 (River Mile 637.0; Snake River at Milner Dam); and the extrapolating the flows for the 94 mile stretch of the Mid-Snake River from River Mile 637.0 (Milner Dam) to River 546.0 (King Hill), or approximately 91 miles and that define the 6 river segments (Milner Dam to Pillar Falls; Pillar Falls to Crystal Springs; Crystal Springs to Box Canyon); Box Canyon to Gridley Bridge); Gridley Bridge to Shoestring Bridge; and Shoestring Bridge to King Hill Bridge). DEQ is interested in various descriptions of minimum flows, maximum flows and mean flows.

   USGS will be assisting DEQ with this component.
   DEQ Technical Services will be assisting DEQ with this component.

2. Tributary Flow Estimates. Extrapolation of flow from the Mid-Snake River (based on item 1 above) and defining the flows for Vinyard Creek, Devils Corral Spring, Dry Creek, Warm Creek, Rock Creek, Crystal Springs, Alpheus Creek, Ellison Creek, Cedar Draw Creek, Niagara Springs Creek, Clear Lakes, Mud Creek, Deep Creek, Briggs Creek, Blind Canyon, Banbury Springs, Box Canyon, Blue Heart Springs, Ritter Creek, Riley Creek, Sand Springs Creek, Salmon Falls Creek, Billingsley Creek, Birch Springs, Stoddard Springs, Decker Springs, Malad River and Power Flume, and Clover Creek.

   USGS will be assisting DEQ with this component.
   DEQ Technical Services will be assisting DEQ with this component.

3. Flow and Load Model Development. Development of an Excel spreadsheet flow model that characterizes the Mid-Snake River in the format in Sections 10.1, 10.2, 10.3, 10.4, 10.5, & 10.6 (2005 USR TMDL Modification), previously noted in item 1; but which also combines the sub TMDLs in order of River Mile location. We are interested in ascertaining the concentration (mg/L) and loads (lbs/day) for TSS and TP from Milner Dam to King Hill and how the various inputs affect the loadings in the river system.

   DEQ Technical Services will be assisting DEQ with this component.
   EPA has provided/or will be providing DEQ assistance with this.

4. Flow Duration and Load Duration Curves Development. Development of a flow duration curve (or exceedance probability curve) for the Mid-Snake River (based on item 1 above); in order to see if a seasonality component to TSS and TP can be formulated for the water user industries. We are also interested in seeing the flow rate (in cfs) versus the fraction of year exceeded (from 0.0% to 100.0%). We want to see each year and how the flows have changed over a period of 10-20 years. And,

we want to know and theorize the relationship between the magnitude and frequency of daily, weekly, monthly (or some other time interval of) streamflow for the Mid-Snake River. A load duration curve would be final component of this component for TP and TSS, so we can see the allowable daily loads and if these have been exceeded.

DEQ Technical Services will be assisting DEQ with this component.
EPA has provided/or will be providing DEQ assistance with this.

5. Groundwater Inputs. One critical component is to estimate spring discharge to the Middle Snake River to potentially accurately predict trends. A study conducted by the Water Resources Board indicated that supply of, and demands for, water are out of balance in the Eastern Snake River Plain and the connected Snake River, and it called for coordinated management of surface waters of the Snake River and the underground waters of the Eastern Snake River Aquifer. We need to know how much actual depletion of water has occurred over the last 10 to 20 years in the Mid-Snake River and what impacts to seasonality or average trends this may have on the flow of the Mid-Snake River. Consideration for both drought and above-average precipitation is necessary; and we need to know this on a segment by segment basis in the Mid-Snake River.

   DEQ Technical Services will be assisting DEQ with this component.
   IDWR will be providing DEQ with assistance on this component.

Snake River Flow = Main Channel Q + Tributary Q + Spring Inputs + Irrigation Returns

Additional Work that
Needs to be done

1. ArcGIS Maps of the overall "umbrella" TMDL; and all of the sub-TMDLs involved. The source material that spells out all of the TMDLs is found at http://www.deq.idaho.gov/media/453119-aquaculture_wasteload_allocations_modification.pdf and specifically in Sections 10.1, 10.2, 10.3, 10.4, 10.5, & 10.6.

2. Macrophyte Mapping. Google Earth Pro mapping of macrophytes in the Mid-Snake River at the Crystal Springs Reach. Is this a doable project? There are questions about nuisance aquatic plant growth that have been raised by the EPA. Is it possible to use Google Earth Pro map between 1993 and 2016 and see if the macrophytes and algae can be viewed to ascertain a percent of cover over the river.

   DEQ is going to attempt ponar sampling of macrophytes for the purpose of getting biomass of macrophytes and particle size distribution of sediments and laden sediments and nutrients.

   DEQ is going to attempt to complete sonar bathymetry of the Crystal Springs Reach using a PDA-type instrument.

VI. Version 14 Database

Version 14 Database

Version 14 Database is the next version (after Version 13) of the TMDL database that was used in the development of the 2005 USR TMDL Modification. However, Version 14 will be expanded as follows:

Pollutants of Interest:

- TSS – concentration and load
- TP – concentration and load
- E. coli – concentration
- Data that covers 2012-2017 (5 years)

Industries of Interest:

- Aquaculture
    1. Production Hatcheries (cold/cool water)
    2. Conservation Hatcheries (cold/cool water)
    3. Warm Water Hatcheries
    4. Fish Processors
- Food Processors
    1. Roast Potato Co. (Eden)
    2. A.C. Enterprises (Hazelton)
    3. IDA-Pride Potatoes (Hazelton)
    4. Heitzman Product Co. (Jerome)
    5. Schutte Potato (Jerome)
    6. J.R. Simplot (Jerome)
    7. Eagle Snacks Inc. (Twin Falls)
    8. TASCO (Twin Falls)
    9. Avonmore West (Twin Falls)
    10. Seneca Foods Corp. (Buhl)
    11. Independent Meat (Twin Falls0
    12. Jerome Cheese (Jerome)
    13. Western Idaho Potato (Jerome)
    14. Russet Valley Marketing (Kimberly)
    15. Keegan Inc. (Twin Falls)
    16. A.E. Staley Mfg. Co. (Murtaugh)

- Industrials
    1. Those associated with Municipalities (Pre-treatment facilities)
    2. Those not associated with Municipalities

- Municipalities
    1. City of Hansen
    2. City of Twin Falls
    3. City of Jerome
    4. City of Hagerman
    5. City of Buhl

6. City of Filer

- CAFO Industry (Dairies, Feedlots, Calf-Cow Operations, etc.)
    1. NPDES Permitted Facilities
    2. Non-NPDES Permitted Facilities

- Hydropower Industry
    1. FERC licensed facilities
    2. Non-conduit exempt projects

- Irrigated Agriculture

  North Side Canal Company
    1. A Drain
    2. C55 Drain
    3. N42 Drain
    4. J8 Drain
    5. S29 Drain
    6. S/S19 Drain
    7. W26 Drain

  Twin Falls Canal Company
    1. A Drain
    2. Twin Falls Coulee
    3. East Perrine Coulee
    4. West Perrine Coulee
    5. Main Perrine Coulee
    6. 43 Drain
    7. 30 Drain
    8. LQ/LS Drain
    9. LS2/39A Drain
    10. 39 Drain
    11. I Drain

- Grazing – BLM, USFS, IDL & Private land ownership (ISWCC & SCDs)

- Recreation