Symposium Report

Ecological Opportunities for Gravel Pit Reclamation On the Russian River

Exploring ideas and research for reclaiming Old Gravel Pits adjacent to the Russian River.

Assessing ecological opportunities for wetlands and fisheries.

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Symposium Presentations and Panel Discussion

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Symposium Purpose:

This symposium was held to bring scientists, managers, and industry together in a format of invited presentations, panel discussion with a diverse group of national and international experts, and round table discussion among all symposium guests. The goals were to review and compile current knowledge, to identify research questions and needs, and to provide a direction for planners and regulatory agencies on how to most effectively manage gravel pits for the future benefit of the watershed.

Introduction

The Symposium addressed concerns of pit capture and predation, and compared the Russian River and its terrace ponds to other river systems where off channel habitat is re-created in old gravel pits which are serving productively as salmonid nursery habitat. Focusing on seasonal nursery habitat suitability for coho salmon, and perennial habitat suitability for steelhead, Symposium goals were to identify data, information, analyses, and strategies to determine:

- If off channel habitat is diminished or lacking in the Russian River watershed.
- How hydraulic connection of the ponds to the River Russian main channel would best restore seasonal ecosystem functions of nursery habitat for salmonids.
- How traditional pit reclamation regulations and efforts could be transformed to allow natural progression of river processes to create and re-establish diminished ecosystem functions of the watershed by re-creation of off channel nursery habitat.

Symposium Conclusions and Recommendations

The consensus of the Symposium participants is that there appears to be real potential to create productive off-channel nursery habitat for salmonids in old gravel pits of the Russian River if strategically rehabilitated and seasonally connected to the main stem Russian River channel. There were some cautions expressed - not to over commit to pit connection as a reclamation strategy until experimental data can be developed to irrefutably predict success. The general sense was that there appears to be much to gain and little to risk by restoring lost, and generally eliminated watershed ecosystem functions of off-channel habitat with reclamation of the pits; and that in the long term, because the river channel is changing with continued deposition of gravels in the reach adjacent to the pits, causing the channel to aggrade, an hydraulic and geomorphic connection is likely inevitable at some point in the future. To gain the information needed to decide whether to connect pits, under what conditions, and what obstacles need to be overcome, it was generally concluded that the approach should be to experiment, measure, and adaptively manage the process. The main conclusions of the Symposium were:

1) 170 years of Euro-American settlement and development of the Russian River Watershed has resulted in the wholesale loss and elimination of off-channel habitat. Loss of this habitat is likely to limit the recovery potential for ESA listed salmonids, particularly for coho salmon.
2) The pits could to be modified to re-create ecologically productive off-channel habitats, including shallow emergent marsh and open water habitats surrounded by seasonally flooded woodlands and mature seral stage redwood-fir, mixed deciduous north coast forest.
3) With the configuration of the Russian River channel and the adjacent terrace pit mines, pit capture of the river channel is not likely to occur.

4) Predation risks to salmonid populations using off-channel habitat are outweighed by the benefit to population growth provided by nursery habitat if sufficient cover and appropriate conditions are created.
5) Hydraulic connections between the river and pits need to be designed to have the proper function for seasonal fish entry and egress, to be geomorphically stable, and to account for potential future scenarios of river channel migration (sediment transport and flood dynamics, lateral erosion/meandering processes).
6) Water temperature and dissolved oxygen (DO) requirements of salmonids are key considerations in developing reclamation strategies, as groundwater and surface mixing with pit waters will increase and can be managed by the design of hydraulic connections, depth, and varied bottom topography.
7) To avoid anoxic conditions, pits may need to be filled to a depth and with a topography such that wind mixing, groundwater current upwelling, or mechanically driven mixing (such as that by windmills) or other means prevent thermal stratification and seasonal formation of anoxic lower strata in the water column.
8) Filling pits to achieve desirable topography and depth could be accomplished by pulling the isolation levees into the pits, and by natural overbank sedimentation and filling during floods, as has occurred in the Passalaqua Pit of the Russian River between the 1980s and 1990s.

Background

ESA regulatory review of pit reclamation strategies by NOAA’s National Marine Fisheries Service (NMFS) Santa Rosa field office found current proposed strategies of keeping pits hydraulically isolated from river channels virtually ensures entrapment of adult and juvenile salmonids, with storm frequency and magnitude causing levee overtopping being the arbiter of impact on ESA listed populations. However, research from locations in California, the Pacific Northwest, Alaska, British Columbia and Europe document the use of, and nursery value of off-channel habitats for anadromous salmonid populations; with old gravel pits and analogous man made habitats connected to main river channels serving the ecosystem functions of seasonal and perennial off channel nursery habitat (See Table 1 attached at end of report).

A body of literature describes potential impacts of gravel pit terrace mining to salmonid habitats. Described in the literature are negative effects of deep pits being captured or incorporated into channel and floodplain systems (e.g. Norman, et al 1992; Kondolf, 1994, 1995.). Within California, the primary research on the effects of riverside gravel pits on salmonid populations has occurred in the lower foothill reaches of central Sierra Nevada rivers (Merced and Tuolumne Rivers). In these systems the primary restoration strategy has been to isolate and/or fill and eliminate riverside gravel pits that support warm water predator species (EA, 1992; McBain and Trush, 1995, 1999). These strategies have been employed based on an assumption that predation would have a significant adverse impact on salmonid populations. These assumptions and strategies have been interpreted by resource agencies to apply equally to coastal river systems such as the Russian River, systems with quite distinct climactic and hydrologic regimes, geology, river morphology, and life history patterns of salmonid use than that found in the Central Valley rivers where these semi-isolation strategies originated. Virtually no information exists on actual predation effects in gravel pits on salmonid populations in the Russian River, and virtually none to support a conclusion that predation would preclude pits incorporated seasonally into the river system from providing the ecosystem functions of off channel nursery salmonid habitat as documented in river systems of the Pacific Northwest. Thus the key unanswered questions considered by the Symposium regarding potential use of the reclaimed pits by salmonids were:

- predator consumption rates of salmonids within the ponds;

- seasonal predator population dynamics: i.e. which predator species occur where and when, and primary prey in those locations;
- how predator population dynamics overlaps with salmonid life history patterns of growth, freshwater migrations, and seasonal habitat utilization;
- the effect of juvenile salmonid size and growth rates on vulnerability to predation; and
- predator species population responses to seasonal habitat dynamics.

With such a large degree of uncertainty, and a pressing need to identify more benign alternatives for reclamation of old riverside terrace pits, NMFS convened the Pit Symposium with specific focus on the Russian River, bringing in national and international experts to present research regarding natural and man-made off channel habitat functions and documented impacts on salmonid populations. Thus the Symposium was organized to provide the scientific and regulatory agencies the tools to develop new vision for reclamation of 800+ acres of Russian River gravel pits currently known to be a population sink for threatened and endangered salmonid populations.

Symposium Program

The Symposium Program format included a half day session of research presentations, an afternoon participant discussion with an expert panel focused on specific questions, and a final session to list key findings, conclusions and outline subsequent actions. The program began with an introduction by co-host Dr. Brian Cluer, Fluvial Geomorphologist for NMFS discussing Symposium purpose and background and introducing the key issues and concepts for Symposium participant discussion and consideration.

Three main issues were identified for Symposium consideration, and for assessing subsequent research needs:

I. Geomorphic Effects: The potential risks and implications of diversion of the river into the pits (pit capture), ranging from streambed disturbance, to effects of the current periodic breaching and overtopping;

II. Salmonid Population Reproductive Success: The risks and rewards of salmonid use of off channel pits with regard for potential stranding (isolation) and/or predation, versus seasonal access to off channel habitat for refuge from floods and riverine predators, and access to seasonally highly productive aquatic ecosystems with abundant food resources documented to accelerate growth, increase marine survival, and thus increase the adult populations.

III. Habitat Suitability and Potential side effects: Potential water quality effects, including:

a) Seasonal water temperature and dissolved oxygen regimes in the pits, the potential suitability as seasonal salmonid habitat for various life history stages, and potential seasonal effects of surface warmed water in pits comingling with high groundwater inflow rates and river surface flows.

b) Eutrophication due to nutrient loading by waste water discharges, fertilizer runoff, and other related water quality and contamination issues.

Context and Background of Russian River Gravel Pits

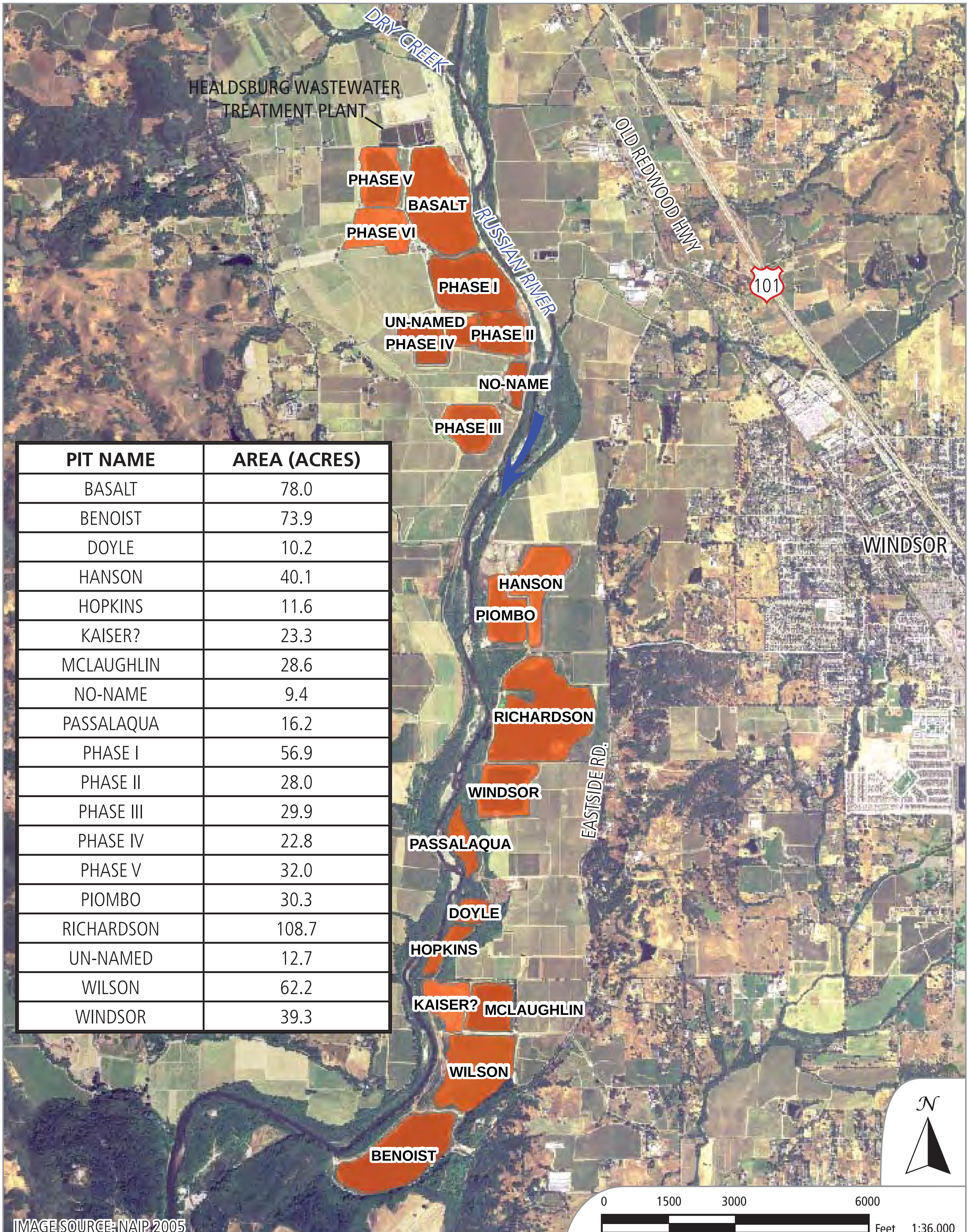
The Russian River (1,400 mi^2 drainage area) flows through three alluvial valleys underlain with gravel deposits that are typically 30-80+ feet deep. Over the past

50 years, private mining companies have mined these floodplain deposits for construction grade aggregate in the Ukiah and Middle Reach Valleys downstream of Healdsburg at rates exceeding 1 million tons per year. This mining immediately adjacent to the river has left deep pits that exceed the depth of the river channel in some cases.

Figure 1a and 1b show the locations and names attributed to the pits and their proximity to the Russian River channel. In most cases, only a narrow strip of land typically at least 200 feet wide separates the river channel from the pits. Figure 2 shows a cross section of the Basalt Pit from riverbed to pit bottom. The Basalt Pit has experienced overtopping and breach events during large floods occurring in 1995, 1997, and 2006.

A key issue identified the Russian River as channelized in many of these areas; the pits are located within former active river meander zones where lateral erosion and meander migration would occur. Currently instream gravel mining, vegetation removal and levee maintenance are required to prevent channel aggradation, overtopping and levee breaching events. Without this channel maintenance, the river will likely over time, or in a single large event, return to its former wider and shallower form engulfing and incorporating the gravel pits into the active channel.

The California Surface Mining and Reclamation Act (SMARA) requires the project owner prepare and implement a post project reclamation plan ensuring future beneficial use of mined lands. In the case of the Russian River gravel pits, original reclamation plans stipulated allowing the Russian River to flow into and deposit sediment that would naturally refill the pits. This approach was changed to keeping the pits isolated in the 1980s. The changed “reclamation” strategy was based on concerns that linking pits to the river would cause streambed capture, induce downstream channel instability, and potentially impact groundwater flows by “plugging” aquifers with fine sediments. Additional



PIT NAME	AREA (ACRES)
BASALT	78.0
BENOIST	73.9
DOYLE	10.2
HANSON	40.1
HOPKINS	11.6
KAISER?	23.3
MCLAUGHLIN	28.6
NO-NAME	9.4
PASSALAQUA	16.2
PHASE I	56.9
PHASE II	28.0
PHASE III	29.9
PHASE IV	22.8
PHASE V	32.0
PIOMBO	30.3
RICHARDSON	108.7
UN-NAMED	12.7
WILSON	62.2
WINDSOR	39.3

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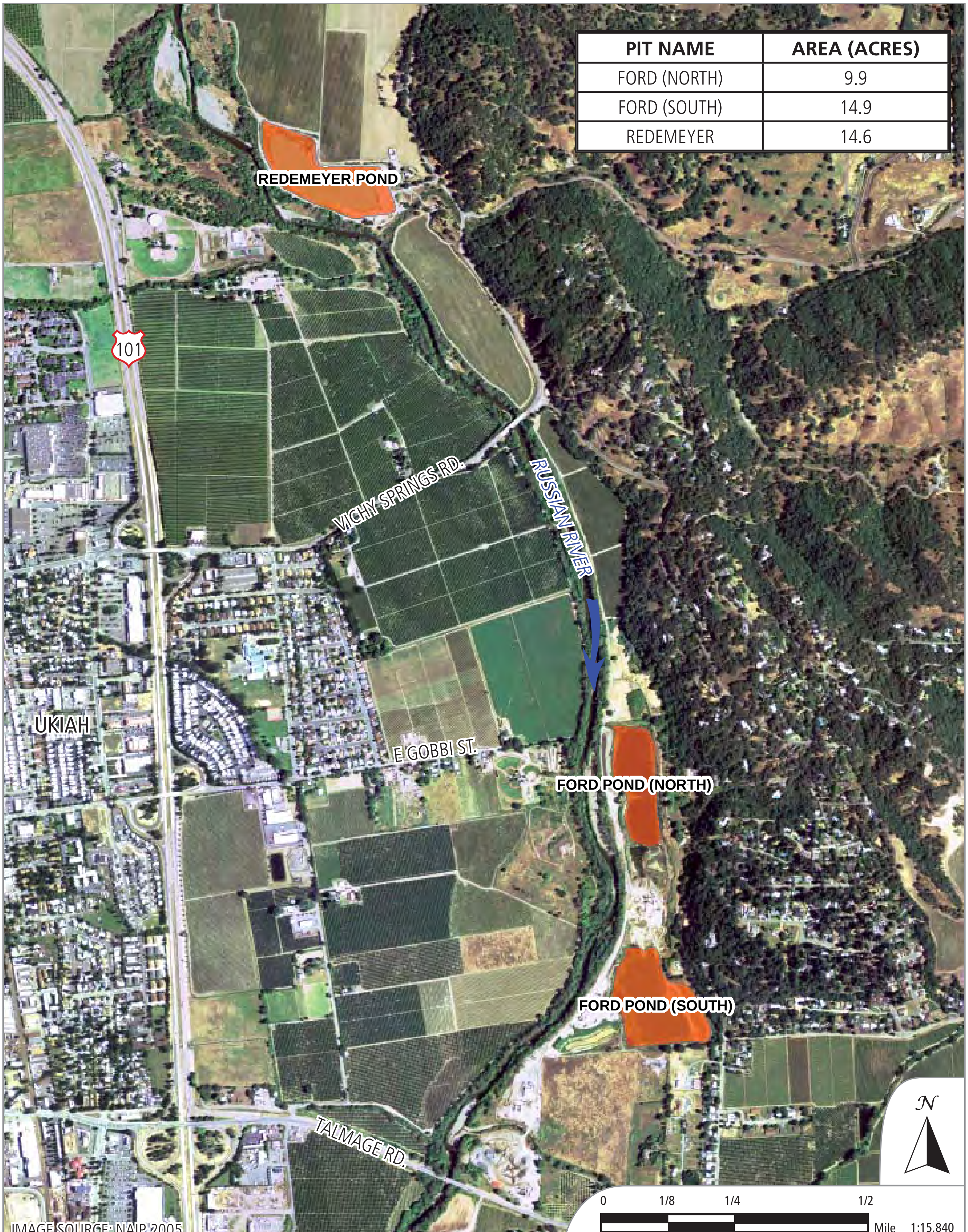
FIGURE 1a: Pit locations and surface areas along the middle reach of the Russian River, south of Healdsburg, Ca.



PIT NAME	AREA (ACRES)
FORD (NORTH)	9.9
FORD (SOUTH)	14.9
REDEMEYER	14.6

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FIGURE 1b: Pit locations and surface areas along the Russian River, east of Ukiah, Ca.

Russian River Middle Reach

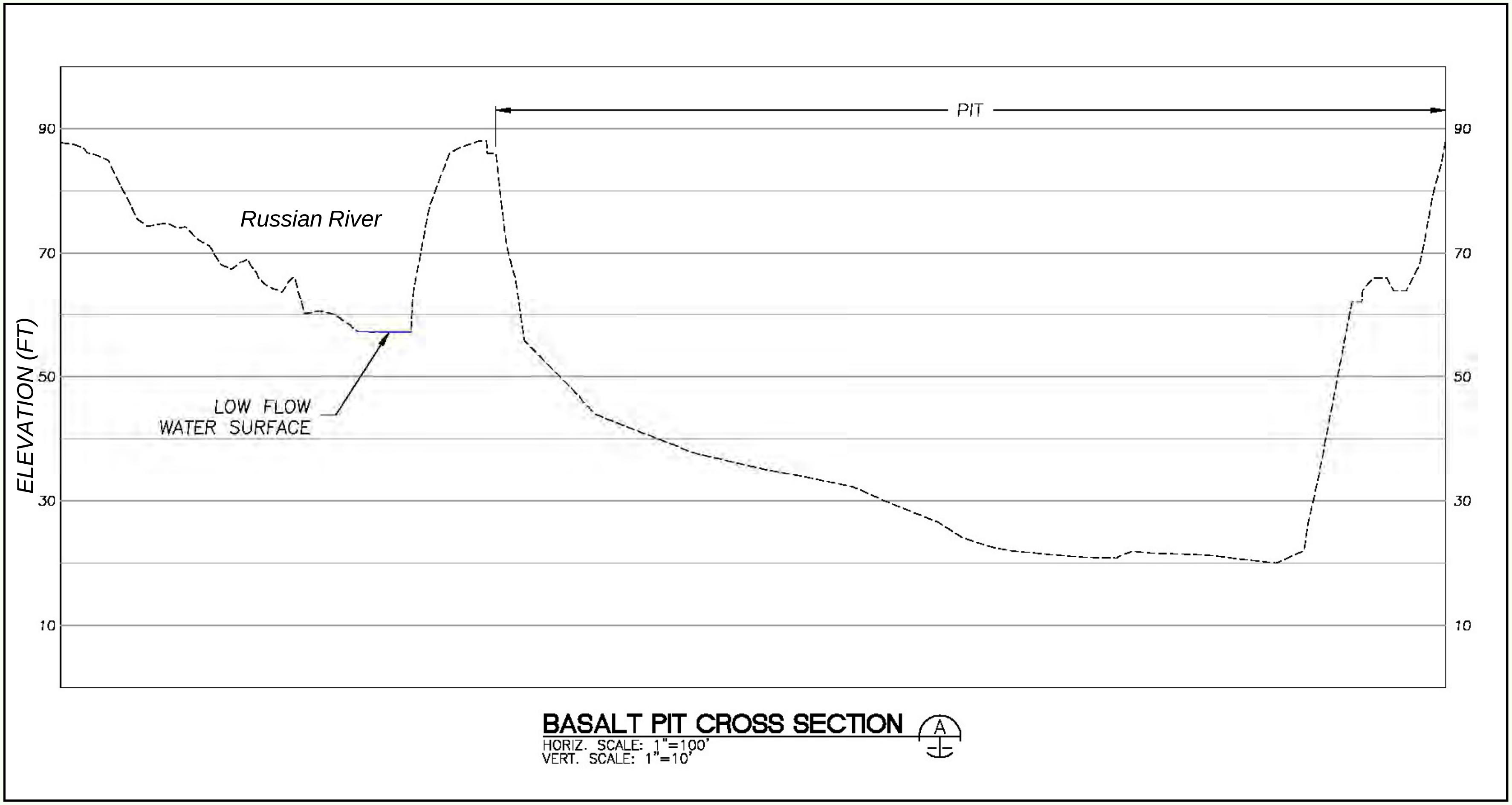

Figure 2: Cross Section of Basalt Pit and the Russian River from east (left side) to west (right side). Note depth of pit (minimum elev 20 feet) to Russian River thalweg near 50 feet.

concerns are that the pits strand salmonids and create warm water predator nurseries that increase predation on salmonids in the main river.

The current prescribed approach to pit reclamation is now to increase frequency of pit flooding, yet hydraulically control levee overtopping events from the river channel by installing weirs, which handle both inflow and outflow. Use of weirs was conceived in the aftermath of numerous levee breaching events, which have occurred repeatedly in some cases. The earthen berms acting as levees isolating pits from the river are subject to erosion and breaching during overtopping events, lateral channel erosion, and subsurface seepage forces. Overtopping events have become more frequent than originally anticipated due to inaccuracies in flood mapping and hydraulic studies, and the loss of river flood channel capacity due to gravel deposition, vegetation growth, and minimal to no channel maintenance.

Weirs would allow overflow into a pit during flood events. The intent is to build a weir large enough, and low enough that flood inflow allows pit water surface to equilibrate to the rising channel flood stage. This is to prevent an overtopping event, which without weir inflow equilibrating river and pit water surface elevations, can precipitate a levee breaching event, because the pit water surface elevation is so much lower than the river floodstage when the levee is overtopped. To limit the length of the weir to 500 feet (due to cost consideration), it must be designed to start overtopping low enough to insure adequate time for filling of the pits prior to river flood stage cresting the levees. Thus the weir must be designed to allow inflow to pits at between the one-and-a-half, to two-year recurrence interval flood. The weirs must be designed and constructed to withstand the force of water plunging into the pit as a cascade, sometimes over 15 feet.

Several aspects of this approach are problematic over the long term.

1) The pits are a long term liability as the weir and nearby channel must be maintained over an indefinite time into the geologic future in order to retain the designed operation;
2) Isolating the pits hydraulically and without low flow outlets back to the river channel ensures fish that do enter the pit in a flood event will most likely be stranded and lost to the population (adult and juvenile fish);
3) Although the intent is to minimize overtopping events to avoid levee breaching, stable weirs must be designed to spill into the pits at almost yearly frequencies in order to be stable and cost effective. Thus the frequency of stranding salmonids in the pits will be increased by between 4 to 20 orders of magnitude.
4) The pits will persist over a *geologic time scale* within the river corridor, serving little watershed ecosystem function, and with only limited wildlife habitat value.

Setting the stage for Symposium

The recognition of these long term problems with the current prescribed approach led to the convening of the Russian River Gravel Pit Symposium as an exploration of alternatives that might facilitate reclamation of the pits into valuable off channel habitats; with the potential for restoring lost watershed ecosystem functions documented to be critically important in maintaining stable salmonid populations. Installation of weirs is expensive, and as outlined above, not necessarily sustainable, nor an action that would improve the ecological functioning of the river system. The impetus for the Symposium was to have top researchers with experience in gravel pit issues, and floodplain use by fish, consider what opportunities exist to integrate pit reclamation on the Russian River with restoration of wildlife habitat, river stability and predictability. The Symposium was designed to be a scientific forum, but it also brought together regulators and planners who are charged with carrying out public policy.

Symposium Abstracts

Floodplain Gravel Pits and the Russian River, Symposium Purpose and Intentions.

Brian Cluer, Ph.D.
Fluvial Geomorphologist, NMFS Habitat Conservation Division, Santa Rosa, CA.

The conventional management of floodplain gravel pits is to excavate them near river banks and then in the retirement phase construct an engineered weir and fuse plug to control when the river flow enters the pit, and to control scour of the connection. The elevation of the weir, and the flow at which it becomes active, are determined by the size of the pit, cost of the weir, and the stability of the bank under scouring conditions. Large pits present fiscal and physical challenges, and increased risks to fish. Also, the weir elevation, once constructed, is static and its hydraulic connection (flooding level) is known at the time of construction. But the river bed is not static and the frequency of river – pit connection can change dramatically on decadal time scales. So the ill effects of capturing and trapping fish during the hydraulic connection can become more frequent than originally intended or designed, or the risk of weir scour can increase. The ongoing responsibility for pit and weir management may be as little as 10 years by Sonoma County rules. With no physical process for refilling planned as part of the reclamation strategy, floodplain pits separated from their river are essentially geologic features that may endure on the landscape for 100's of thousands of years, if not longer.

Pits trap fish during even brief hydrologic connectivity, and without special out migration provisions in the design, the fish will not contribute to the river's population. Floodplain pits represent a risk to Endangered Species Act (ESA) listed salmonids that may last millennia. However, there is potential that properly constructed floodplain pits can benefit fishes and other aquatic species. Located at river's edge essentially, many pits intersect cold groundwater sources, and with carefully considered and creative reclamation, could potentially provide fish access to and from productive off-channel feeding and rearing habitat, an entire class of habitats that are no longer widely available in the Russian River watershed.

In this symposium we intend to explore what is known about the local Russian River pit settings from physical, biological, and chemical perspectives. Three main areas of concern are presently known:

- Pit capture (diversion or avulsion of the river into the pits), and associated geomorphic processes, are the main physical science issue, with pit partial refilling/re-contouring an opportunity to explore.
- Fish production concerns are two fold; can the pits become a source or sink for salmonids due to hypothetical predation, and access/egress concerns.
- The third concern/issue is water quality, where mercury methylization, water temperature, and dissolved gases are the key, and where refuge from floods and

subsequent refuge from persistent river suspended fine sediments is an opportunity.

The local pits will be compared to other pits, and other natural analogs in settings with similarities and differences. In this symposium, we intend to explore the potential, and limitations, of integrated hydraulic connections between terrace pit mines and the river, and creative grading to reclaim the pits to functioning off channel aquatic habitat. Additional information and research needs will be identified to address the feasibility of incorporating abandoned pits into a productive re-creation of lost aquatic habitat features, rather than isolating them from the river.

Historic Off Channel Habitat in the Russian River Basin: An Estimate of the Original Geomorphic and Hydrologic Setting, Ecological Function, and Opportunities for its Creation.

Mitchell Swanson,
Swanson Hydrology + Geomorphology, Santa Cruz, CA.

The ecological function of floodplain wetlands hydrologically connected to main stem rivers has garnered the interest of biologists with regard to the available aquatic habitat mosaic and the population and reproduction dynamics of fish and terrestrial wildlife. Recent investigations of rearing salmonids in emergent marsh wetlands found along river floodplains of California Central Valley rivers such as the Cosumnes and Sacramento have found higher juvenile growth rates chinook and steelhead as compared to those rearing in main stem river channels. Similar functions have been identified in emergent marshes and lagoons of coastal estuary systems. The main advantages appear to be abundant food, which offset high temperatures, and cover from predators. Many off channel habitats along river systems have been completely lost or severely degraded by hydrological modifications associated with historic Euro American period land reclamation in the late 19th and early 20th centuries.

The Russian River basin supported significant off channel floodplain wetlands prior to 1900, mostly associated with the constricted valley drainage outlets of tectonic pull-apart basins. These included: the Laguna de Santa Rosa wetlands complex at the west end of the Santa Rosa Plain, which drains into the Russian River mainstem through Mark West Creek; and floodplain wetlands associated with downstream end backwater zones above the outlets of the Lower Alexander and Middle Reach Valleys. Laguna de Santa Rosa is historically well documented as a series of perennial lakes, which were probably seasonally connected and fed by several tributary streams that still support salmonid spawning; the timing of lake expansion and connection would have likely coincided with periods of juvenile salmonid migration and thus provide opportunities for ad fluvial rearing. The lower valley wetlands along the main stem Russian River are associated with scour and lateral migration of the Russian River channel during large floods and bedload transporting events; these have been largely destroyed by a take over of agricultural lands, but relicts still appear as slough channels, oxbows and low areas isolated and blocked by overbank sediment deposits. These features appear to have intersected shallow groundwater in summer periods while connecting to the main stem river during winter overbank flood events, again within the seasonal timing of salmonid migration.

Aside from the key issues of predation and water quality concerns, the opportunities to create off channel habitat in these historical areas is constrained by private land ownership and the high economic value of farmlands. Gravel pits offer an alternative to create emergent marsh floodplain wetlands and shallow shoals connected hydrologically to the main stem river and restore off channel habitat function. In addition, significant restoration of riparian forest and other valley floor habitats is possible given the potential to create gradients of landscape and soil water interfaces. As lateral erosion, meandering processes have been suppressed along most of the Russian River, geomorphic and hydrologic conditions appear highly favorable to manage river channel pit capture and to create the proper seasonal flooding cycle of the original systems for marsh and habitat development. In addition, there are opportunities to naturally create restored marsh through overbank sedimentation of fines and dynamic prograding deltaic processes. Several concepts have been prepared for existing and proposed pits and the potential exists institutionally for careful, research guided adaptive management, experimentation and hypothesis testing.

Importance of Off-Channel Habitat, Migration, and Salmonid Life History Stages.

Sean A. Hayes Ph.D.
Research Fishery Biologist, NMFS Southwest Science Center, Santa Cruz, CA.

Work from Scott Creek, a small coastal watershed in central California has provided insights on the challenges faced by coastal salmonids. Based on results from both steelhead and coho salmon, it is has become clear that summer through fall seasons in these coastal watersheds can be especially challenging to fish for several reasons associated with low flow, shallow/narrow stream channels and warmer summer temperatures. Preliminary work on avian predation indicates the stream is probably at carrying capacity for predators. Age 0 juvenile densities drop off rapidly during fall months and are probably due in part to low flow, clear water with limited refuge habitat making fish more susceptible to predation. Growth has been shown to be much slower during summer and fall months in comparison to winter and spring. Seasonal studies of diet and invertebrate community composition are underway and we hypothesize that there is probably a reduction in available forage associated with shrinking stream channels. In addition, data from fish carrying temperature loggers suggest there is limited thermal refuge in these habitats and fish are potentially at the mercy of varying stream temperatures. While warmer temperatures do not typically challenge coho salmon thermal limits under the riparian canopy, the elevated metabolic rate under reduced forage potential is not an ideal combination. This contributes to an overall small coho salmon smolt size with a mean of 103 mm fork length. In comparison, the minimum smolt size threshold for marine survival of coho salmon returning to the Scott Creek watershed appears to be about 110 mm, based on scale analysis to back calculate size at ocean entry.

While the Russian River is a larger system, there is presumably a greater challenge placed upon it from loss of off-channel nursery habitat, and agricultural and urban water demands. As such, it is likely that juvenile coho salmon face similar challenges in the upper tributary rearing habitat and would benefit from off-channel habitat improvements that may serve as refuge from both thermal challenges and avian predation, while providing nursery habitat. However, the potential forage benefits and increased risks from introduced predatory fish need to be considered in designing how best to reconnect the river with new off-channel habitat.

Russian River Terrace Gravel Pit Mines, Source or Sink in the Recovery of the River's Salmon and Steelhead Populations

John McKeon
Natural Resource Management Specialist, NMFS Protected Resources Division, Santa Rosa, CA.

Over 800 acres of gravel pit mine "ponds" currently exist on the terraces of the "Middle Reach" of the Russian River (Dry Creek confluence to the Wohler constriction), along with significant additional acreage of such ponds in the Ukiah Valley. Past "reclamation" practices are documented to cause the pits used by Sonoma County Water Agency for aquifer recharge to act as a sink for Federally protected salmonid populations.

Analysis of the river's morphology from air photos indicates there has been a wholesale loss of off-channel habitat throughout the basin even in just the last 70 years. The loss of this habitat is considered a significant factor in the decline of the river's salmonid populations, particularly for coho salmon (*Oncorhynchus kisutch*).

The role of off-channel habitat in salmonid life histories is documented in the scientific literature to include refuge from floods, drought, temperature extremes, and predators. It has also been documented as highly productive winter and summer rearing habitat; at times supporting much higher densities and growth rates than main channel habitats; with relatively small areas of off channel habitats having been shown to produce outsize percentages of a watershed's production of coho salmon smolts.

The documented off-channel habitat attributes contributing to salmonid productivity include:

- Extensive shoals and shallows (less than 4 meters deep);
- Complexity of morphologic features (coves, peninsulas, sloughs…bottom topography; *i.e.*, complex and extensive "edge" habitat);
- Areas of emergent vegetation along the margins, submerged (native) aquatic vegetation (SAV) to 4m depths;

- Broad multi-story riparian zone with inundation-tolerant fringe of overhanging and/or trailing vegetation, pro-grading to gallery forest;
- Submerged large and small woody structure; (with all of the above contributing to the “heterogeneity” of habitat)
- Seasonal flooding;
- Access to adjacent floodplain;
- Return access to perennial water as floodwaters recede;
- Perennial and stable temperature inflows provided by groundwater;
- Seasonally appropriate extended-period, or perennial connections to main channels of rivers and streams;

The “reclaimed” Russian River ponds may potentially offer the only opportunity in the watershed for re-creation of significant acreages of off-channel habitat. Other alternatives for restoration of off-channel habitat in the Russian River watershed could be prohibitively expensive due to extreme high land values in this premium-wine grape growing region.

This presentation briefly reviews past and proposed Russian River terrace pit mine “reclamation” practices and the documented and expected use by salmonids. We also briefly review the scientific literature with respect to restoration of off-channel habitat, as well as the biotic, geomorphic, and hydrologic characteristics, and salmonid use of such habitat. We compare this ideal of highly productive off channel habitat, with current characteristics and conditions of some of the existing Russian River ponds. Monitoring data of dissolved oxygen and temperature profiles through a 5 month period are presented which indicates high groundwater inflow rates to the ponds, and preliminarily, that these fundamental physical attributes are capable of supporting populations of rearing salmonids throughout the year.

Our aim is to foster a discussion of the feasibility, research requirements, and potential actions necessary to change an expected trajectory of these ponds as perpetual sinks for salmonid populations, and instead consider the potential to recreate these ponds into off-channel habitat capable of aiding in the recovery of the watershed’s endangered and threatened populations of Pacific salmon and steelhead (*Oncorhynchus mykiss*).

From Aggregate Mining to Restoration in Willamette River Floodplains.

Peter B. Bayley[1], Peter Klingeman[2], and Guillermo Giannico[1]

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Aggregate mining in N. American floodplains often replaces agricultural land uses. A mining operation may last up to one or two decades prior to reclamation, but both processes can be contemporaneous. In this study, we monitored fish communities for six years at three reclaimed gravel-mined properties in the Willamette River floodplain during incipient restoration. Standardized seasonal sampling was completed using gill nets, boat electrofishing, minnow- and hoop-traps, as well as two-way traps in connecting channels. Age 1+ chinook salmon juveniles entered recently reclaimed gravel ponds at moderate to high water levels in the spring. Proportions of hatchery and wild fish in the ponds were similar to those found in the river at the time. Somatic growth was high and survival to age 2+ was significantly greater for wild than for hatchery chinook salmon. Fourteen of 20 native fish species present in the main river channel were found off-channel; while the corresponding ratio for non-natives was 12 of 15. Non-native species were more common in ponds during the summer, but during the relatively short flooding periods the fish community found in the floodplain zone consisted almost exclusively of native fish species.

A mining operation that leaves deep pools with limited floodplain in between will not provide the most suitable off-channel conditions for native fish. While few floodplains can be restored under all ecological and physical criteria, key ecological functions can be restored given a sufficient approximation to natural hydrological variation, and the capacity for local channel migration in the long-term. When planning a reclamation project, floodplain topography and the establishment of vegetation should receive particular consideration. Diversity of aquatic organisms adapted to natural floodplains is associated with a variety of water depths and connectivity of temporary and permanent ponds with the river channel during different seasons. Fish food production is dependent on low-gradient floodplain surfaces between permanent water bodies, as well as the latter. Therefore the proportion of floodplain area that is converted to gravel ponds is as important as their size, shape, connectivity, and distance from the river channel. The foregoing criteria are consistent with the restoration of all floodplain fauna and flora, and an attempt to engineer the landscape for a particular species is not recommended.

Floodplain Gravel Pits as Wetland Habitat: Lessons From the Passalaqua and Richardson Pits on the Russian River, California

Matt Kondolf
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Abandoned floodplain gravel pits commonly intersect the water table, and have developed into wetlands supporting birds and aquatic species in many parts of the world, in some cases by design, in others by hazard. Guidelines from experience in the UK emphasize the need for gently-sloping banks, to maximize the area of shallow water for fish at a range of water levels. Gently sloping banks also favor riparian vegetation establishment because there are larger areas with shallow water table. Fine-grained sediment also favors vegetation establishment because the soil better retains moisture when the water table drops below the root zone of the trees. Pits create off-channel habitats, which have been used successfully as salmon rearing habitats in the Pacific Northwest, but whose suitability for this purpose in California may be limited because higher water temperatures support warmwater species that prey upon juvenile salmonids. Isolating such pits from connections to the mainstem river has been a primary purpose of a multiple river restoration projects totaling about $30 million along the Merced and Tuolumne Rivers, which have many pits, either former in-channel extractions or floodplain pits that were later captured by the river.

Pit geometry exerts a strong control on revegetation potential, as illustrated by vegetation transect sampling on two pits along the middle reach of the Russian River, south of Healdsburg, California, both located on the left-bank floodplain within 100 m of the main channel, and both excavated in the 1970s. Both pits now support woody riparian vegetation along their margins (mostly cottonwoods, *Populus spp*, and willows, *Salix spp*). The Passalaqua Pit is located behind a low natural levee and acts like a high-flow channel of the Russian River: it is frequently inundated by high flows from the mainstem, which enter its upstream end and pass through downstream into another abandoned pit, from which waters freely drains back into the main channel. Passalaqua Pit has been rapidly filling in with sediment, and thanks to this deposition has gently-sloping banks and supports a band of riparian vegetation 22-28m wide. By contrast, the Richardson Pit (located about 400 m upstream) is hydrologically isolated from the main channel by a high, engineered levee, which has breached at about its midpoint, but due to the lack of a outlet, there is no flow-through and river water simply pours through the breach on the rising limb of floods, depositing a delta. The excavated slopes of the Richardson Pit are steep, and thus there is a narrow band along the pit margins with suitably shallow water tables for establishment of woody riparian vegetation. Except for the delta at the levee breach, the band of riparian vegetation along the margins of this pit is typically 5-7m wide.

End of Abstracts

Symposium Discussion and Recommendations

There is little doubt that significant off channel habitat was sustained and widespread historically in the Russian River Watershed; and that most of it has been eliminated by land management activities. Mitchell Swanson began the research presentations with an analysis of historical documentation and geomorphic evidence of off channel habitat extent in the lower Alexander Valley and Middle Reach Valleys including floodplain and low terrace sloughs, and alcoves and oxbows within active channel meander belts. In addition, there is abundant historic evidence of off channel habitats in the original Laguna de Santa Rosa, a large lake and wetland system with perennial cold water lake depths up to 25 feet, which were situated within the Mark West Creek watershed at the west end of the Santa Rosa Plain (one significant finding at the Symposium was linking of the historic lakes to an 1899 observation of a coldwater species of submerged aquatic vegetation near Sebastopol). Recent population studies of juvenile coho salmon conducted by NMFS science labs, California's Coho Salmon Broodstock Program and by the Yurok Tribe on the Klamath system have found complex migration patterns and extensive adfluvial rearing (personal communication, David Hines, NMFS, Monica Hiller, Yurok Tribal Fisheries) i.e. migration away from natal fry-emergent creeks to mainstem tributaries and/or rivers then up into rearing areas of alternate tributaries, creeks and sloughs. This evidence along with archeological and historical accounts supports a developing new understanding that the Laguna, and other lost off channel habitats were likely critical seasonal salmonid habitat and critical population-supporting nursery rearing areas.

Present Extent of Off Channel Habitat

The historical evidence indicates that there was once an abundance of off channel habitats in the Russian Rivers watershed that, with the exception of relatively small features such as alcoves situated within the active meander belts, are now eliminated or isolated. However, key limitations to alcoves as productive habitat within meander belts is their exposure to annual scour, lack of fine sediment soils and mature vegetation, and limited production of food resources. These key characteristics are what enable off channel habitats to become nursery habitat in supporting abundant salmonid populations.

Current Suitability of Gravel Pits as Salmonid Habitat

The physical and habitat characteristics of the riverside gravel pits as currently configured in the Middle Reach near Healdsburg offer limited value as off channel habitat for salmonids:

First, hydrologic connection has been generally limited to levee flood overtopping and breach episodes, with the notable exception of the Richardson Pit, which had a connecting channel that was active each year for about 10 years (mid-1990s to mid 2000s).

Second, the pits are steep-sided and deep with little shoreline and shallows to support shoals, emergent wetlands and seasonally flooded floodplains, all of which are characteristic of productive off channel habitats.

Finally, the existing configuration of the pits present potential challenges for maintaining suitable water quality conditions. However, limited data indicate even without modification, a portion of the water column within the pits (10 - 30 foot depths) likely maintains suitable conditions of DO and temperature for perennial steelhead rearing; and significant ground water inflows at varying rates maintain a reservoir of colder water (11-13 degrees centigrade) in the lower strata of each pond. The full annual seasonal dissolved oxygen and temperature profiles of each pit are not fully documented. The high rates of groundwater inflow likely have a component of underflow seepage from Dry Creek located just to the northwest. However, more data collection is required to understand the seasonal dynamics of how each pit functions.

The best long series data set exists for the Syar Basalt Pit, which is the most northerly pit situated on the west bank just downstream of Healdsburg. The Basalt Pit has unique characteristics in that it is the discharge point for the City of Healdsburg's wastewater treatment plant. The discharges may have negative effects. The plant in 2008 upgraded to tertiary treatment before discharge, though may still load the pit(s) with nutrients potentially contributing to eutrophic conditions. Associated algal blooms and die-offs can cause both hyper- and hypo-oxic conditions, high CO^2 concentrations, and do contribute to capture of solar energy and resulting warming of water temperatures at both the surface and at depths to at least ten feet.

Due to high rates of ground water flow (including nutrients) all the Syar Grace Ranch ponds are likely similarly affected, though to a lesser degree. A major challenge is current pit depths (most greater than 50 feet). With the low dissolved oxygen saturation of high rates of groundwater inflow, and wind mixing of surface strata currently limited to 25-30 feet, an anoxic layer at the bottom of the ponds likely contributes to anaerobic decay and associate water quality issues of possible hydrogen sulfide and methane gas releases.

Thus potential eutrophication, seasonal stratification, lack of circulation at depth, turnover events, and anoxic conditions currently affect seasonal aquatic habitat suitability for salmonids. Temperature (and likely DO) stratification ended Oct 15, 2008 uniformly in all the ponds when temperature profile recording data loggers show uniform temperatures top to bottom. When loggers were installed 5/28/09, ponds were fully stratified. Thus relative seasonal duration of a thermally stratified water column is unknown.

Results and Next Steps:

There was broad agreement by Symposium participants, presenters and by NMFS that off channel habitats were once an important historic element for salmonids under prior unmanaged conditions of the Russian River Watershed. There was also general consensus that loss of these historic watershed features is likely a significant factor limiting recovery of salmonid populations. General Symposium consensus was also formed around the proposition it is worthwhile to seriously consider modifying "reclamation" of gravel pits to restore some of the ecosystem functions generally eliminated from the watershed by the historic wholesale loss of off channel habitat throughout the watershed.

The challenges in doing so include: creating the varied bottom topography, extensive edge and subsurface shoals and surrounding surfaces that support benthic, floodplain, and wetland habitat with depths appropriate to support the temperature, dissolved oxygen, and light conditions appropriate for highly productive off channel habitat. The other major challenge is connecting the pits to the main channel for seasonal flooding and seasonally appropriate surface outflow of groundwater inputs such that the connections provide temporally appropriate linkages accommodating the life history migration patterns of salmonid species, and limit that of predator species. A concern was raised this not affect surrounding groundwater. With smolt outmigration timing occurring at the highest annual groundwater levels in spring, surface outflow to the river would likely only be a fraction of the seepage from the ponds through the gravel levee to the river.

To address these challenges, consensus was formed on the desirability of re-grading the available fill around the pits to create suitable vegetated floodplain and marsh surfaces and subsurface shoals. If the volume of fill available is not sufficient to immediately create extensive suitable shoals, appropriate depths of varied bottom topography and complex edges, the pits being open to overbank sedimentation would allow the pits to naturally fill over time. An excellent analog in the watershed is what has occurred, and is well-documented, at the Passalaqua Pit down river. The effects of having deeper pits connected to the river while they fill with overbank sediments, a process which may require decades, will have to be explored. Another source of fill would be the waste silts of wash water from gravel processing, but this practice was recently suspended due to concern over mercury concentration in waste silts. Process water could provide over 100,000 tons per year of fill. This possibility will be more carefully examined.

Several additional recommendations emerged from Symposium discussions:

1) More data on gravel pit water quality is needed to assess suitability. The primary data needed is the year-round seasonal, incremental-depth water column profile recordings of temperature and dissolved oxygen in different water year types (i.e. wet, normal, dry).
2) Conceptual plans to create the topography and bathymetry for off channel habitats, including cut and fill calculations are needed as well as construction methods and cost estimates. Hydraulic modeling and sediment transport analysis is needed to estimate the effects of overbank sedimentation over time linked to the processes and evolution of the main channel (i.e. future channel with, and without gravel mining and maintenance).
3) Investigate whether wastewater is causing eutrophic conditions in the Basalt Pit, and to a lesser degree, the impacts on the adjacent pits, and whether the city of Healdsburg should seasonally discharge into another location or further upgrade its water treatment before discharge; and
4) Investigate whether gravel wash waste silts can safely be discharged into the Basalt Pit, or other pits, as a means to create the varied bottom topography and edges at desirable depths for habitat, or for use creating complex floodplain features of marsh and/or seasonal wetland/slough habitat.

Geomorphic and Pit Capture Risks

A well-documented effect of gravel mining in active floodplains near rivers is stream capture (sometimes referred to as pit capture), where the channel flows into a pit that is a lower elevation than the original stream profile. Capture means that the river flowline or thalweg, the lowest point in the channel, actually goes into and out of the old gravel pit. Capture can cause a number of negative geomorphic effects, including inducing channel bank and bed instability both upstream and downstream through accelerated erosion, channel headcutting and incision, disruption in sediment transport continuity, and particularly in cases with high stream energy, “sediment hungry water” can increase erosion and degrade habitat upstream and downstream of a pit. In addition to stranding hazards, there are documented cases where rivers flow into pits direct migrating salmon into warm water predator habitat of the captured pits, and where pits become predator nurseries that subsequently invade the main river channel. Finally, there is concern that gravel pits act as heat sources, causing thermal impacts to adjacent river channels.

The Russian River gravel pits along the Middle Reach are deeper than the riverbed, often by 30 feet, are separated by only a narrow strip of land, and as such represent a weak defense against the ongoing risk for pit capture. There have been at least three overtopping and breaching events (1995, 1997, 2005) that partially eroded the embankment separating the pits from the river, however the water elevations between river and pit equilibrated relatively quickly and the driving force for erosion dissipated during the peak flood. However, because of the high degree of channel stability in the Middle Reach, (armored banks and a high degree of lateral stability under present conditions), and hydraulic conditions that do not maintain a hydraulic gradient across the pit surface long enough to fully erode the berm, there have not been actual streambed “capture” events. Floods flow into pits and once the water surface equilibrates with the river, flow ceases and sediment continues uninterrupted in the river.

The recent past suggests that actual pit capture is not likely under present conditions; however future conditions are highly uncertain. The channel in the Middle Reach continues filling with gravel, losing flood capacity and sediment transport ability, and is thus showing signs of shallowing, with a likely eventual result, potentially expanding across the valley floor by meandering. This stems from the recent history of intensive gravel mining and channelization (straightening and deepening) between 1940 and 1970 followed by a 20 + year period of no mining (1987-present). If left to evolve as is, the existing channel may fill with sediment and meander onto the valley floor, and flow into and out of gravel pits. Future avulsion risk with and without instream mining will have to be addressed through hydraulic modeling analysis of sediment transport. It may turn out that the present strategy to keep the river channel and pits separated with weirs for managing flood events will not be a sustainable solution and that a more realistic management strategy will involve incorporating the pits into the active channel. In this case, management should be geared towards having the best outcome in terms of habitat function and water quality.

In the short term, one potential advantage of connecting the pits to the river would be to dissipate the hydraulic forces that make breach episodes difficult to control. Connecting the pits by lowering the levees and allowing the water levels to rise at the same rate as the river can accomplish this. Under present conditions, and under the prescribed conventional reclamation strategy, spill events are minimized, meaning that water in the river is held until a set spill elevation, and this can result in over 15 feet of head (water surface) difference between river and pit. Overtopping flow into the pit comes with great force of a cascade all at once and the main challenge is to control erosion at the plunge pool. To design a weir to withstand overtopping, there is a balance between the width and depth of the weir to control hydraulic force (i.e. to provide armoring and foundation stability) and weir cost. This results in expensive “roller hardened” concrete structures that spill fairly often and must be constructed in the riparian streambank zone which obstructs the already severely compromised vegetation growth. In contrast, allowing a connection between pit and river allows the water surfaces to rise together during a flood such that there is never a large head difference. This essentially eliminates the need for a weir as it minimizes potential hydraulic force. While future lateral migration of the channel into the pits is a real possibility in the Russian River, connection under present channel conditions appears feasible and desirable from a channel stability point of view.

Next steps for geomorphic issues:

1) Assess the hydraulics, sediment transport and geomorphic stability of the Basalt, Phase 1 and No-name pits with and without connection to the main Russian River channel assuming future condition with and without instream gravel mining. Integrate a multiple variable analysis of physical processes and habitat as well as environmental, market and natural resource economic and social impacts and benefits (State of New Jersey Department of Environmental Protection, 2007; Riley, 2009)

2) Develop and analyze a series of pit connection options in order to assess the best scenario for filling by natural overbank sedimentation and to achieve desired seasonal connection timing and duration to accommodate seasonal life history migration patterns of salmonids.

Fish Population Dynamics and Off Channel Habitat

The Pit Symposium created an opportunity to consider and apply new and broader information and research regarding large-scale fish population dynamics and the seasonal or perennial function of off channel habitats as they might apply to the Russian River, with an emphasis on potential population benefits for coho salmon, Chinook salmon, and steelhead.

Based upon a review and presentation of research, there was a general consensus that under the right hydrologic and morphological conditions, off channel habitat provides superior rearing habitat as a result of abundant food resources, refugia from cold and warm water conditions in the main channel, from riverine based predator populations, and high flood velocities and also refuge from turbidity. Population studies presented at the Symposium found superior salmonid juvenile growth in off channel rearing habitats, mainly flooded riparian woodlands, emergent marsh and seasonally flooded wetlands and shallows, some within modified floodplains including agricultural fields and ditches on the Willamette River (Bayley, 2001, 2003, 2004; Bayley, Klingeman and Giannico Pit Symposium Presentation 4 Appendix A) and the Yolo Causeway on the Sacramento River (Sommer, et al 2001a, 2001b) and the Cosumnes River (Moyle, et al 2007). Examples were presented showing functional off channel habitat in connected gravel pits, again with superior rearing habitat for juvenile salmonids as compared to main river channel habitats.

In terms of salmonid fish populations, the general conclusion of researchers is that use of off channel habitats is a risk versus reward trade off. The research conclusions expressed during the Symposium was that fish appear to be adapted to, and likely have a significant survival and reproductive advantage in seeking off channel food resources in naturally productive, shallow wetlands and/or seasonally flooded areas where terrestrial foods such as insects and earthworms, etc. emerge from soils of terrestrial landscapes when flooded. These areas can be natural grasslands, or forests, or modified areas such as agricultural grasslands, fields, and even drainage ditches. Food resources are often concentrated and abundant, and fish appear to actively migrate to them. At the same time, there are risks of *individuals* being stranded away from the main channel and killed by loss of dissolved oxygen, warming lethal temperatures, freezing, desiccation, and/or predation by fish, avian or terrestrial wildlife. However, evidence presented by NMFS researchers (Sean Hayes, NMFS SWR Fisheries Science Lab) shows that even small increases in smolt size mean much greater chance of survival and return from the ocean. Thus, the superior juvenile spurts of growth rates observed in seasonal off channel habitats (e.g. Yolo Bypass and Willamette River) directly lead to greater ocean survival, such that there likely is a significant overall benefit to a *population* by having off channel rearing in nursery habitats, even if only a portion of the population accessing that habitat survives. It is appears likely the appearance of dead fish in off channel locations, or die offs in closed, highly-productive coastal lagoon systems does not necessarily indicate population declines, because the outsized potential for ocean survival will actually increase population abundance of adult returns from sea, despite the losses observed. However, having only smaller, more abundant fish numbers rearing in less productive main river habitats can indicate probable population collapse, due to the low survival rates of such smaller slow growing fish (e.g. the Carmel River on the central coast).

Presentations and discussions at the Pit Symposium spent considerable time considering the habitat conditions that can cause off channel mortality, including stranding and death in high temperatures, low dissolved oxygen, from predation or a lack of entrainment flow (i.e. lack of flow direction to attract fish to escape, etc.). The Russian River pits experience seasonal stratification in dissolved oxygen and temperature that create top and bottom strata potentially unsuitable for salmonids: i.e. too warm surface strata and too little dissolved oxygen at depth. However, at least in 3 of 5 ponds there appears to be a sustained zone of appropriate temperature and dissolved oxygen throughout most of the stratification events of late spring to early fall seasons, while some studies of other pits on the other side of the river suggest such a cool oxygenated zone may not occur on a sustained basis. However wind aspect and fetch, along with rates of groundwater inflow are unquantified in the two studies. Temperature profile monitoring of the Syar Ponds does indicate high inflow rates maintaining very cold bottom layers uninfluenced by surface strata warming through summer and early fall. More information is needed to assess these factors and how thermal and DO stratification would differ seasonally and with various river connections, a varied bottom topography designed to create upwellings of cold water inflow, and with a surrounding mature riparian zone within the North Coast Forest, which 200 years ago was the native seral stage plant community which covered this terrane of low elevation alluvial valleys of high groundwater tables, rich soils and an average of over 30 inches of rain annually (personal communication, Dr. Peter Baye 2009).

A significant observation in off channel studies, notably in isolated gravel pits of the Willamette River (Bayley, Klingeman, Giannico presentation 4, Appendix A), is that hypothetically unsuitable water temperatures for salmonids appear to be offset by abundant food resources. This has also been observed in Chinook and steelhead juvenile fish in the Yolo Bypass studies (Sommers, 2001). There are other observations in coastal lagoons suggesting fish movement in response to late season zones of low dissolved oxygen (Sean Hayes, NMFS SWR Fisheries Science Lab, Presentation 3, Appendix A). It is possible that fish move into high production / high temperature zones to feed and then retreat to deeper, cooler waters (Alice Rich, AAR, personal communication).

Symposium conclusions were that real life fish behaviors are complex, hypothetical temperature thresholds don’t always apply, and success of reclamation of pits as off channel habitat will be dependent on creating conditions that supply salmonids both abundant food resources and thermal refuges in any pit with seasonal connections to the main river channel.

In terms of predation, it was notable in the Symposium presentations and in all of the salmonid population studies of off channel habitats used successfully by salmonids (Willamette, Yolo Bypass, Cosumnes, Yakima), species such as large mouth and small mouth bass and pike minnow were all found present with salmonid species in similar numbers, inferring that losses to predation may not be significant in some cases. In contrast, studies in Tuolumne and Merced Rivers in California, the cases upon which it appears that the recent policies for isolating pits on the Russian River have been based, assumed that high rates of juvenile salmon mortality were occurring where small mouth bass occurred in and around warm water of river-captured gravel pits (McBain and Trush 1999; EA 1992b). The assumption that predation was causing significant losses in Chinook salmon drove restoration strategies and large scale projects ($10 million) that were geared towards filling and isolating pits. But post-project meetings and studies indicate that researchers were still trying to measure whether predation was causing significant losses (TRWC, 2005; McBain and Trush, 2006). Recent predation studies carried out in the Columbia River (Zimmerman, 1999) indicate that though small mouth bass prey on salmonids opportunistically, diet studies indicate foraging behaviors almost exclusively focus on benthic prey, and in which researchers speculated only dead salmonids may have been consumed. Thus, it appears likely there is little data on actual predation rates to base the claim that predation in pits would have a significant effect on survival or reproductive success, or is a limiting factor for population growth. Many of the population studies in these systems have not addressed predation losses specifically, however there are indications juvenile salmonid rearing may occur away from the feeding areas of presumed predators either spatially or temporally, with salmonids migrating and rearing along the fringes of the river channel mostly at night and corpuscular hours. Also, that outmigration of salmonid smolts and ad fluvial migration of rearing juveniles occurs when stream temperatures are low, earlier or later than peak feeding seasons of warm water predator species. In the cases of the Tuolumne and Merced Rivers, it is likely worthwhile to review the population datasets and see if correlation can be drawn with other potential limiting factors that have been identified, mainly streamflow, (Mesick, USFWS, 2008) temperature of reservoir releases, ocean conditions, Bay-Delta conditions [i.e. NH_4 discharges and resulting collapse of the Delta's pelagic ecosystem (Parker, et al, 2009), and reversal of Delta flows to State and Federal Pumps at Tracy (NMFS 2009)], etc.

The Symposium revealed the great complexities to predation on salmonid populations, especially in off channel habitats. One possible explanation for survival of salmonids is that the appearance of small, vulnerable juvenile salmon may precede warming and appearance of warm water predators, and in this time juvenile salmon may grow to a size that enables their escape. Other possibilities are that the characteristics and habitat complexity of off channel habitats, including food-rich shallow emergent cover may allow small salmonids to feed and hide in shallow waters where abundant food may offset temperature problems; and faster growth rates and resulting larger fish may be better able to avoid predation when they migrate into deeper water and intermingle with predator species. It may also be important in some cases that the predator species are not full time resident fish, having to move out of off channel habitats as water recedes. This could explain the difference between permanently connected deep warm water ponds such as the Tuolumne River pools versus seasonally flooded habitats, such as the Yolo Bypass and Cosumnes River. However, the predator populations in the Willamette River Pits were apparently multi-year resident fish, as are those in the pits of the Russian River. It could also be that the productivity in the off channel areas is so high that predators simply are drawn to other food sources.

These are all open questions in our understanding the linkages of available habitat to fish behavior. Yet, the evidence is that of growth and survival of juvenile salmon has been documented while rearing and living amongst similar numbers of native and non-native predators.

Recommendations and Next Steps:

1) Collect more water quality data in the Russian River pits to document dissolved oxygen and temperature regimes over a year. These must be done repeatedly with multiple incremental profile points.

2) Assess whether any pits, such as Richardson or Redemeyer, might be useable for off channel population studies such as conducted in the Willamette River (i.e. two way traps).
3) Assess whether controlled population experiments in the gravel pits might be conducted using pit tagged juvenile coho from the local hatchery (note: there was concern regarding use of hatchery fish due to the finding that wild fish faired better in population studies).

The water quality of the Basalt Pit, and to a lesser degree the adjacent pits, will need to be addressed in light of the treated wastewater discharges made from the City of Healdsburg's wastewater treatment plant. There are indications that these discharges may be overloading nutrients and causing algal blooms, eutrophic conditions, increased solar warming and other related water quality issues.

Table 1: Summary of selected literature regarding species use and habitat characteristics supported by off channel habitats in stream systems for anadromous fish, primarily coho salmon

(Compiled by NOAA Fisheries Santa Rosa Field Office (McKeon and Cluer) and Mitchell Swanson; table compiled by Mitchell Swanson;)

Publication	Location	Hydrologic Setting	Perennial Connection to River?	Topical Fish Species	Physical Characteristics of off channel Habitat	Habitat Dimensions	Habitat Function	Results
Everest, Reeves and Sedell, 1985	Fish Creek, Oregon Cascades west slope, elevation 1200 M	Upper Clackamas River Basin, snowmelt, mountain/canyon bedrock controlled canyon confined; forested	Inferred	Steelhead and Coho Salmon; Chinook and resident trout also present	Created Perennial side channels	200m long (no depth stated, but riffle pool habitat	spawning	Spawning and rearing for all three species, but less density than natural side channels
ibid	Same	same	Inferred	same	Created Off-channel "rearing" ponds	90m by 60 m; d = 0.2-1.25m	Rearing and spawning	Coho smolt production increased 18%
2004 Stream Habitat Restoration Guidelines: Final Draft Washington Dept of Fish and Wildlife	Washington State	Varied; most cited literature from Pacific Northwest; Forested and open alluvial plain	Inferred	All salmonids	Side Channels, Off Channel Ponds Habitat Restoration; commercial gravel pit pond modifications.	Range of average created areas: 4,000 m^2 and 23,000 m^2; coho ponds less than 0.75 – 3.5 m deep; observed use in depths up to 15 feet deep; habitat area 600 – 23,000 m^2 (5.6 acres)	Rearing spawning, multiple salmonid species, predominately beneficial to coho for anadromous spawning and rearing; preference by resident cutthroat trout	Literature review results: use of off channel habitat is species specific; perennial off channel access improves habitat function and reduces entrapment Off channel usually has lower turbidity, greater stability, better temperature regimes, high invertebrate production
Lister and Finnigan; rehabilitating off channel habitat	British Columbia	Coastal Mountain watersheds snowmelt dominated; forested	Inferred	Coho primarily; minor use by Chinook and sockeye; coastal cutthroat trout	Side channels; overflow, side flow, groundwater fed	Depths: 0.25 m minimum riffle depth; 0.50 minimum pond depth	Spawning rearing for coho and cutthroat	
ibid	Same	same	Inferred	same	Off channel ponds	O.5 – 1.5 ha (3.8 acre) area typical size; depths 0.75-3.5 m	Rearing and overwintering	Smaller ponds produce larger numbers of fish than larger ponds; shallows shoals for feeding, deeper pools for winter survival
Morley, Garcia, Bennett, Roni (2005)	Pacific Northwest	Western Washington; west slope Cascades; Olympic Peninsula Skagit River, and British Columbia streams range from snowmelt to coastal rainfall; open alluvial plains, forested floodplains	Inferred	Primarily coho salmon; chum salmon	Side channels, natural and constructed; temperatures range from low of 8C in winter, to 20C peak summer	Surface areas: 0.08 0.67-ha (1.65 acre); depths less than 1.0 m	Coho (90% of fish observed) rearing, spawning	Fish densities (primarily coho) were found to be the same in natural and constructed side channels;

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Publication	**Location**	**Hydrologic Setting**	**Perennial Connection to River?**	**Topical Fish Species**	**Physical Characteristics of off channel Habitat**	**Habitat Dimensions**	**Habitat Function**	**Results**
Bryant 1988	Yakutat, southeast Alaska	Glacial outwash stream setting; no details provided	Yes and some ponds have streams flowing into them.	Coho Salmon	Old gravel pit ponds	Shallows less than 1.0 to pools 3.5 m deep (3-11.5 feet); Areas range between 7,644 (1.8 acres) to 35,000 m^2, (8.6 acres)	Spawning rearing	Good utilization and growth in deeper ponds with shallows for feeding and good food production, but also need depths for overwintering survival
Brown and Hartman, 1988	Carnation Creek, Vancouver Island, BC Canada	Small stream 3.2 km long anadromous fish habitat 10 km^2 watershed area. Winter rainfall dominated flood plain areas.	Ephemeral to intermittent connection to main stream. Seasonally flooded ephemeral floodplain swamps in fall and winter and intermittent tributaries with flow in winter and as isolated as ponds -	Coho Salmon	Natural floodplain wetlands and ephemeral tributaries; "swamps" have dense vegetation, sedges and muck substrate.	Narrow strip of floodplain, overall area 3 km long 50 hectares (123 acres); individual pond areas ranged between 115 and 668 m^2 Depths range from seasonally dry to a minimum of 8 cm for measuring using fish traps; an inference is made to having fish use at shallower depths. Upper ranges of depth not stated.	Juvenile rearing, overwintering	Utilization for overwintering and rearing only in years with early Fall storms when connection occurs (indicates all years above average flow). Use as refugia for winter, high velocities and sediment/turbidity and debris torrent events in main channel. Successful use dependent upon late spring flows to ensure migration to main channel and low trapping and mortaility.
Nickelson, Solazzi, Johnson and Rodgers, 1992	Oregon coastal streams	21 Oregon coastal streams winter storm dominated runoff with constructed habitat in channel and off channel; includes large rivers and small streams directly flowing into ocean.	Yes, as intent of the design but of off channel ponds alcoves constructed into stream banks, however some were blocked access due to debris or low flow (affected fish use)	Coho Salmon	Constructed off channel habitat ponds and alcoves constructed inot streambanks; some had installed logs, "brush" and boulders for cover; no reference to vegetation	No reference to depth; refereed to another reference for stream information (Nickelson, 1992)	Winter habitat for rearing and refuge from high flows	Found use of off channel ponds and alcoves superior to devices in constructed in channel pools (weirs, brush placements, dammed pools

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Publication	Location	Hydrologic Setting	Perennial Connection to River?	Topical Fish Species	Physical Characteristics of off channel Habitat	Habitat Dimensions	Habitat Function	Results
Hall and Wissmar, 2004	Cedar River, Washington	West slope Washington Cascades flowing into Lake Washington; floodplain habitats affected by urbanization and flow regulation; flows provided by spring flow upwelling and tributary inflows	Yes during period of study for spawning (Sept to January)	Sockeye salmon	Off channel ponds on floodplain, one is an natural oxbow pond partially damned by railroad fill; other is an old gravel pit with a levee; in water woody debris	Pond 1: 0.68 Ha (1.7 acre) during summer low flow; depth mean 1.0 m maximum 3.0 m.; 4.8 – 20° C Pond 2 (old gravel pit): 3.8 Ha (9.3 acres); depth 2.0 m average 3.1 m maximum; temp. = 3.3° - 20.7 ° C	Spawning and rearing habitat	Study looked at off channel habitat for spawning versus disturbed in channel habitat. Redd presence was examined through multi-variable statistical analysis, including physical geometric variables, upwelling and cover an distance from shoreline, substrate size and water temperature. Low Do in oxbow pond attributed to primary connection to groundwater may have suppressed spawning; the gravel pit appeared to have upwelling from oxygenated river flows (hyporheic), which may have attracted spawners. Spawners had preference for areas less that 100 cm deep.
Swales and Levings (1989)	Coldwater River, British Columbia, tributary to Fraser River	Off channel ponds in upper reaches of Coldwater River and Nicola River floodplains – termed “unstable” meaning subject to erosion and meandering processes?; snowmelt dominated flow, elevations 1,000M above MSL; flows into ponds are predominately groundwater	Varied between perennial connection and ephemeral. but generally ponds are seeded with coho fry in spring freshet and return to main river in spring freshet; ponds are periodically blocked by beaver dams	Coho salmon, Chinook salmon, steelhead, dolly varden char, mountain whitefish	Off channel floodplain ponds with depth enhanced by beaver dams; high in-pond food invertebrate production and vegetation cover	Small ponds (3) studied: 0.1 – 1 Ha (0.2 – 2.4 acres); depth 0.01 to 2.0 m (.03 – 6.6 feet); with emergent grasses, sedge, and trees; mud/silt substrate. Temperatures pond’s mean 5.5° - 7.7° C (ponds warmer than river in winter and cooler in summer). .	Rearing, overwintering, high flow and predator refugia	Found off channel ponds to be primary rearing area for coho and used by many other salmonid species and char. Appears essential for coho overwintering, especially with low temparature river systems. Note: Makes reference to study by Swales, et al 1986 where coho were found in density of 4,000 juvenile fish per 1 Ha pond.
Publication	Location	Hydrologic Setting	Perennial Connection to River?	Topical Fish Species	Physical Characteristics of off channel Habitat	Habitat Dimensions	Habitat Function	Results

Table 1: Summary of selected literature regarding species use and habitat characteristics supported by off channel habitats in stream systems for anadromous fish, primarily coho salmon

(Compiled by NOAA Fisheries Santa Rosa Field Office (McKeon and Cluer) and Mitchell Swanson; table compiled by Mitchell Swanson;)

Sommer, Nobriga, Harrell, Batham, Kimmerer, 2001	Yolo Bypass, Sacramento River, California	Seasonally flooded wetlands in flood bypass channel, levee toe drain channel; also tributary inflow (Cache and Putah Creeks)	Only winter during overflow flood stages	Chinook salmon (also, splittail and steelhead)	Flooded wooded floodplains, seasonally emergent wetlands, open ponds	Large wetland complex area (1250 Ha overall in Yolo Basin Wetlands; 11 Ha flooded woodland, 75 Ha perennial wetlands; 940 Ha seasonal wetlands) over; depths from shallows >0.1 m to over 5 m in channels; depth and area dependent upon flood volume. Temperatures: 10° - 21°+ C	Rearing; large-scale food production for juvenile fish, notably more dipteran drift. Yolo bypass offers refuge from sterile rip rap main stem river channels and away from areas in Delta subject entrainment by water supply diversion pumping at Tracy, CA	Found higher rates of juvenile Chinook salmon growth as compared to those reared in main channel river. Fish apparently able to overcome higher temperatures with higher available food consumption.
Norman, et al 1992	Washington State Rivers	Large Pacific Northwest Rivers with broad outwash floodplains.	Varies: gravel pit connections ranged from captured to side valley and isolated	Chinook salmon, coho salmon, steelhead	Natural "wall base" wetlands and ponds from river channels, oxbows on wooded floodplains; compared to old gravel pits	Natural off channel "Wall base" wetlands are small (3 acres [1.2 hectares typical]); old gravel pits are much larger 5 to 250 acres [2.0 – 101 hectares).	Natural "wall base" wetlands are key components to salmonid habitat; gravel pits have limited habitat value and impacts to main stem	Gravel pit mining has negative effects on river channels and off channel habitats in terms of river stability, stream temperature, and hydrology.
Washington Division of Geology and Natural Resources, 2004	Eastern Washington State, Yakima River	Large river draining eastern Cascades into Basalt Plateau and the Columbia River	Varies between perennial connection to isolated and rare large flood connection (1996 flood)	Chinook salmon Coho salmon Steelhead, mountain whitefish; predator species northern pike minnow, pumpkinseed fish, etc.	Large old gravel pits on floodplains that are situated in narrow valleys that broaden downstream; channel migration zones range between 600 and 2,800 feet wide	Study of 16 off channel pits, some captured ("avulsed") ranging in area between 1.9 to 150 acres in area (1.6-60 hectares); maximum depth 8 – 33 feet. Pit temperatures ranged between 10° - 25°+ C , increasing in the downstream direction.	Rearing in ponds	Gravel pits can be desirable for off channel habitats for salmonids if water quality conditions are favorable (i.e. correct temperature), which also excludes the abundance of predator species; preference was given to upstream pits that would fill over time and thus shallow areas for northern pike minnow.
Bayley, et al 2001	Williamette River near Eugene, Oregon	Large modified river draining central Oregon cascades and interior coast range mountains, perennial and regulated by dams	Seasonally connected by floods	Chinook salmon and non-game native and exotic species, some predators	Large gravel pits located within the meander belt of the river; vegetated in floodplain forest and wetlands	Two pits studies for fish population and physical change: Harrisburg 22 acres (8.9 Ha) max depth 13 feet; and Endicott 22 acres (13.6 Ha) and up to 27 feet deep at maximum river stage	Rearing in shallow wetlands and flooded shoal areas	Gravel pits showed superior juvenile growth rates for wild Chinook salmon as compared to river rearing fish; fish thrived despite surface water approaching near lethal temperatures which was offset by high food supply.

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PROGRAM

8:30 – 8:45	Sign in, greeting, seating.
8:45 – 9:15	Introduction, Purpose of the Symposium. *Dr. Brian Cluer, NOAA Fisheries - Habitat Conservation*
9:15 – 9:45	Historic Off Channel Habitat in The Russian River Basin: An Estimate of the Original Geomorphic and Hydrologic Setting, Ecological Function, and Opportunities for its Creation. *Mitchell Swanson, Swanson Hydrology + Geomorphology*
9:45 – 10:15	Importance of Off-Channel Habitat, Migration, and Salmonid Life History Stages. *Dr. Sean Hayes, NOAA Fisheries Science Center, Santa Cruz*
10:15 – 10:30	Break
10:30 – 11:00	Recovery of Russian River Salmon and Steelhead and the Role of "Reclaimed" Terrace Gravel Pit Mines, Source or Sink? *John McKeon, NOAA Fisheries - North Coast Team*
11:00 – 11:45	From Aggregate Mining to Restoration in Willamette River Floodplains. *Dr. Guillermo Giannico and Dr. Peter Bailey, Oregon State University, Corvallis OR*
11:45 – 12:15	Floodplain Gravel Pits as Wetland Habitat: Lessons From the Passalaqua and Richardson Pits on the Russian River, California. *Dr. Matt Kondolf, University of California, Berkeley*
12:15 – 1:15	Lunch
1:15 – 2:15	Panel discussion A
2:15 – 2:30	Break
2:30 – 3:30	Panel discussion B
3:30 – 3:45	Preliminary findings
3:45 – 4:00	Wrap up

Symposium:
Ecological Opportunities for Gravel Pit Reclamation On the Russian River

Exploring ideas and research for reclaiming old gravel pits adjacent to the Russian River.

Assessing ecological opportunities for wetlands and fisheries.

Wednesday January 21, 2009

Fountain Grove Inn, Santa Rosa, CA

NMFS-SWR
Habitat Conservation Division

ORGANIZERS:

- NMFS, Santa Rosa Office
- Swanson Hydrology + Geomorphology

SPONSORS:

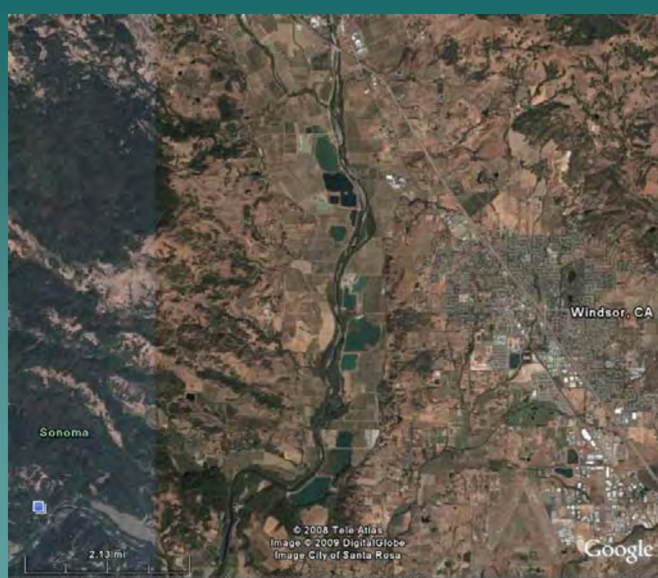
- NMFS Habitat Conservation Division
- Syar Industries
- Granite Construction Materials

Symposium Outline

- Presentations:
  - Introduction
  - Historical view of aquatic habitat in the basin
  - Importance of off-channel habitat to salmonids
  - Use of off channel habitat / man-made habitat by salmonids
  - Experience from the Willamette River pits
  - Restoration potential of Russian River pits
- Panel Discussion:
  - Concerns
  - Solutions
  - Prepared questions and questions from the group
- Expected results:
  - A sense of whether connecting pits has merit
  - List of information needed to proceed
- Symposium proceedings:
  - April

RR near Ukiah

RR near Windsor / Healdsburg



Purpose:
present and discuss the science of managing floodplain pits adjacent to river.

- Symposium intentions
  - Explore what we know about the local pits
  - Explore what's been learned from other settings
  - Explore the concerns and potential for making hydraulic connection
    - Physical processes
    - Biological processes
    - Chemical processes

Conventional thinking:

- Locate pits near river bank,
- Separated by narrow and fragile earthen berm.

Reclamation phase, build overflow weirs, hardened to resist scour.

Allow inflow and back flow without damaging berm.

Design discharge and frequency of flooding.

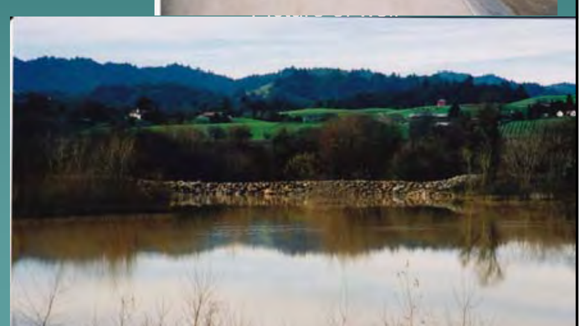
Not static, changes with scour/fill in channel.

Intentions for flood weirs:

- Prevent pit capture of the river, and ensuing channel degradation.

Stable flood weir design:

- Related to;
  - Pit volume,
  - Design flow rate,
  - Geotechnical strength and scour resistance of earthen berm.
- Large pits and weak berms require;
  - Expensive construction,
  - Or
  - More frequent connection to river.



- Conventional thinking
  - Manage for separation from the river.
  - No physical process for filling, essentially a geologic feature, lasting 10's of thousands years, maybe much longer.
  - Ongoing responsibility varies
    - ~20 years by Sonoma county mining permit.
  - Once "reclaimed", performance bonds go away.
  - "Liability phase" begins
    - long term geomorphic, biologic, and WQ liability.
    - The "liability phase", lasting millennia, requires diligent combination of fighting bank erosion and managing the river through fill and scour cycles.
  - Not a long term solution.

Concerns that drive the conventional approach

- Pit capture
  - Geomorphic ripples upstream and downstream
- Water quality
  - Temperature
  - Mercury
  - Groundwater interactions
- Fish
  - Predator source

But with sufficient geomorphic controls, would we rethink our current approach?

- Potentially 100's acres of wetland wildlife habitat adjunct to the river
  - ◆Habitat almost eliminated from the watershed

Potential of reconnecting pits to the river, …..

- Sediment refuge
  - ◆Mainstem has high suspended sediment for extensive periods

Concerns

- Concerns ? :
  - Pit capture
    - Geomorphic ripples upstream and downstream
    - Maintaining channel alignment and capacity
  - Water quality
    - Temperature
    - Anoxic depth
    - Mercury accumulation
    - Groundwater interactions
  - Fish production
    - Source for predators
    - Sink for salmonids

Concerns - Opportunities

- Concerns ? :
  - Pit capture
    - Geomorphic ripples upstream and downstream
    - Maintaining channel alignment and capacity
  - Water quality
    - Temperature
    - Anoxic depth
    - Mercury accumulation
    - Groundwater interactions
  - Fish production
    - Source for predators
    - Sink for salmonids

- Opportunities ? :
  - Geomorphic controls
    - Restoration
    - Grading
    - Controlled deposition
  - Water quality
    - Cold water source
    - Control anoxia, depth
    - Control mercury accumulation
    - Sediment refuge
  - Fish production
    - Habitat and connection favoring salmonids
  - Ecologic restoration
    - Hydraulic connection of off-channel wetlands and riparian.

Symposium Guests:

- Experts in:
  - Fish behavior
  - Fisheries habitat
  - Geomorphology
  - Hydraulics and hydrology
  - Riparian ecology and vegetation
  - Fisheries restoration and recovery
- Representatives from:
  - Government
  - Consulting
  - Industry / Landowner
  - Regulatory
  - Planning

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Presentation 2: Mitchell Swanson

Ecological Opportunities for the Russian River Gravel Pits
Geomorphic and Hydrologic Context

A Review of Historic and Existing Conditions Off Channel Habitat and an Estimate of Historic Function

Ecological Opportunities for the Russian River Gravel Pits
Geomorphic and Hydrologic Context

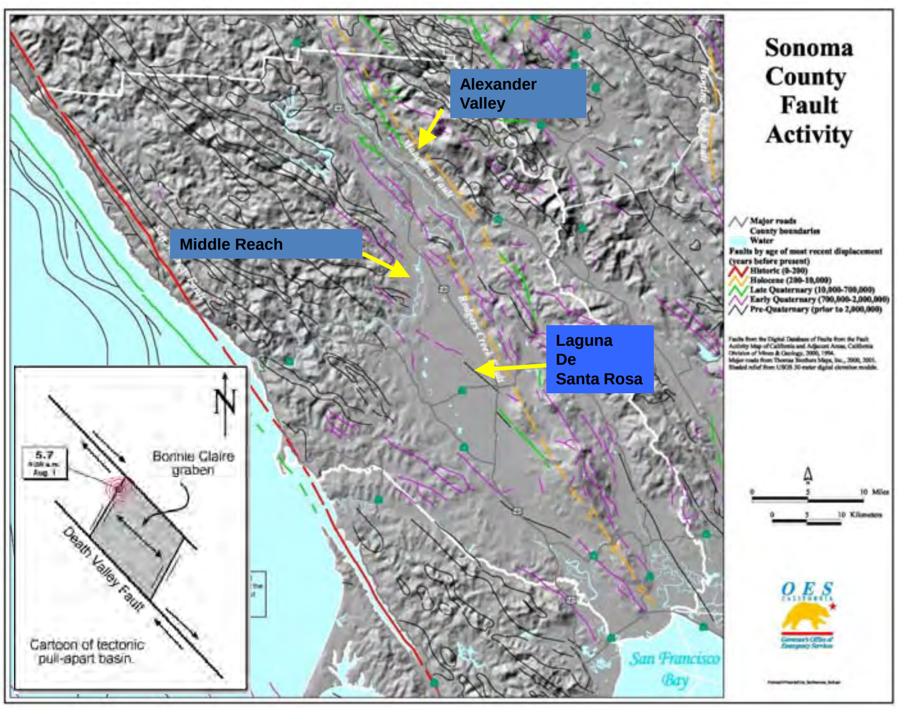
Topics:

1. Historical Evidence of off channel habitats and approximate ecological function
2. Historical destruction of off channel habitats by land use
3. Geomorphic characteristics and existing pits and some observations
4. Opportunities and Research Needs

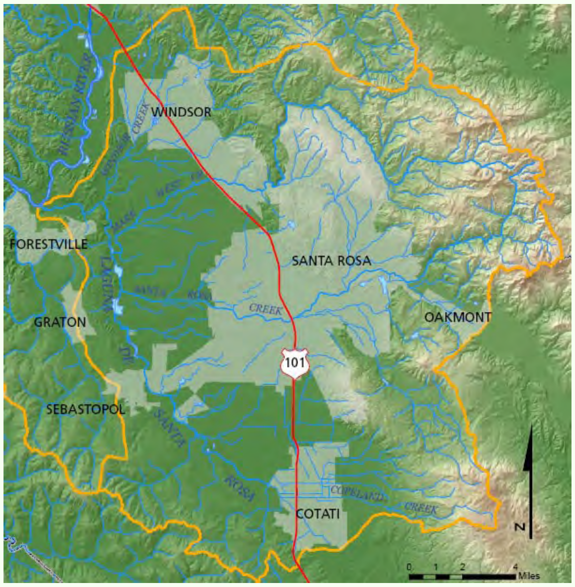
Regional Location

DRAINAGE AREA = 1,485 sq. mi

RUSSIAN RIVER WATERSHED



Laguna de Santa Rosa



Watershed Map

- 260 square miles
- 5 primary creeks
- Drains into Russian River through Mark West Creek
- Lower Creek in backwater of Russian River

Laguna de Santa Rosa

"Historic Lakes up to 25 ft Deep"

14-mile-long waterway, with a floodplain of more than 7500 acres.

Storing up to 80,000 acre-feet of water. For the residents of Guerneville, this can result in a 14-foot reduction in the height of the 100-year flood.

Laguna de Santa Rosa

Plate 9: Quaternary deposits and faults

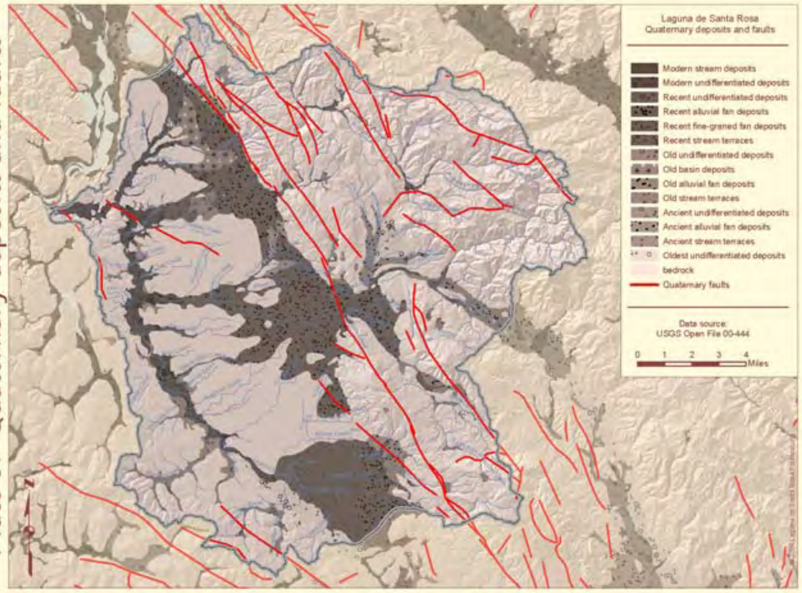


Plate 4: Early diseños and maps of the Laguna

c1842 Llano de Santa Rosa (B-128) courtesy Bancroft Library

1857 Molinos Rancho courtesy Robert W. Curtis

1877 Thompas H Thompson, p42 courtesy David Rumsey

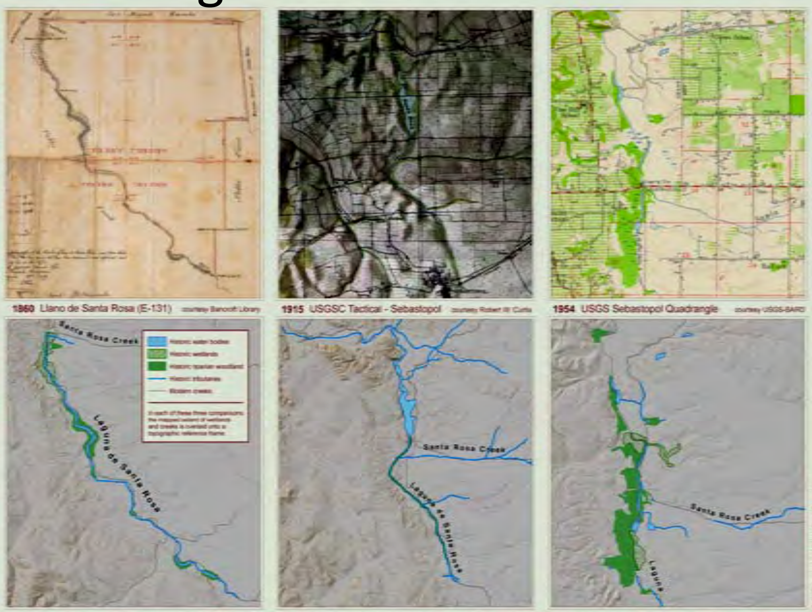
c1845 San Miguel Rancho (B-664) courtesy Bancroft Library

1858 Cañada de Jonive (B-107) courtesy Bancroft Library

1898 Reynolds and Proctor, p44 courtesy David Rumsey

Laguna de Santa Rosa

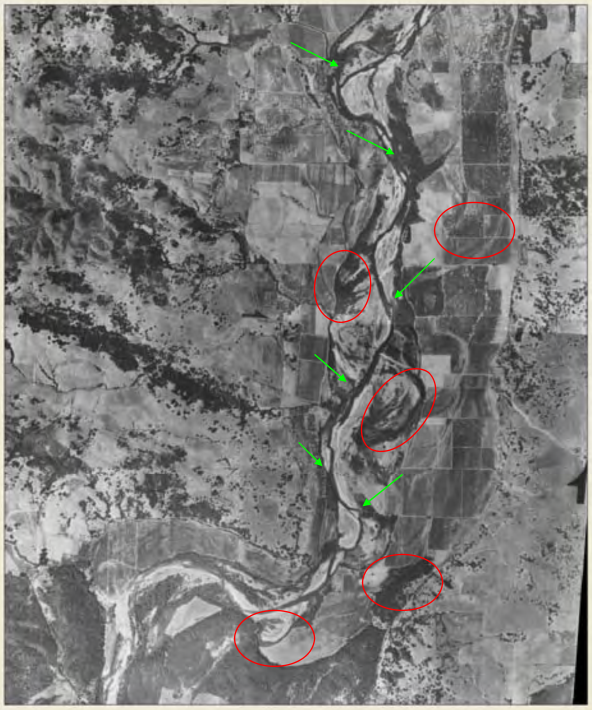
Documenting historic wetlands



Russian River Middle Reach

Russian River Setting
Middle Reach Study Area

- 8.5 miles long from Healdsburg to Wohler Bridge
- Valley floor is an alluvial floodplain built by historic and ancestral Russian River
- Valley outlet is constricted forming backwater control in large floods
- Large gravel bars bisected by a low flow channel
- Banks generally stable but erosion increasing
- Channelization 1800s to 1970; dredged 1940-1970s
- Gravel Mining 1940-2007



Russian River Middle Reach

1942 aerial photo

- Isolated oxbow sloughs / wetlands variable connection during flood events
- Alcoves connected to river on gravel bars mst perennially although pre-dam river dried in summer (pre-1958)

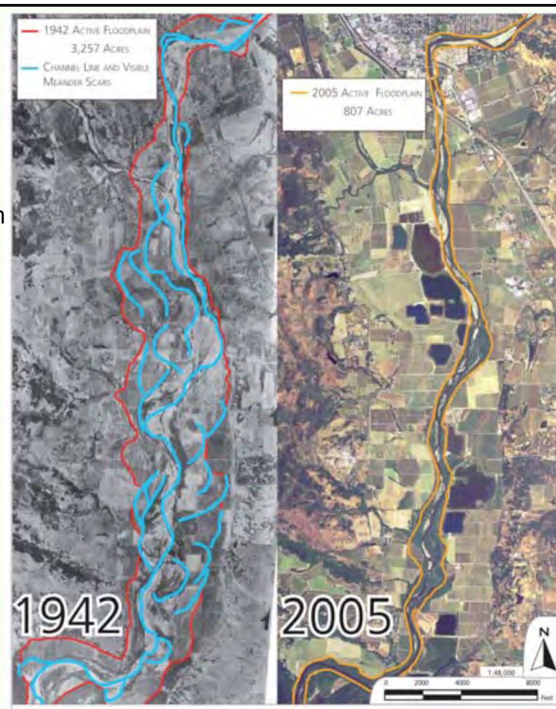
Summary

1942

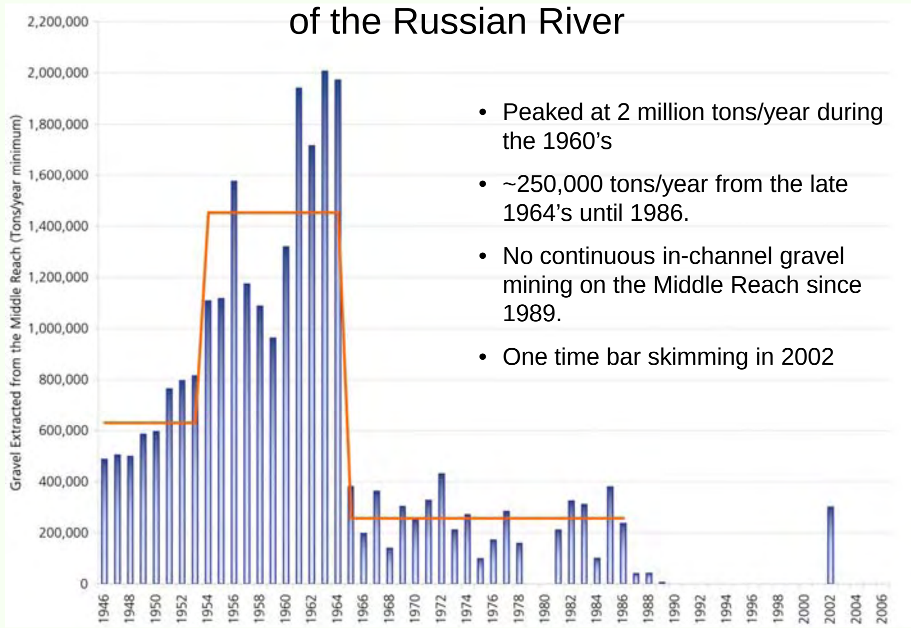
- **3,257 acres** active floodplain
- Sediment load deposited on **floodplain**
- **Channel migrated** across floodplain as point bars built up and cut banks eroded

2005

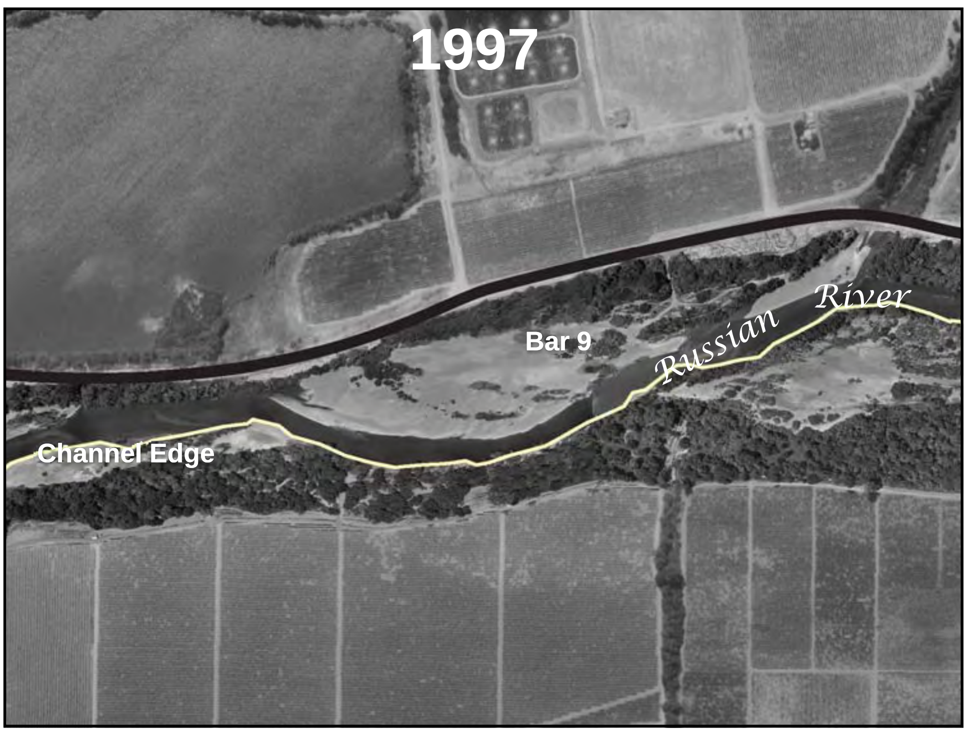
- **807 acres** active floodplain
- Sediment load deposited on **alternate bars** within the channel
- **Channel confined** to a single straightened path
- 800+ acres of gravel pits connected to river during 5-30 years floods



Annual Gravel Extraction Rates on the Middle Reach of the Russian River



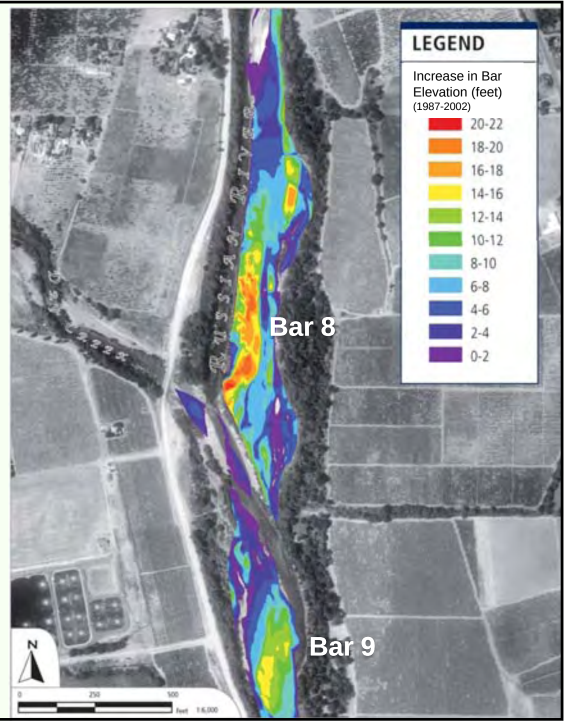
- Peaked at 2 million tons/year during the 1960’s
- ~250,000 tons/year from the late 1964’s until 1986.
- No continuous in-channel gravel mining on the Middle Reach since 1989.
- One time bar skimming in 2002



No In-channel Mining Era
1987-2002

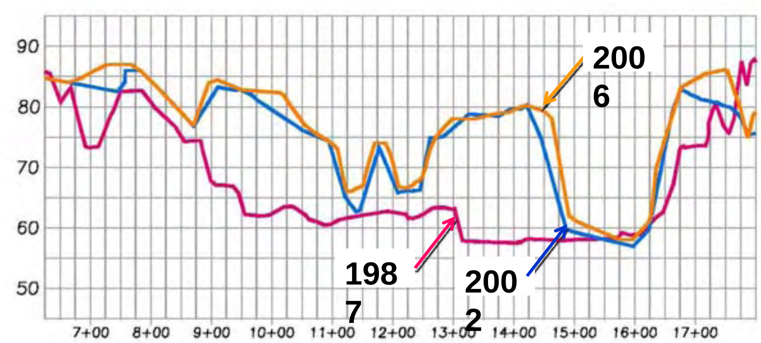
Channel filling

- Analysis by SH+G shows during this time period:
  - The upper Middle Reach was dominated by sediment deposition
  - Bar 8 built up to 20 ft in 15 years
  - 826,111 cubic yards (net) of deposition occurred on the bars of the Middle Reach

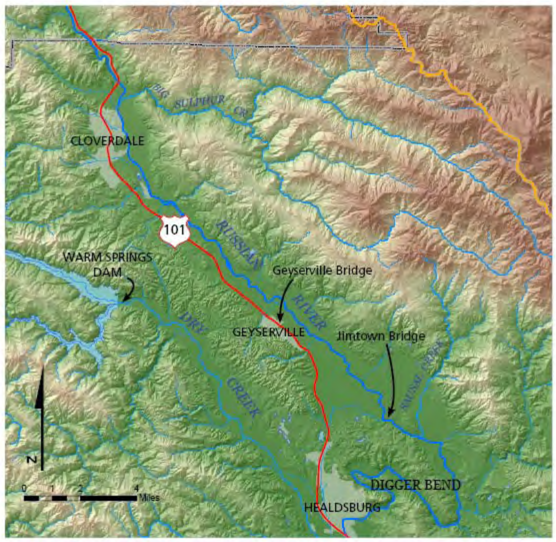


No In-channel Mining Era
1987-2002

BAR 8

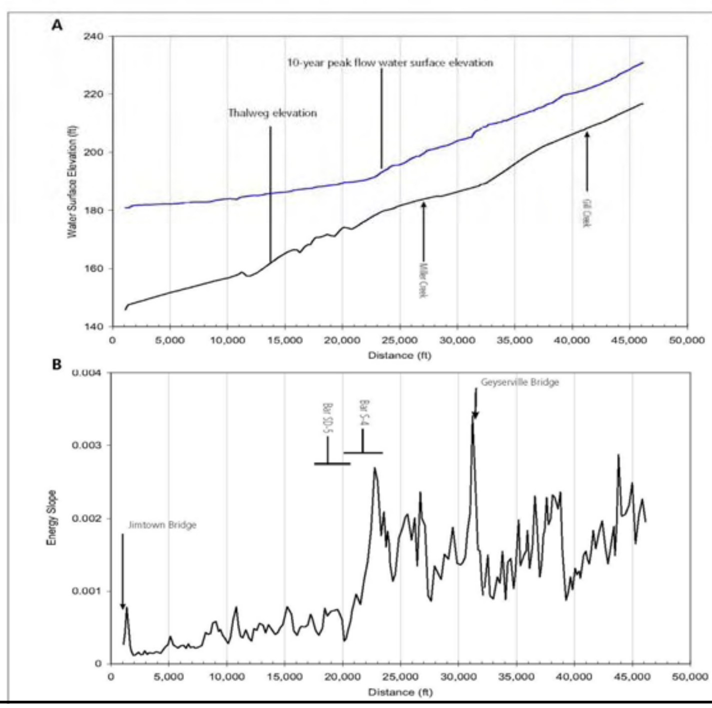


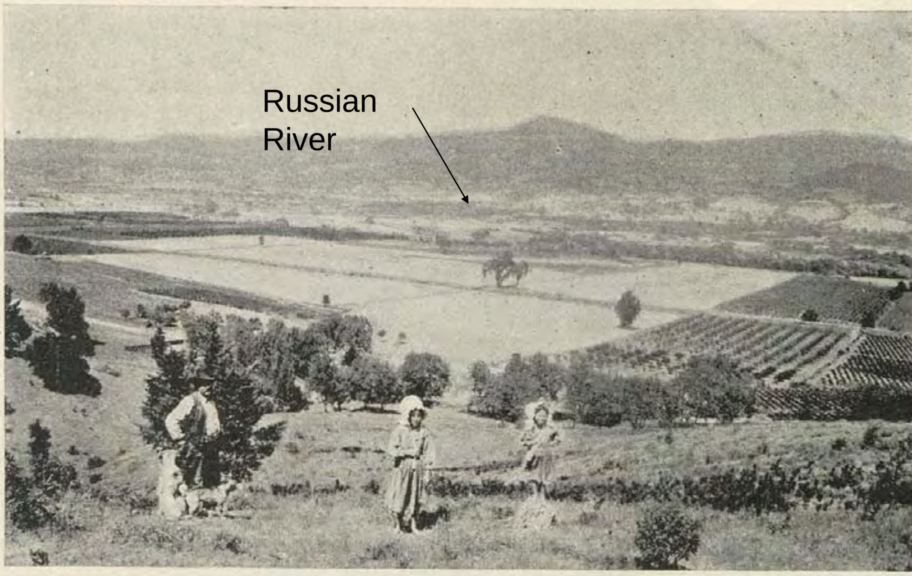
Russian River Alexander Valley



Russian River Setting
Alexander Valley Project Study Reach

- 7.5 miles from Gill Creek to Jimtown Bridge
- Valley floor is an alluvial floodplain built by historic and ancestral Russian River
- Valley outlet is constricted forming backwater control in large floods
- Large gravel bars bisected by a low flow channel
- Bank erosion / channel avulsions common
- Reclamation / channelization since 1800s; gravel mining 1900s to late 1990s.

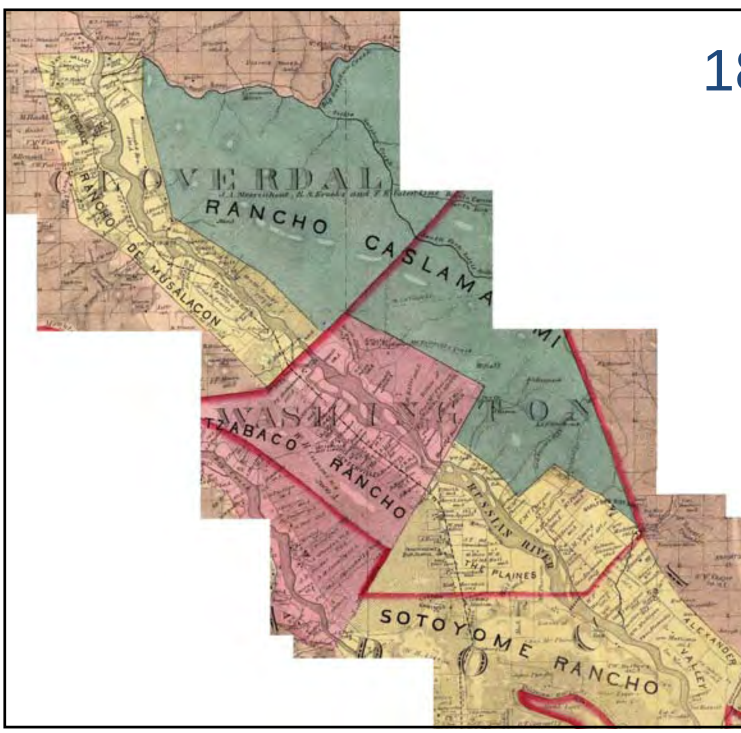


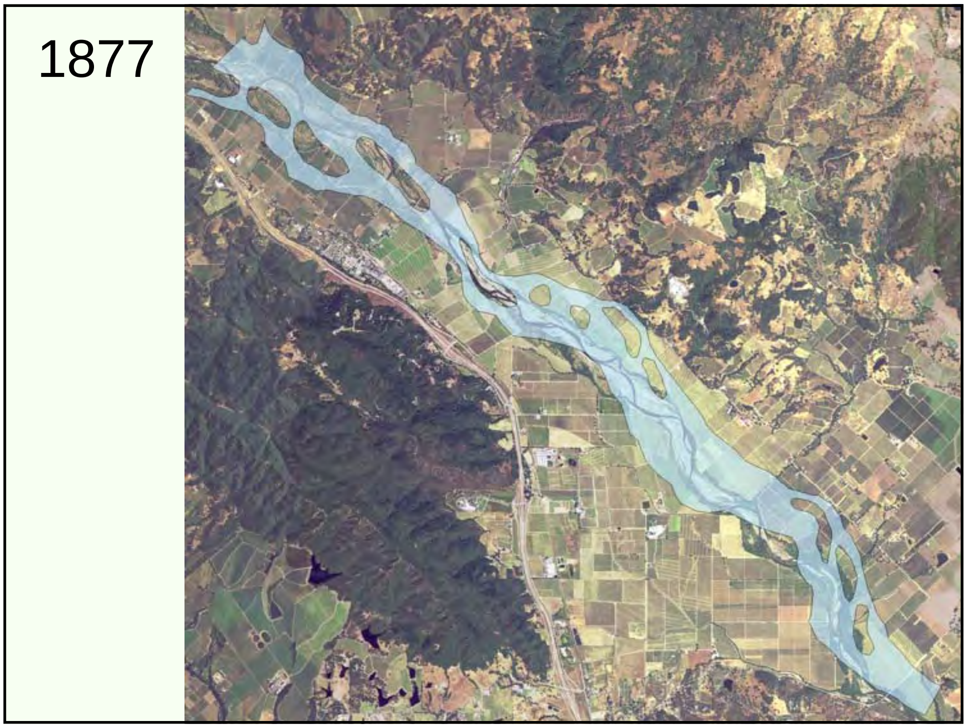


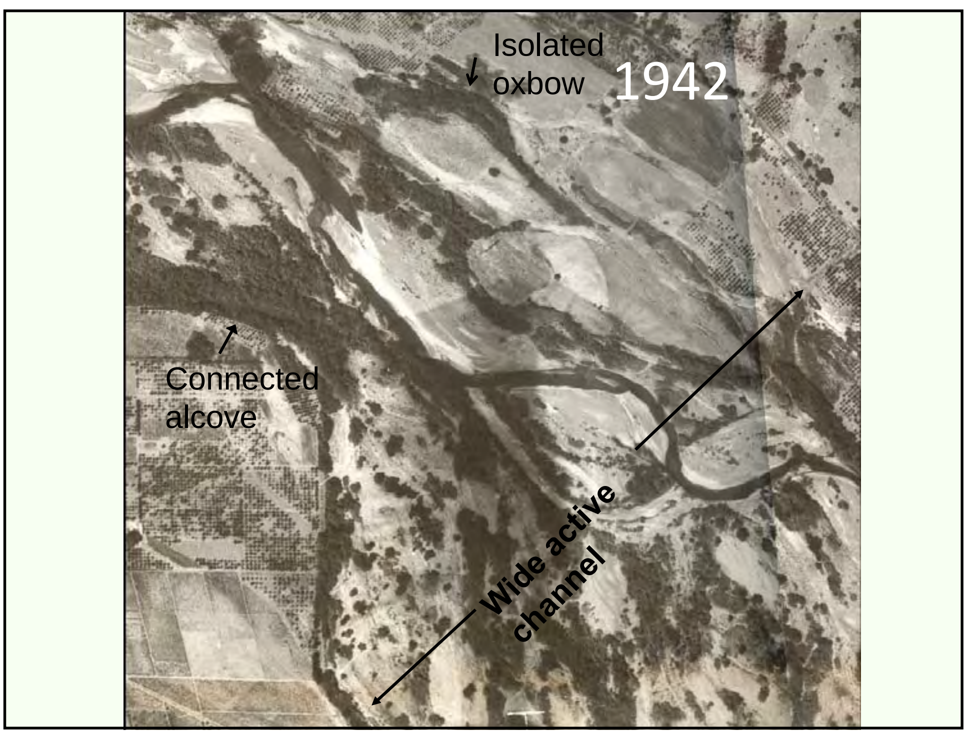
J. H. Anderson's Orchard and Ranch, near Geyserville.

1898 Postcard ~ high agricultural use of the valley floor

1877




1877

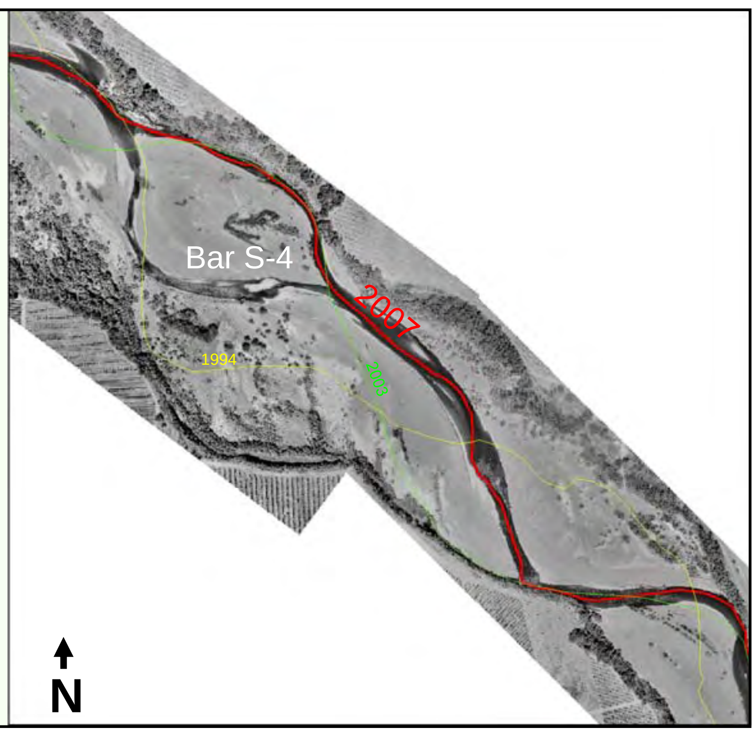

Isolated
oxbow
1942
Connected
alcove
Wide active
channel

Russian River Alexander Valley

2005

2007

Thalweg



Russian River Gravel Pits

- Summary of Historical Conditions:
  - Large off channel water bodies existed, connection to mainstem river likely seasonal during flood season for floodplain landforms, may have had perennial connections to Laguna de Santa Rosa and Mark West Creek
  - Off channel habitats within the active channel would have been intermittently connected as surface flow may have dried out annually in summer.
  - In all cases, shallow groundwater or underflow could have fed isolated water bodies of off channel habitat.

Gravel Pits Today

800 + acres of former floodplain

Open water with fringe wetlands

Generally on steep slopes

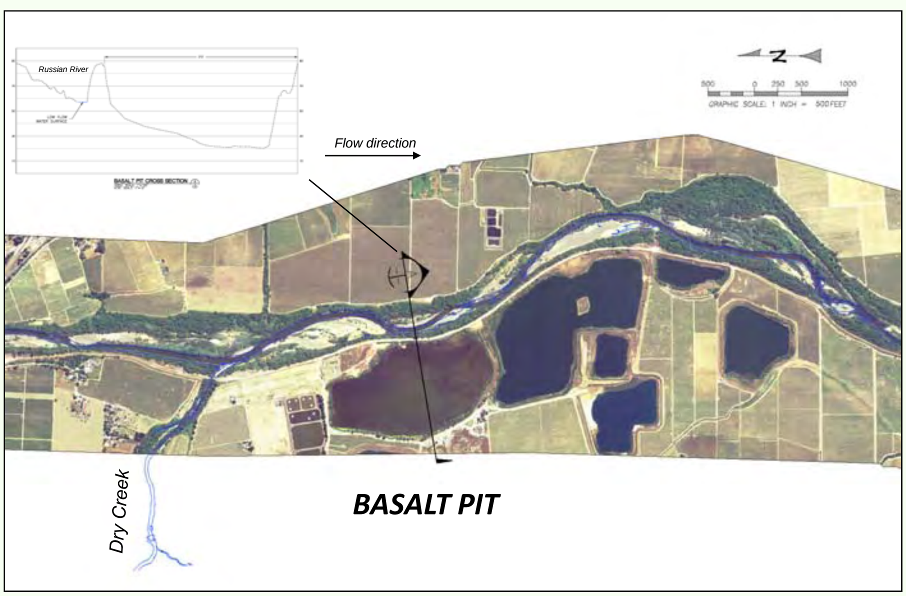
Use of weirs to control overflow

Inflow/outflow

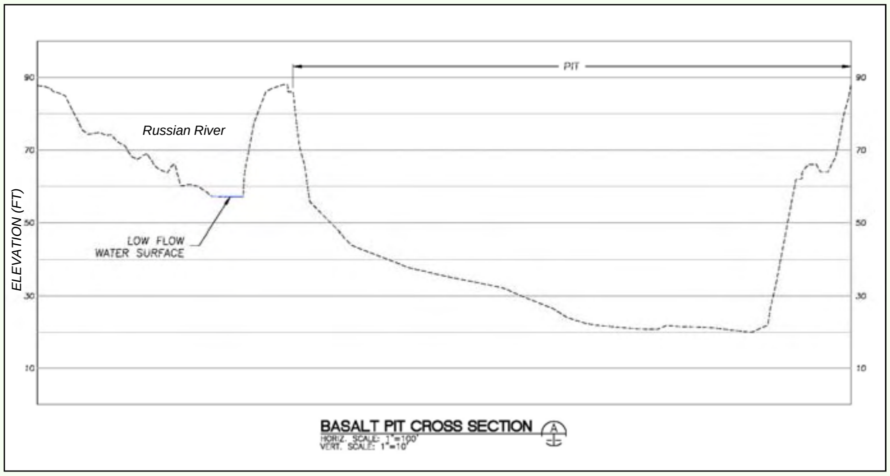
Russian River Gravel Pits today
what are they now and what could they become?

- Middle Reach Russian River
  - Deep – generally 1-30 feet below river bed
  - Generally isolated from river under low flow
  - Connected by backwater flooding of lower valley or by flood overtopping in large floods (e.g. 1995, 1997 and 2005)
  - Strategy has been to minimize overflow event frequency and to control overflows in order to prevent “pit capture”
  - Original intent was to reclaim by filling with natural sedimentation from Russian River – actually occurred in one case (Passalaqua Pond – topic of Kondolf talk)
  - Filling by discharge of processing waste silts – used in one case successfully near Basalt, but during period of high peak aggregate production so volume was much higher; used for Basalt Pit until 2007 over concerns of Hg concentration in waste silts.

Russian River Middle Reach



Russian River Middle Reach



Gravel Pit Connections

Overtopping/Breaching not capture

Overtopping/Breaching not capture

Russian River Middle Reach

1986

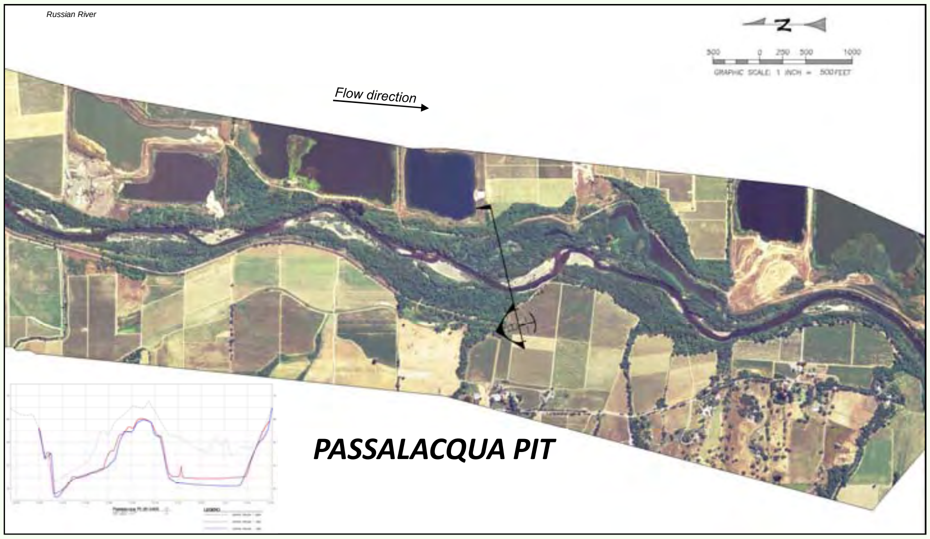
1995

2005

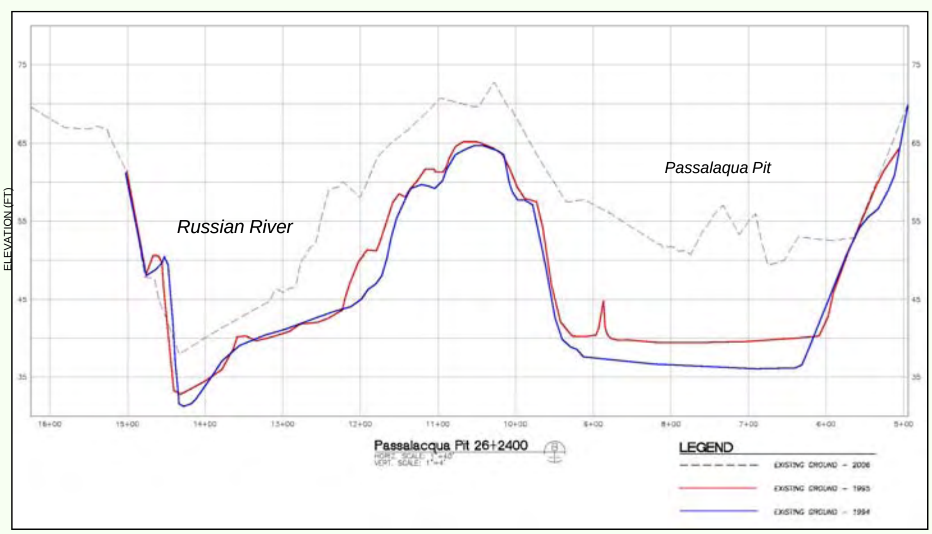
Passalaqua Pit excavated 1975-80

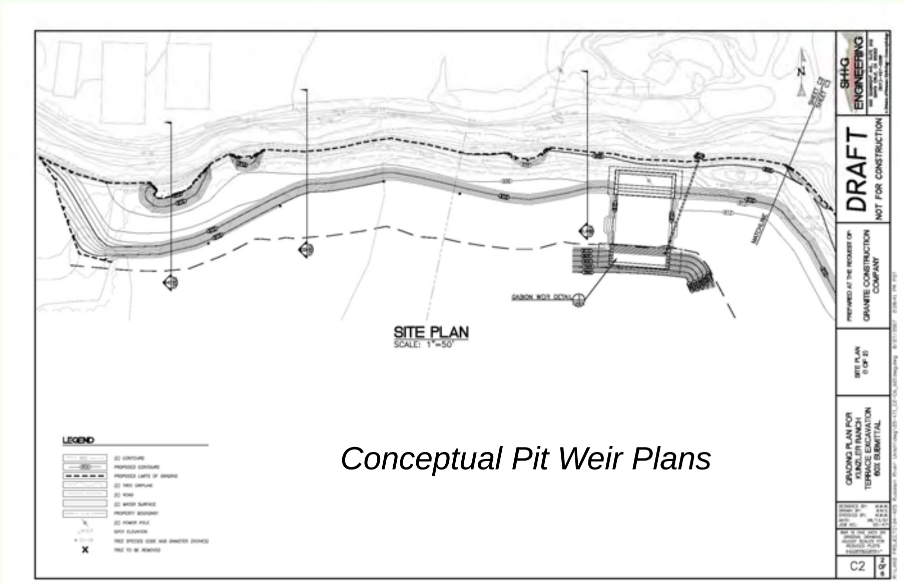
Pit Filling by waste silts (1970)

Russian River Middle Reach



Russian River Middle Reach





Conceptual Pit Weir Plans

Russian River Gravel Pits today
what are they now and what could they become?

- Opportunities to replace historic off channel habitats
  - Create off channel habitats from open water to emergent marsh similar to well documented fish productive Yolo Byass wetland complex (Sommer, 2001)
  - Use natural sedimentation processes to create wetlands direct grading and/or through dynamic deltaic processes
  - Address stability through reducing head differential during floods

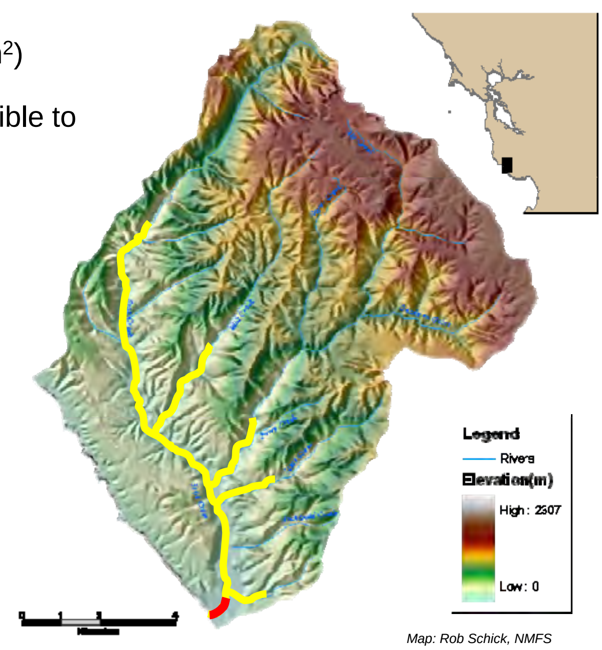
Russian River Gravel Pits today
what are they now and what could they become?

- Issues:
- Overtopping / geomorphic stability must be designed and tested – how much armoring is needed?
- Set overtopping/connection function meet ecological needs
- Invasive plant management
- Regulatory/permitting process
- Groundwater, dissolved oxygen, methly mercury

Presentation 3: Sean Hayes

Scott Creek

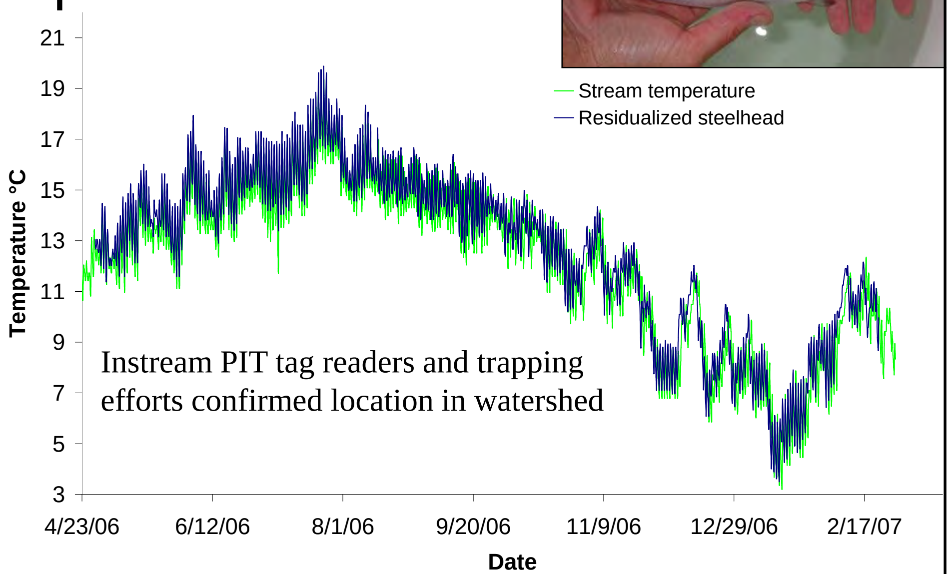
- •Small watershed (75km^2)
- •23km of stream accessible to anadromous fish
- •Only 5 common fish species
- •Small hatchery
- •Dynamic flow regime (28m^3 s^{-1} to 0.1m^3 s^{-1})
- •Small Estuary

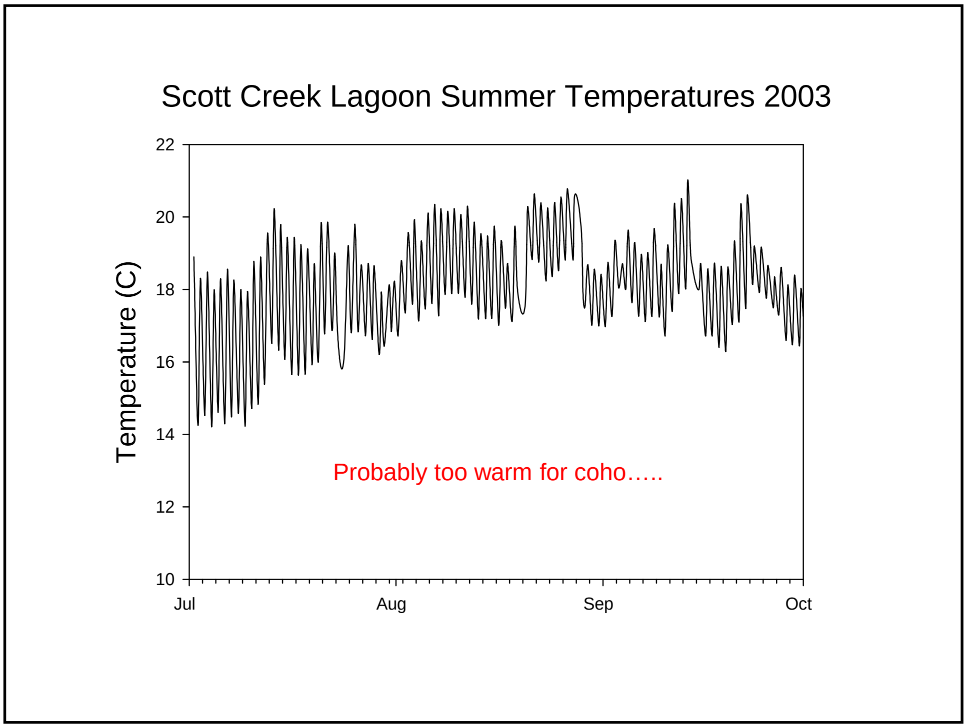


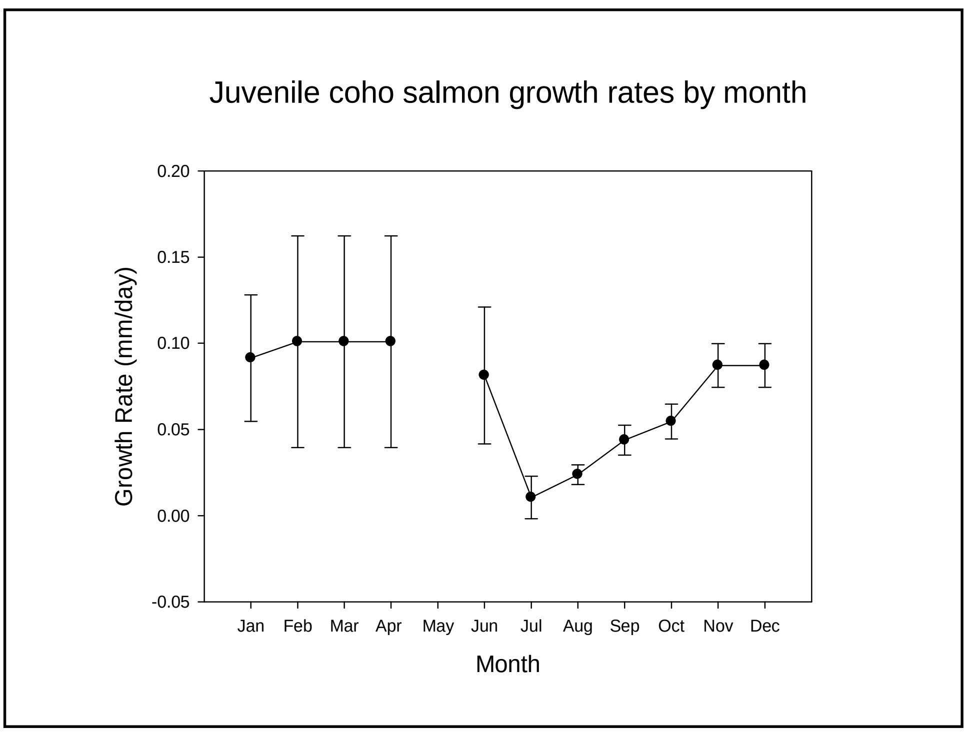
Scott Creek coho challenges

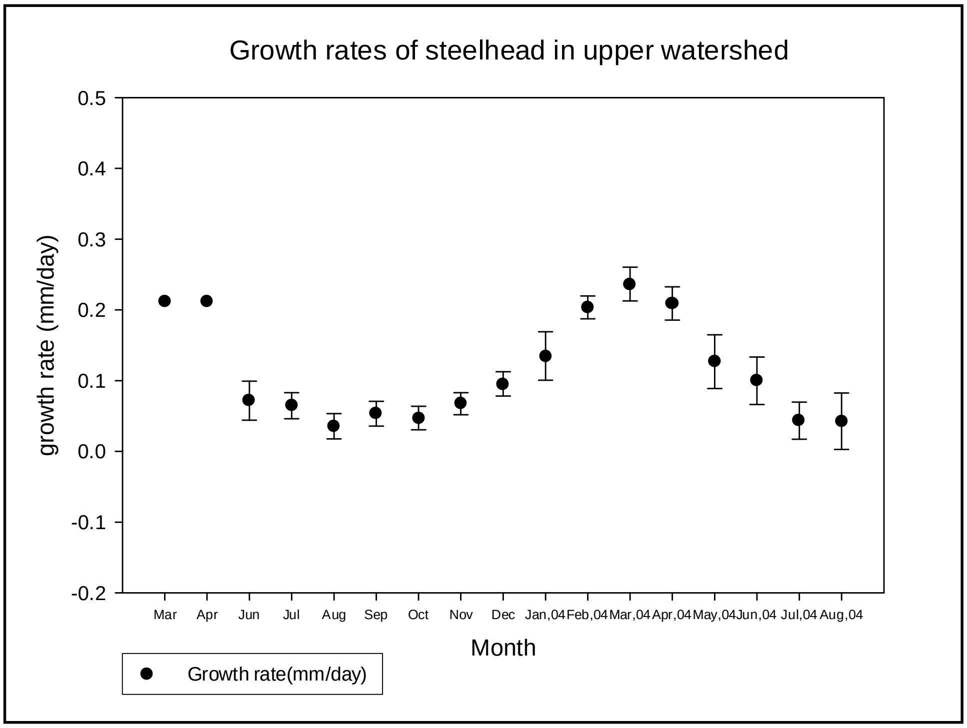
- Low flow
- Warm temperatures
- Limited off channel habitat
- Predators

Archival tags in the riparian corridor




Scott Creek Lagoon Summer Temperatures 2003
Temperature (C)
22
20
18
16
14
12
10
Jul
Aug
Sep
Oct
Probably too warm for coho…..


Juvenile coho salmon growth rates by month
Growth Rate (mm/day)
0.20
0.15
0.10
0.05
0.00
-0.05
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

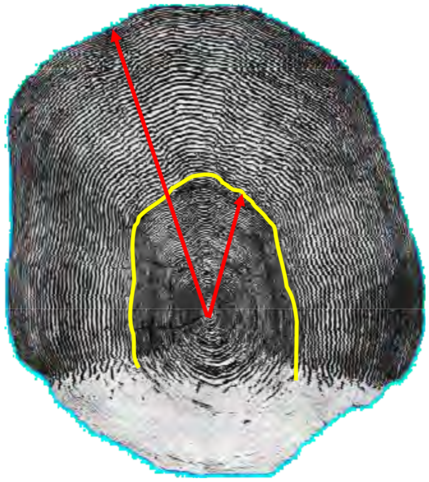

Growth rates of steelhead in upper watershed
growth rate (mm/day)
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
Mar
Apr
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan,04
Feb,04
Mar,04
Apr,04
May,04
Jun,04
Jul,04
Aug,04
Month
Growth rate(mm/day)


But where does food come from?
• Upper watershed growth poor
• Insect diet
• Low flow
• Low light


Predators…
460 Kcal/day= 50-100 coho parr


Marine Survival
Back calculating size at ocean entry from adult scales

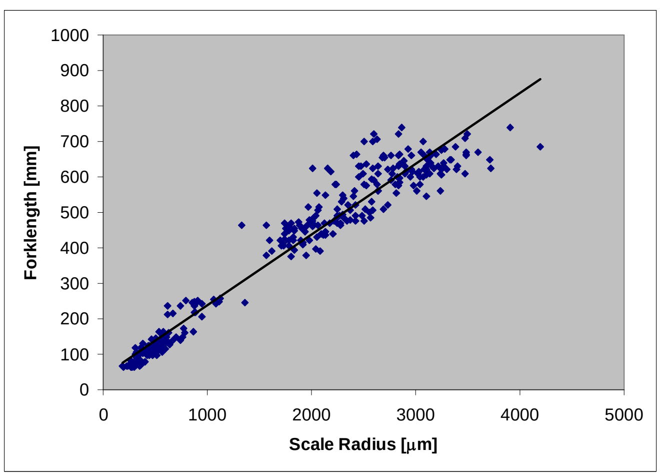
Scale Morphology



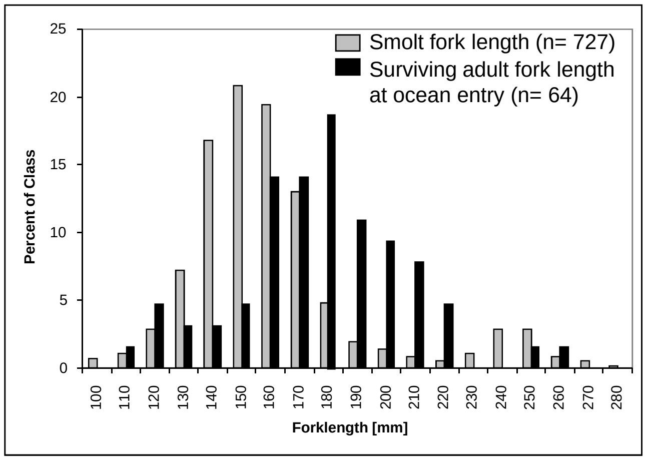
- •Scale Radius
  - •Generate fork length on scale radius regression n=330 R^2=0.95
- •Ocean Entry Radius
  - •Calculate ocean entry fork length for returning adults

Correlation between fork length and scale radius

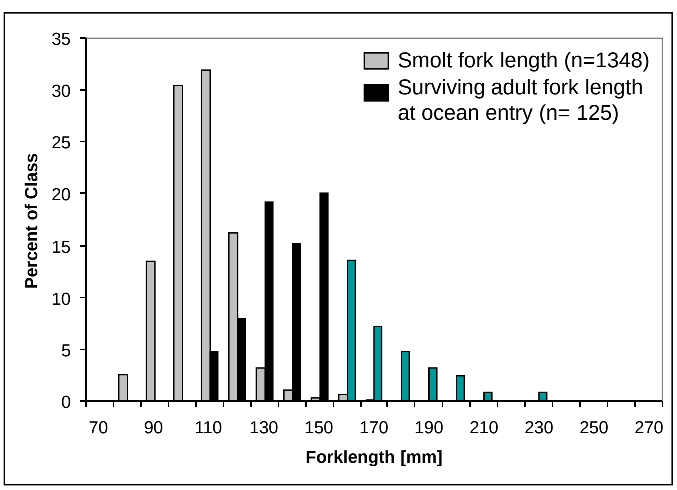
n=330 FL=0.1994(SR)+38.105 R^2=0.95



Influence of size at ocean entry on marine survival of hatchery coho



Influence of size at ocean entry on marine survival of wild coho

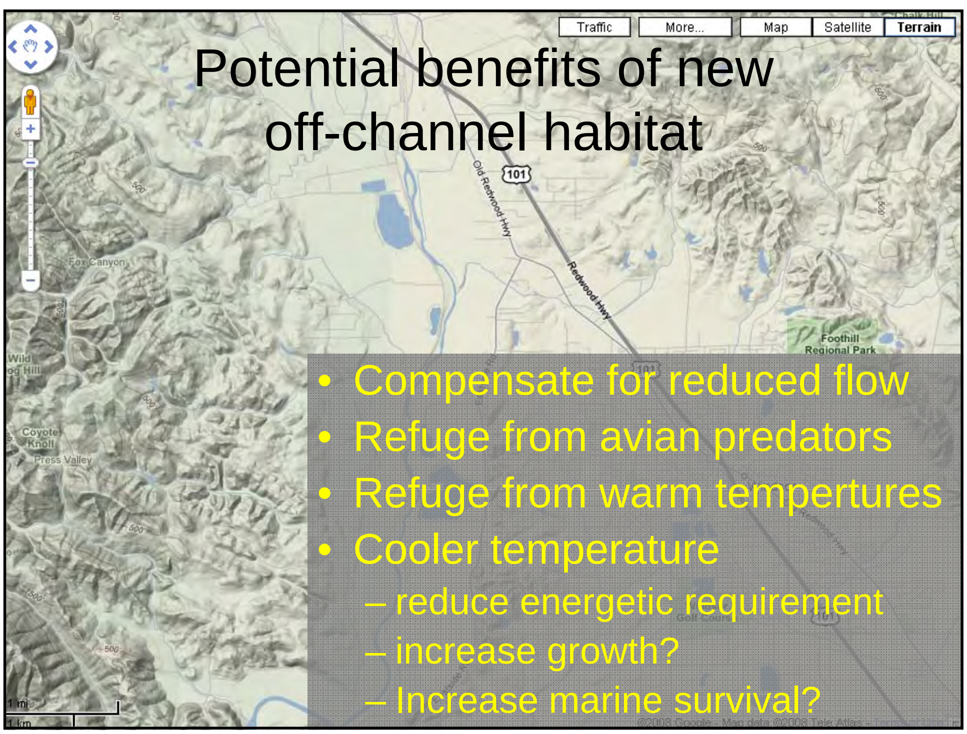


Russian River coho smolt lengths

Data from Table 17

Obedzinski, M., et al. 2007. Russian River Coho Salmon Captive Broodstock Program Monitoring Activities Annual Report. University of California Cooperative Extension and Sea Grant Program Santa Rosa, California 95403. 94.

	Spring release Group					Fall release Group				
	n	FL(mm)	95% CI	WT(g)	95% CI	n	FL(mm)	95% CI	WT(g)	95% CI
2005 Mill	0	NA		NA		576	118	± 0.9	16.8	± 0.4
2005 Sheephouse	0	NA		NA		255	118.6	± 1.3	16.8	± 0.5
2005 Ward	0	NA		NA		87	111.1	± 2.1	13.7	± 0.8
2006 Mill	0	NA		NA		354	108.9?	± 1	14.1	± 0.4
2006 Palmer	64	~~94.9~~	± 1.6	10	±0.5	180	111.2	± 1.5	15.3	± 0.6
2006 Sheephouse	13	~~100.7~~	± 4.6	11	±1.5	117	112.2	± 1.8	15	± 0.8
2006 Ward	0	NA		NA		120	~~103~~	± 1.7	12.1	± 0.6
2006 Gray	13	101	± 3.4			38	107.5?	± 2.1		
2007 Mill	243	~~99~~	± 1	10.8	± 0.3	621	~~99.5~~	± 0.6	10.8	± 0.2
2007 Palmer	117	~~97.8~~	± 1.5	10.3	± 0.4	233	~~97.4~~	± 0.9	10.2	± 0.3
2007 Sheephouse	53	~~99.8~~	± 2.3	10.9	± 0.8	58	~~96~~	± 2.3	9.9	± 0.8
2007 Ward	119	~~93.5~~	± 1.5	8.9	±0.4					
2007 Green Valley	0	NA	NA			487	112.7	± 0.9	16.1	± 0.4



Potential benefits of new off-channel habitat

- Compensate for reduced flow
- Refuge from avian predators
- Refuge from warm tempertures
- Cooler temperature
  - reduce energetic requirement
  - increase growth?
  - Increase marine survival?

Presentation 4: John McKeon

Past “Reclamation” Strategy for off channel gravel pit mines: “**Isolate”**

Infrequent dead-end for ESA listed Russian River fish: **Chinook salmon, coho salmon** and **steelhead.**

• Proposed “Reclamation” Strategy:
Pre-emptive flooding thru hardened weir >$2M

Frequent dead-end for ESA listed Russian River fish

Can we restore/create/rehabilitate off-channel habitat

function?

Off-channel habitat

- provides refuge from floods, drought, temperature extremes, and predators;
- Can be highly productive winter and summer rearing habitat;
- Higher densities and growth rates than main channel habitats.
- Increase watershed carrying capacity
- Increase fitness of individuals/ and survival
- Result in population increases
- Buffer population swings from stochastic events

Off-channel salmonid productivity is dependent on the habitat attributes of:

- Extensive shoals and shallows (less than 4 meters deep);
- Complexity of morphologic features (coves, peninsulas, sloughs…bottom topography; *ie*, complex and extensive "edge" habitat);
- Areas of emergent vegetation along the margins, submerged (native) aquatic vegetation (SAV) to 4m depths;
- Broad multi-story riparian zone with inundation-tolerant fringe of overhanging and/or trailing vegetation, pro-grading to gallery forest;
- Submerged large and small woody structure;
- Seasonal flooding;
- Access to adjacent floodplain, and;
- Return access to perennial water as floodwaters recede;
- Perennial and stable temperature inflows provided by groundwater;
- Seasonally appropriate extended-period, or perennial connections to main channels of rivers and streams.

The Following Slides Are Examples of:

- Naturally occurring off channel habitat;
- Enhanced off channel habitat, and;
- Newly created off channel habitat projects;

These are examples from the very small, to quite large scale projects.

OLYMPIC PENNINSULA project

EAGLE CRK SPRINGS project, Eastern Cascades

OXBOW LAKE "THE COVE" project, New England

Kwatna River- $137,000 British Columbia

- An Upper Columbia River project, WA

Physical Attributes of Russian River ponds:

- Steep banks to depth;
- 30 to 50 foot depths;
- Significant groundwater inflows;
- Infrequent main channel connection, *ie,*
  25-30 year event;
- High nutrient inputs (treatment facility releases);
- Seasonal (spring-summer) temperature stratification;
- Anoxic lower strata 10-30 ft thick;
- Seasonal ~ 10 foot groundwater level change;
- With previous four attributes causing:
  potential methane release events with potential to strip all strata of oxygen.

Biotic Attributes of Russian River ponds

- Low benthic productivity
- Algal blooms, hyper-oxic and hypoxic conditions likely causing hypercapnia in fish (reduced ability to respire, (CO_2 build up in blood)
- Minimal to no emergent vegetation along the margins
- Minimal overhanging and/or trailing vegetation along the margins
- Minimal submerged large and small woody structure
- methylization of mercury occurring under anaerobic conditions

Temperature and Dissolved Oxygen in Russian River off channel ponds

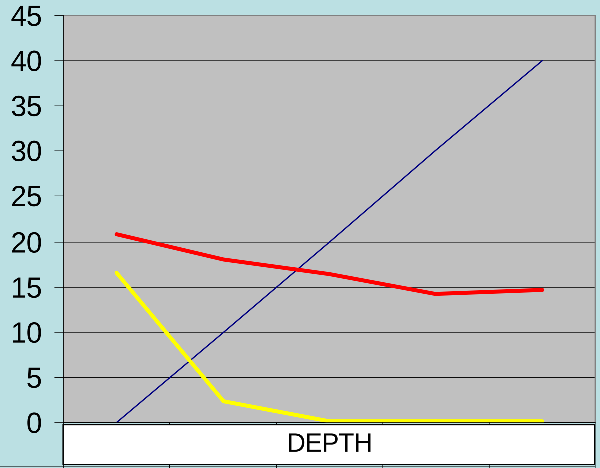
The following five charts display a single day of readings (5-28-08) of Dissolved Oxygen and Temperature, measured at 10 foot increments of depth, from the surface to the bottom in 5 of the Syar gravel pit ponds located near the mouth of Dry Creek.

- Results show a strong stratification pattern after a warm dry spring (2008).
- Surface temperatures in ponds are below 21 degrees C, with a large reservoir of much colder water below.
- Dissolved Oxygen remains above 5mg/l to depths of 25 feet (except Basalt and Phase II ponds)

In the following 5 charts the Y axis represents both Temperature in degrees C, and DO in mg/l.

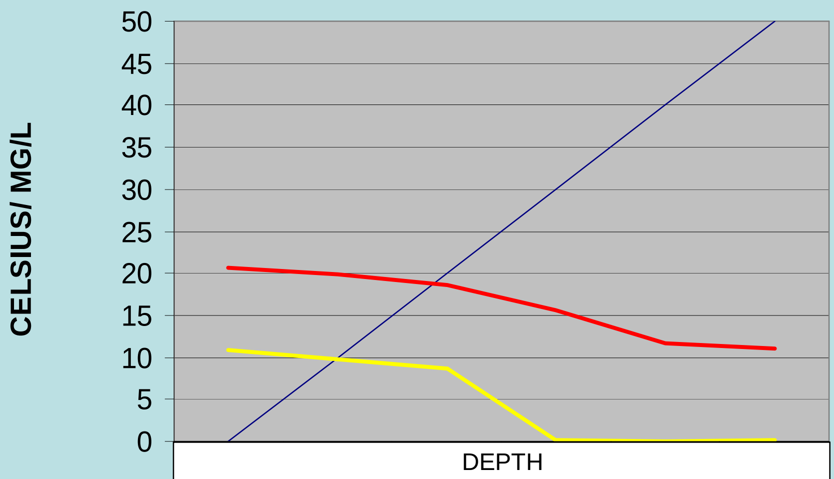
The X axis represents depth, with the data chart below the x axis showing the corresponding Temperature and DO data recorded at each 10 foot increment of depth.

BASALT POND



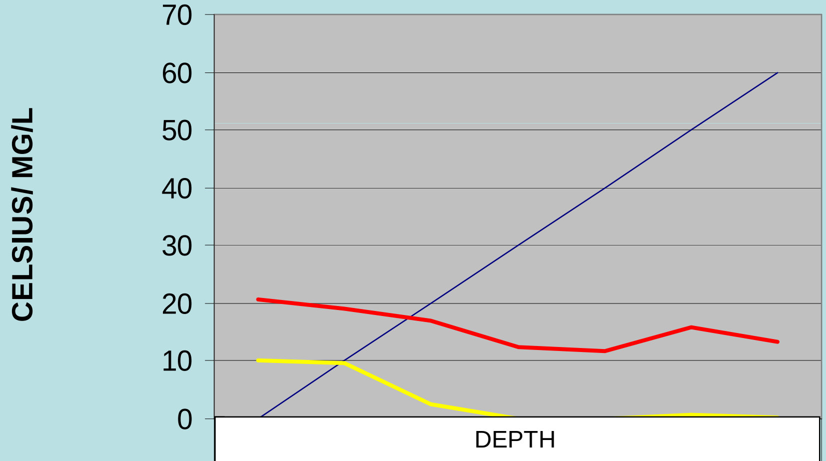
DEPTH	0	10	20	30	40
TEMPERATURE	20.8	18.1	16.4	14.2	14.6
DO	16.5	2.3	0.2	0.21	0.17

PHASE I POND WATER QUALITY



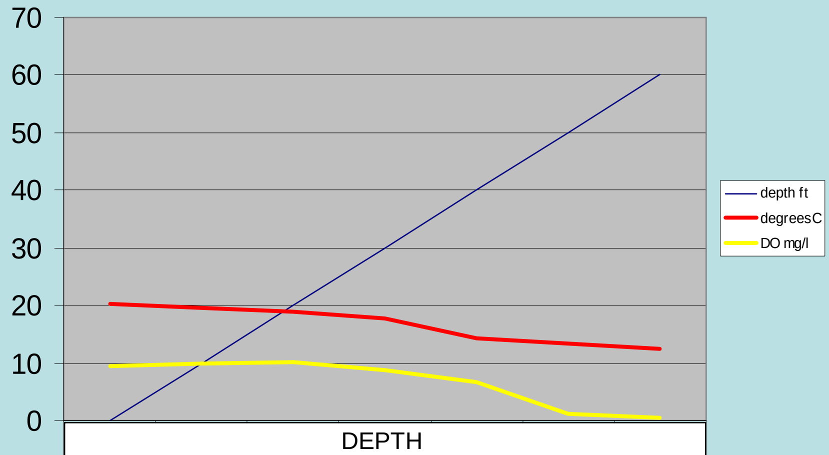
depth ft	0	10	20	30	40	50
degreesC	20.6	19.8	18.6	15.6	11.6	11
DO mg/l	10.91	9.8	8.69	0.09	0.05	0.18

PHASE II POND WATER QUALITY



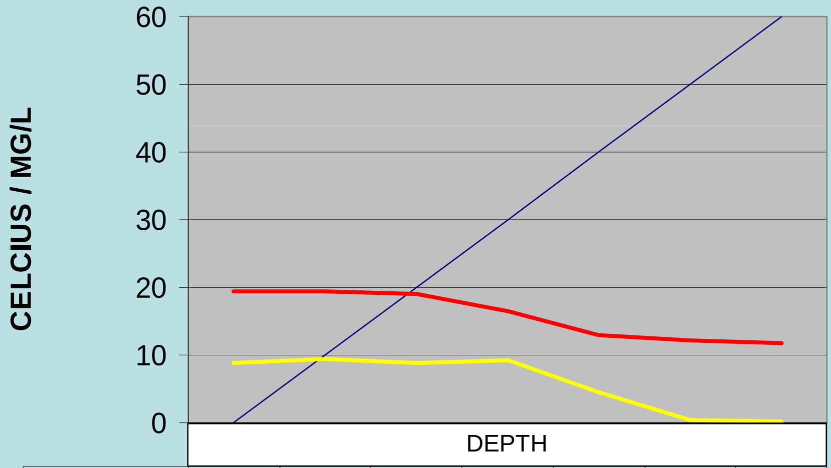
depth ft	0	10	20	30	40	50	60
degreesC	20.6	19	17	12.4	11.7	15.8	13.4
DO mg/l	10.17	9.6	2.52	0.05	0.11	0.79	0.16

PHASE IV POND WATER QUALITY



depth ft	0	10	20	30	40	50	60
degreesC	20.2	19.5	18.9	17.7	14.3	13.4	12.5
DO mg/l	9.43	9.8	10.18	8.7	6.76	1.16	0.55

PHASE V POND WATER QUALITY



depth ft	0	10	20	30	40	50	60
degreesC	19.5	19.4	19	16.5	13	12.1	11.7
DO mg/l	8.82	9.5	8.75	9.3	4.5	0.31	0.16

Vertical Temperature Profiles Recorded from **5/ 28 /2008** through **12/ 10 /2008**

The following 5 charts display the recordings of continuous data loggers recording light (lumens), and Temperature (^{o} C) deployed in each pond over a period of 5 months.

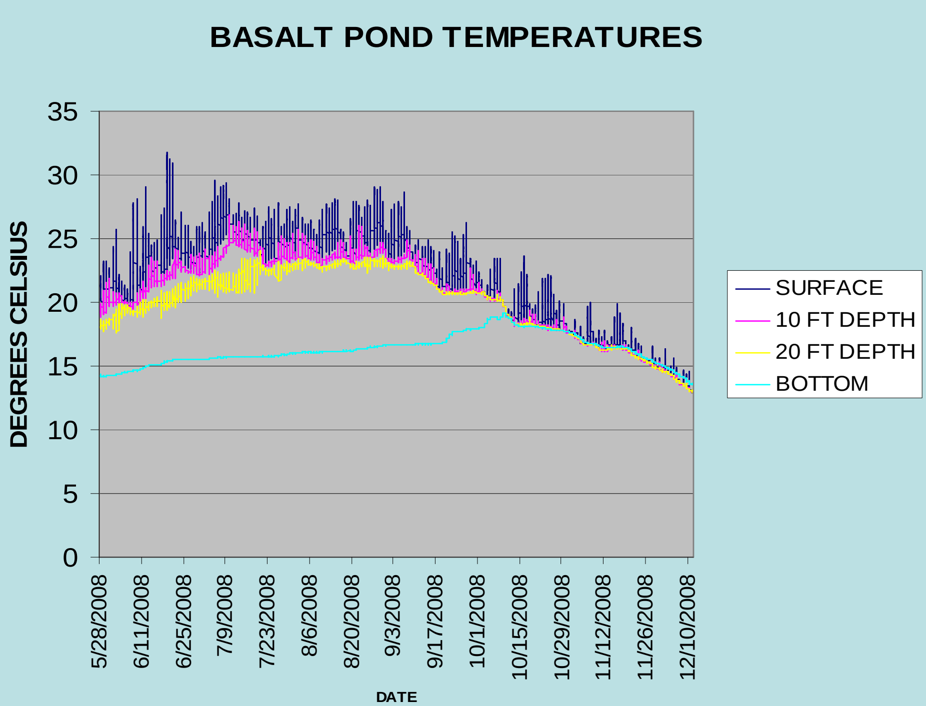
Temperature and lumens were recorded every 15 minutes. Lumens is displayed only in chart of Phase II pond.

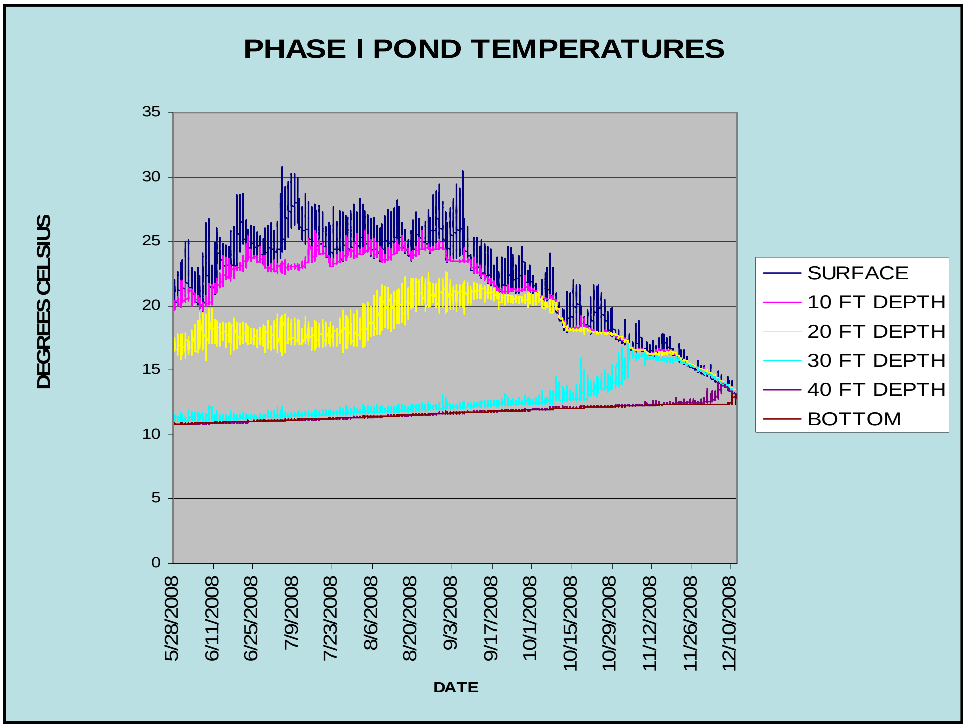
Loggers were attached to a line suspended by a float and anchored to the bottom. Loggers were attached to the line at the surface and at each 10 foot increment of depth down to the bottom

Temperature Profile Monitoring Results:

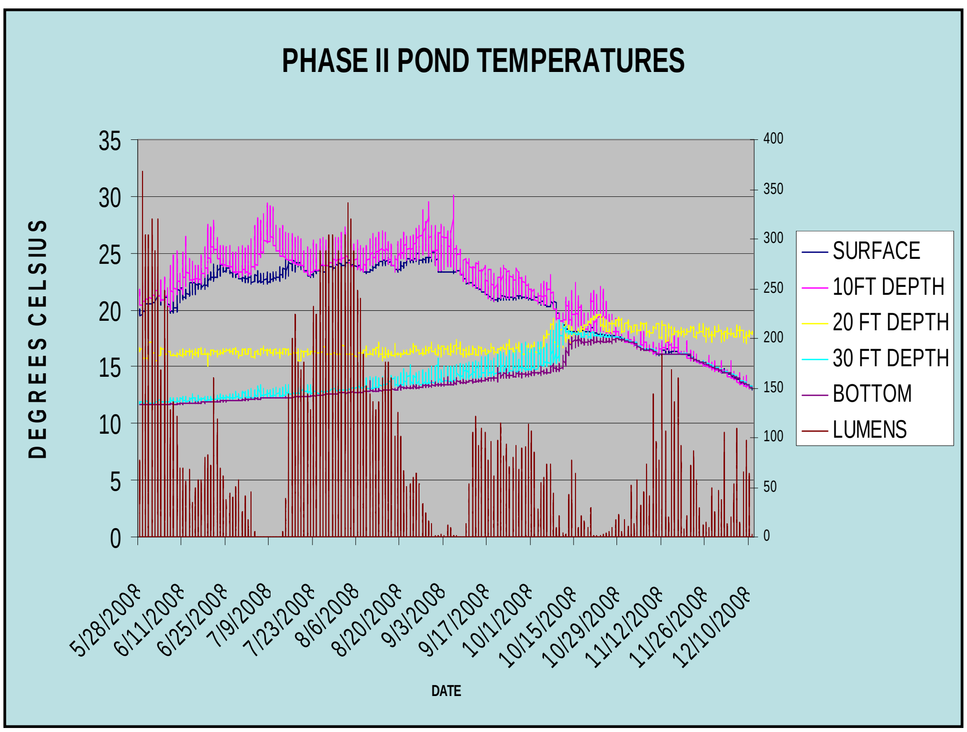
- Surface Temp of only two ponds exceed 25º C thru summer;
- Strata below 10 foot depth remain below 22º C thru summer with exception of Basalt and Phase V ponds;
- Lower strata in all ponds remain much colder through summer
- Level or minimal increase in slope of lower strata temperatures recorded through the summer indicate high rates of groundwater inflow, as does divergence of slope between upper and lower strata;
- Rates of inflow greatest in Phase IV, followed in order by Phase I, Phase II, Basalt and Phase V;

- Phase II chart showing lumens indicate Algal blooms are cyclic (Blooms indicated by decrease in lumens);
- Blooms correlate with Temp spikes, with peak of blooms causing 10 depth temps to exceed surface Temps;

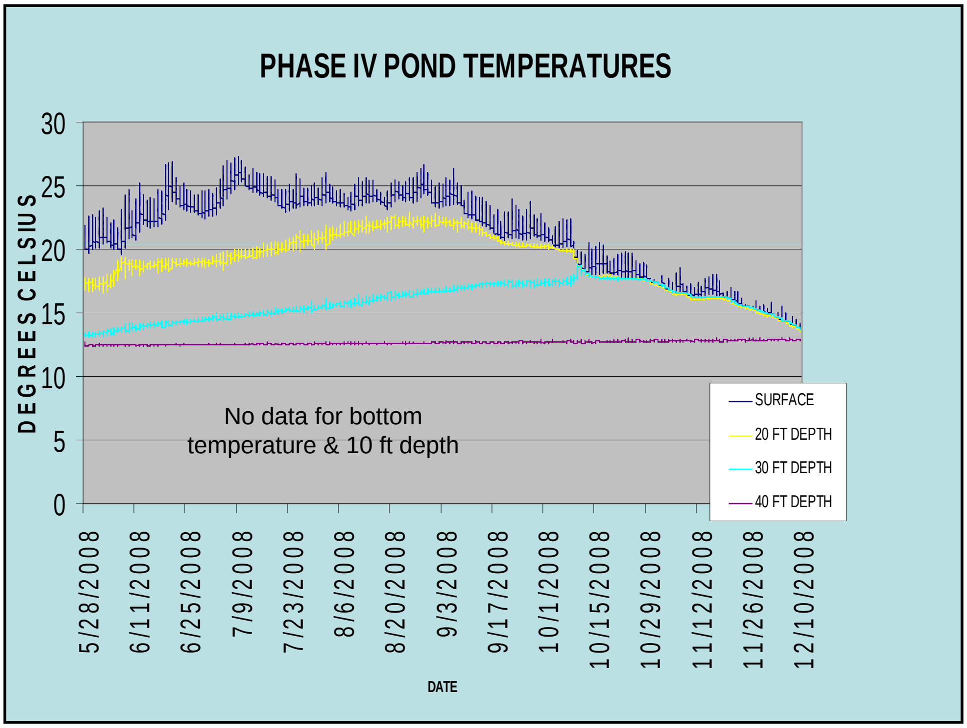




PHASE I POND TEMPERATURES
DEGREES CELSIUS
35
30
25
20
15
10
5
0
5/28/2008
6/11/2008
6/25/2008
7/9/2008
7/23/2008
8/6/2008
8/20/2008
9/3/2008
9/17/2008
10/1/2008
10/15/2008
10/29/2008
11/12/2008
11/26/2008
12/10/2008
DATE
SURFACE
10 FT DEPTH
20 FT DEPTH
30 FT DEPTH
40 FT DEPTH
BOTTOM



PHASE II POND TEMPERATURES
DEGREES CELSIUS
35
30
25
20
15
10
5
0
400
350
300
250
200
150
100
50
0
5/28/2008
6/11/2008
6/25/2008
7/9/2008
7/23/2008
8/6/2008
8/20/2008
9/3/2008
9/17/2008
10/1/2008
10/15/2008
10/29/2008
11/12/2008
11/26/2008
12/10/2008
DATE
SURFACE
10FT DEPTH
20 FT DEPTH
30 FT DEPTH
BOTTOM
LUMENS


PHASE IV POND TEMPERATURES
DEGREES CELSIUS
30
25
20
15
10
5
0
No data for bottom temperature & 10 ft depth
SURFACE
20 FT DEPTH
30 FT DEPTH
40 FT DEPTH
5/28/2008
6/11/2008
6/25/2008
7/9/2008
7/23/2008
8/6/2008
8/20/2008
9/3/2008
9/17/2008
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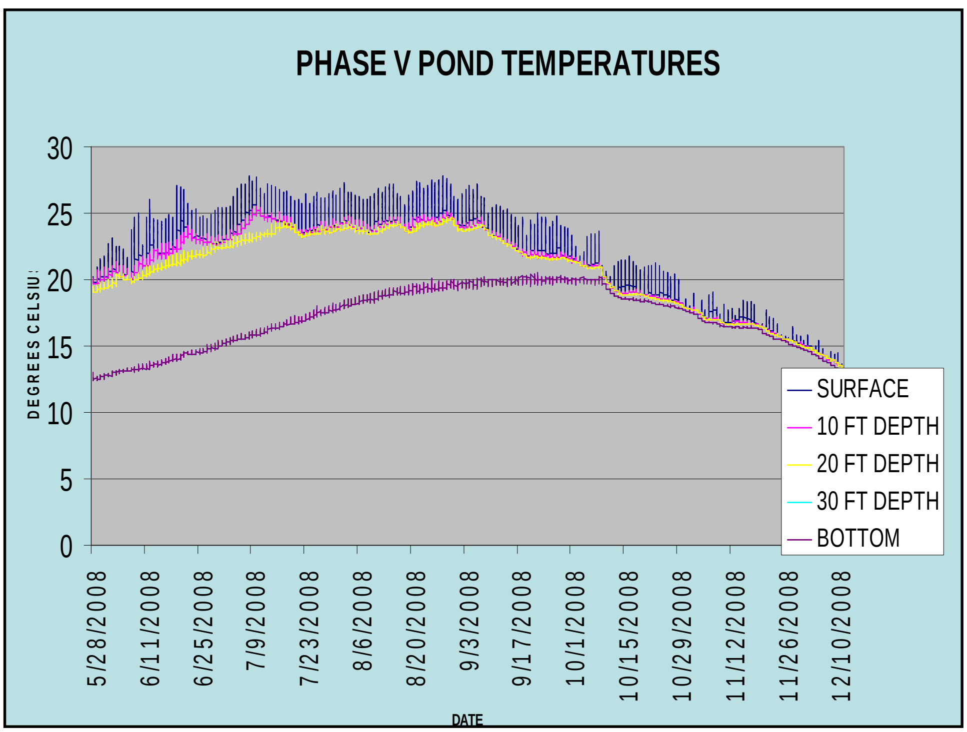
10/29/2008
11/12/2008
11/26/2008
12/10/2008
DATE


PHASE V POND TEMPERATURES
DEGREES CELSIUS
30
25
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15
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SURFACE
10 FT DEPTH
20 FT DEPTH
30 FT DEPTH
BOTTOM
5/28/2008
6/11/2008
6/25/2008
7/9/2008
7/23/2008
8/6/2008
8/20/2008
9/3/2008
9/17/2008
10/1/2008
10/15/2008
10/29/2008
11/12/2008
11/26/2008
12/10/2008
DATE

Conclusions

- Present bottom topography and depth, lack of shoals and shallow complex edge habitat, minimal fringe and overhanging vegetation and SAV, large and small wood, all limit suitability of ponds as salmonid rearing habitat.
- Surface strata water Temps are significantly increased due to heat absorption of algal blooms fed by sewage treatment discharges.
- Lack of seasonally appropriate ingress and egress connection to the main Russian River channel limits potential salmonid use.
- Groundwater inflow rates maintain Temps suitable for salmonid habitat rearing through the summer period.
-
- Without diurnal algal bloom-caused oxygen depletion, wind mixing is sufficient to maintain suitable DO for salmonid rearing down to 25 feet of depth.

From Aggregate Mining to Restoration in Willamette Floodplains

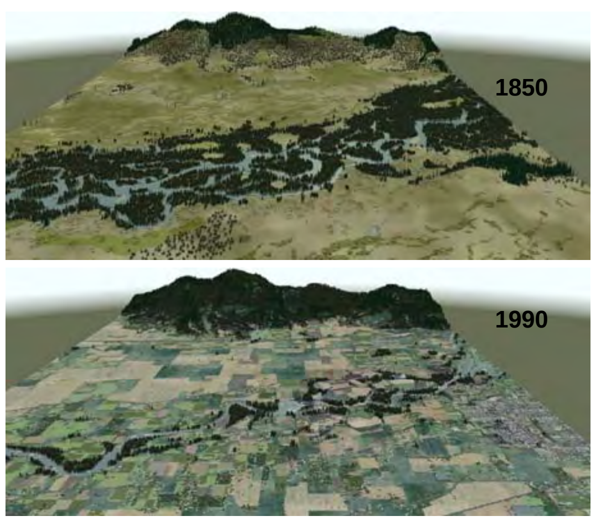
Peter Bayley

Peter Klingeman

Guillermo Giannico

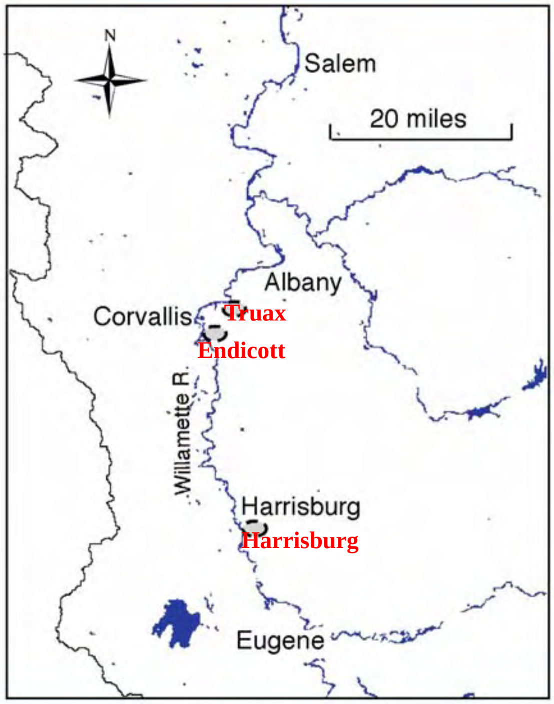
Oregon State University OSU

Willamette River Lowlands: Then & Now

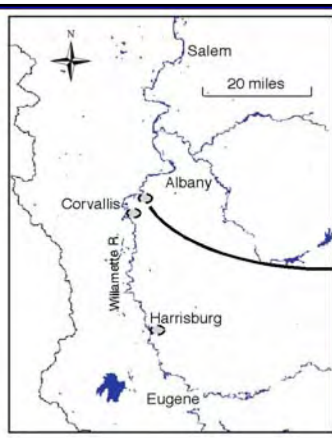


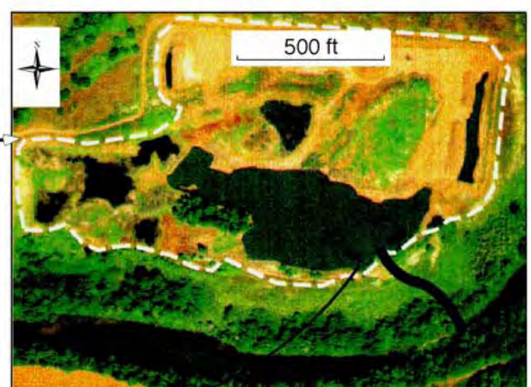
From: "Willamette River Basin Planning Atlas, Trajectories of Environmental and Ecological Change". D. Hulse, S. Gregory & J. Baker (eds) Pacific Northwest Ecosystem Consortium

Gravel Pit Location Along Willamette River

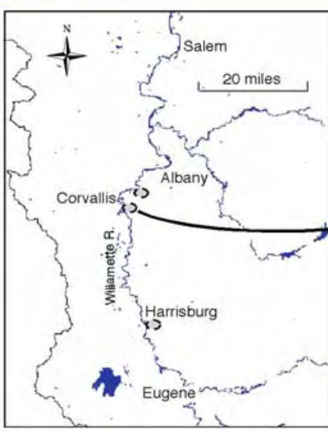


Truax Gravel Pit

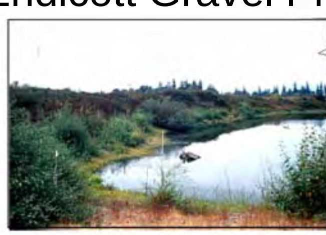




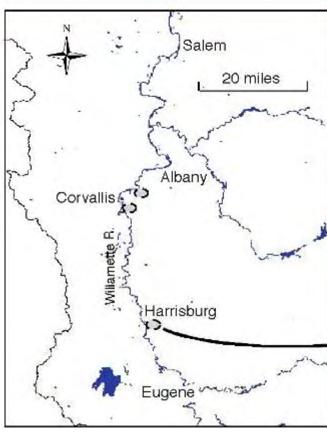
Truax Island and Gravel Pit



Endicott Gravel Pit



Endicott Point Bar and Gravel Pit



Harrisburg Gravel Pit

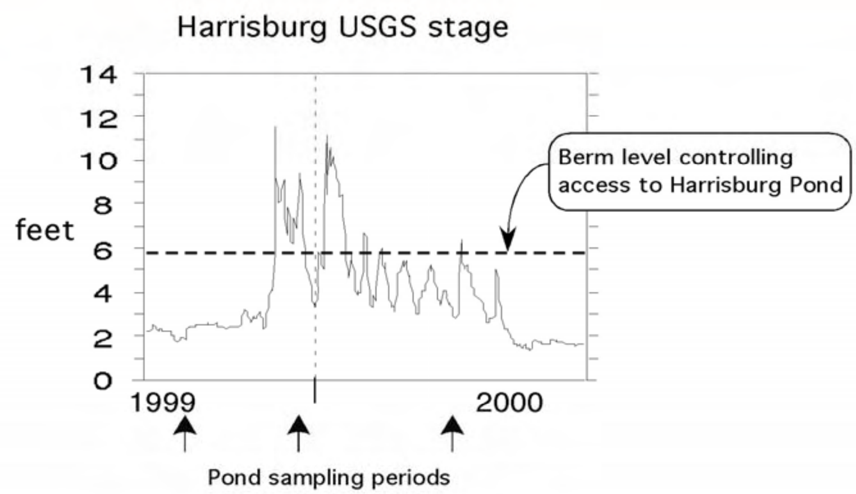
Harrisburg Floodplain and Gravel Pit

Harrisburg Berm and Willamette Secondary Channel

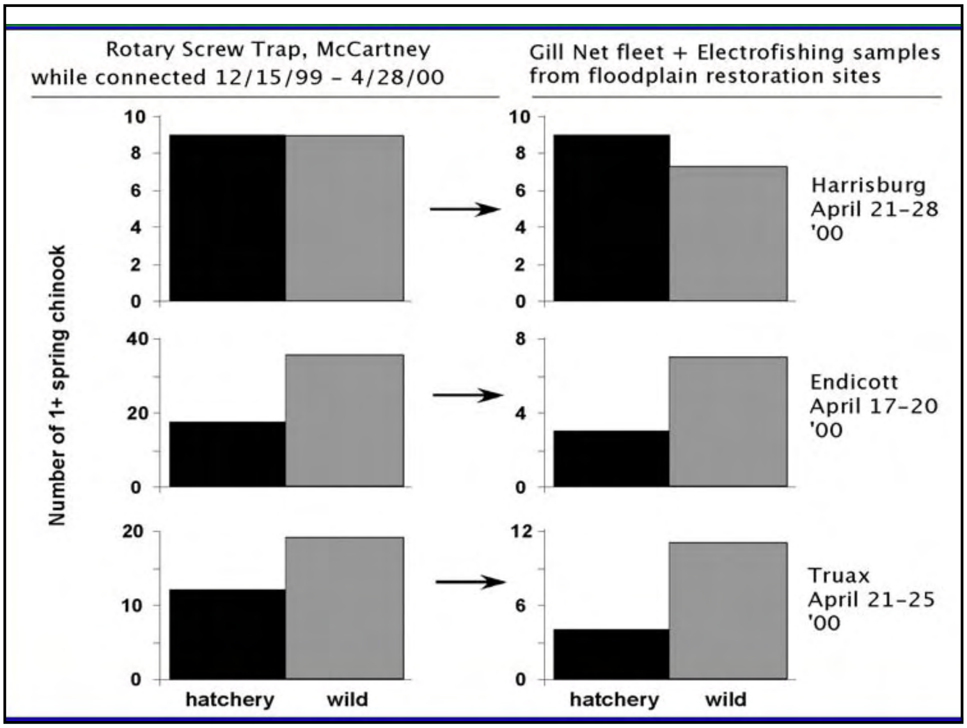
Two-way Fish Traps in Harrisburg Connection Channel

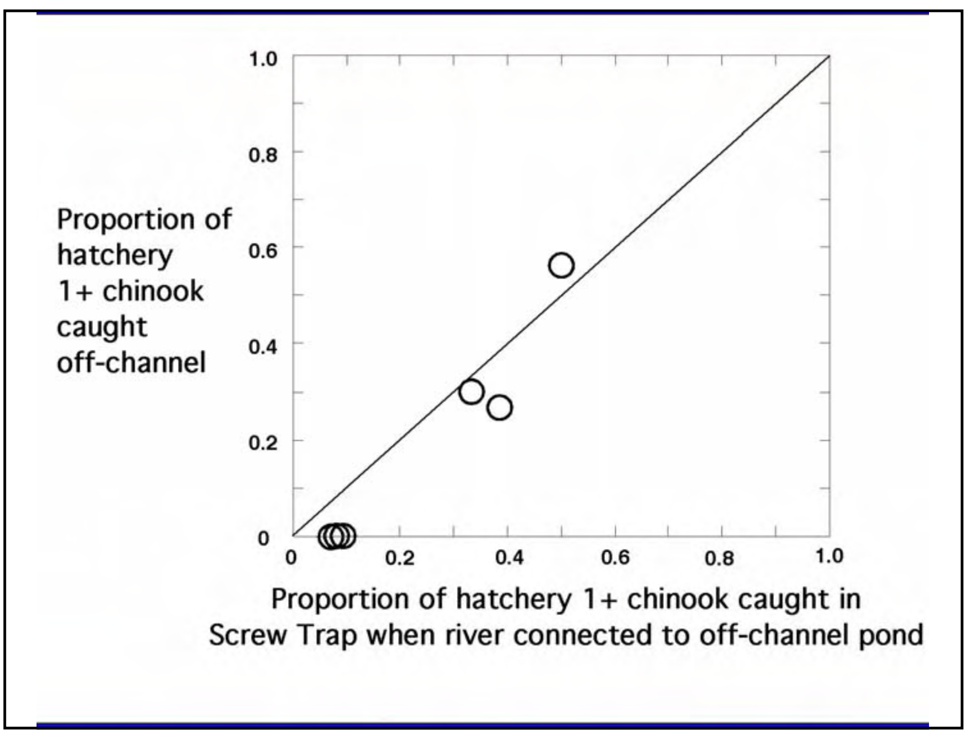
Compared to Hatchery Fish….

- Do wild fish use floodplain habitats to greater extent?
- Is wild fish survival higher in these habitats?



Harrisburg Berm During Flood


Rotary Screw Trap, McCartney
while connected 12/15/99 - 4/28/00
Gill Net fleet + Electrofishing samples
from floodplain restoration sites
Number of 1+ spring chinook
Harrisburg
April 21-28
'00
Endicott
April 17-20
'00
Truax
April 21-25
'00
hatchery
wild
hatchery
wild

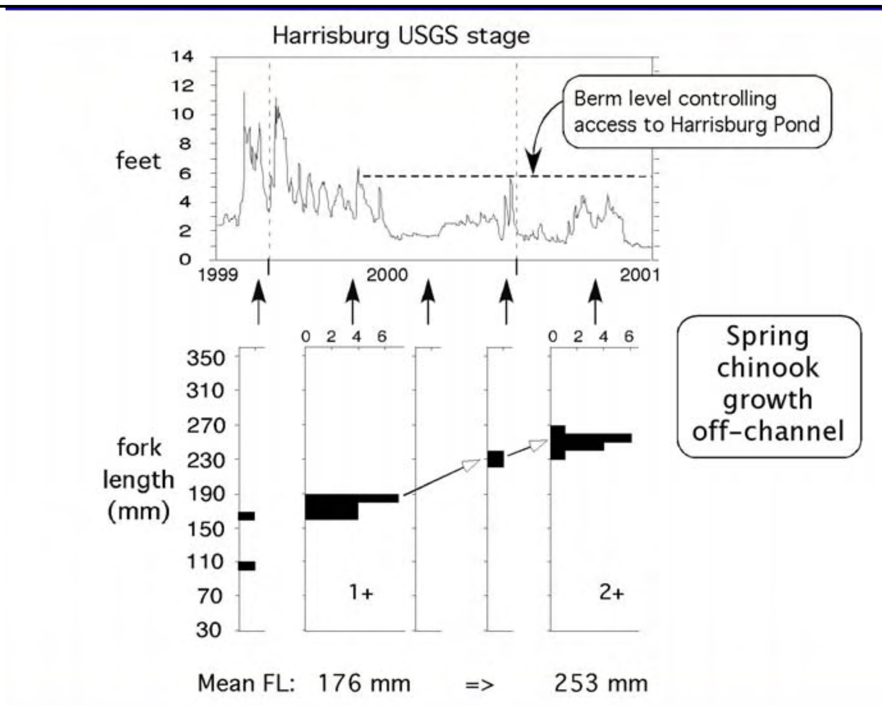

Proportion of
hatchery
1+ chinook
caught
off-channel
Proportion of hatchery 1+ chinook caught in
Screw Trap when river connected to off-channel pond

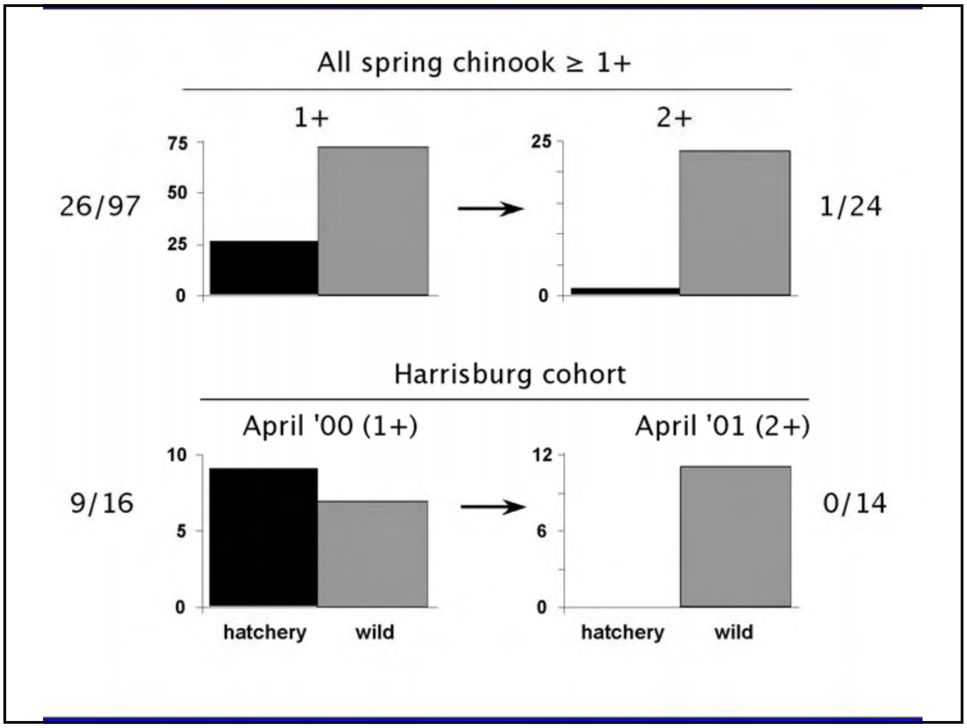
Compared to Hatchery Fish….

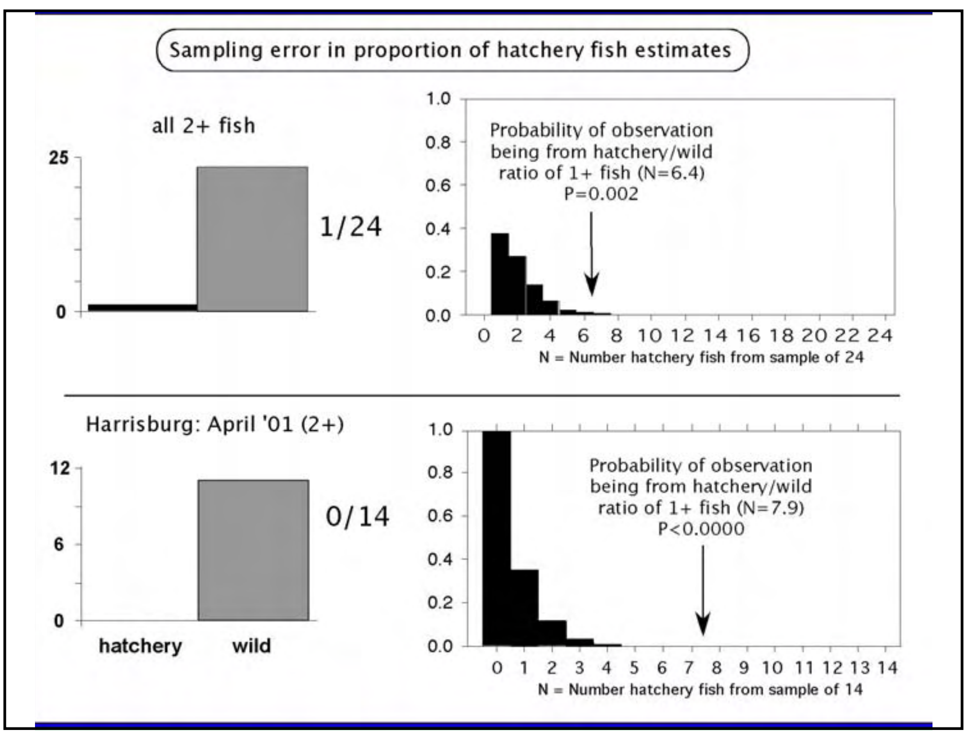
- Do wild fish use floodplain habitats to greater extent?

NO

- Is wild fish survival higher in these habitats?




All spring chinook ≥ 1+
1+
2+
26/97
1/24
Harrisburg cohort
April '00 (1+)
April '01 (2+)
9/16
0/14
hatchery
wild
hatchery
wild


Sampling error in proportion of hatchery fish estimates
all 2+ fish
1/24
Probability of observation being from hatchery/wild ratio of 1+ fish (N=6.4) P=0.002
N = Number hatchery fish from sample of 24
Harrisburg: April '01 (2+)
0/14
hatchery
wild
Probability of observation being from hatchery/wild ratio of 1+ fish (N=7.9) P<0.0000
N = Number hatchery fish from sample of 14

Compared to Hatchery Fish….

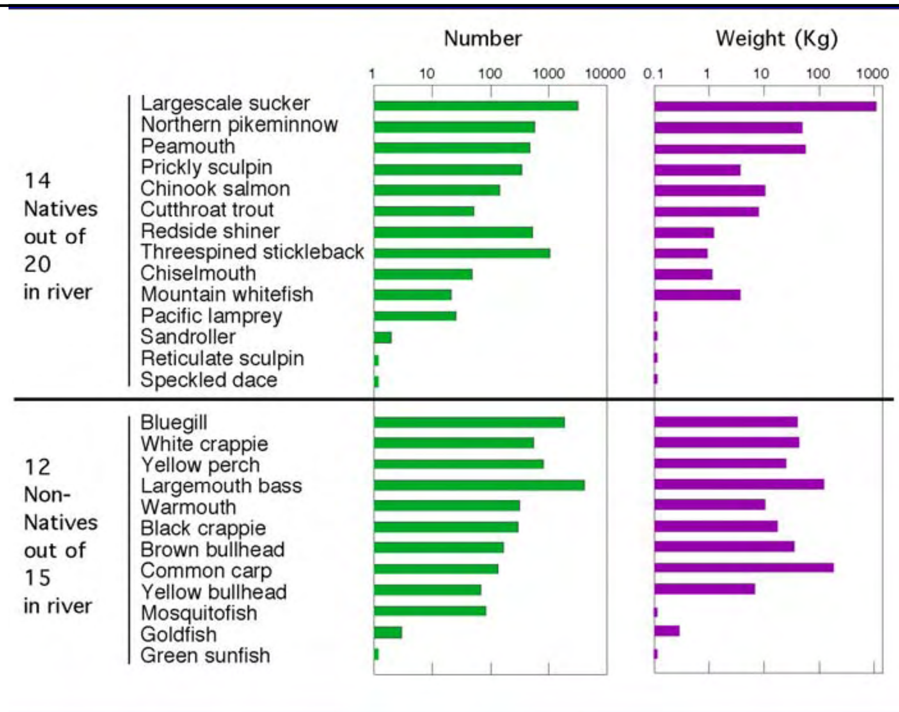
- Do wild fish use floodplain habitats to greater extent?

NO

- Is wild fish survival higher in these habitats?

YES

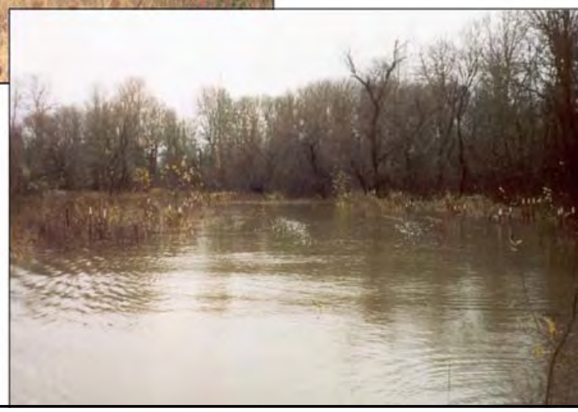
What about benefits of floodplain restoration for native fish species in general?



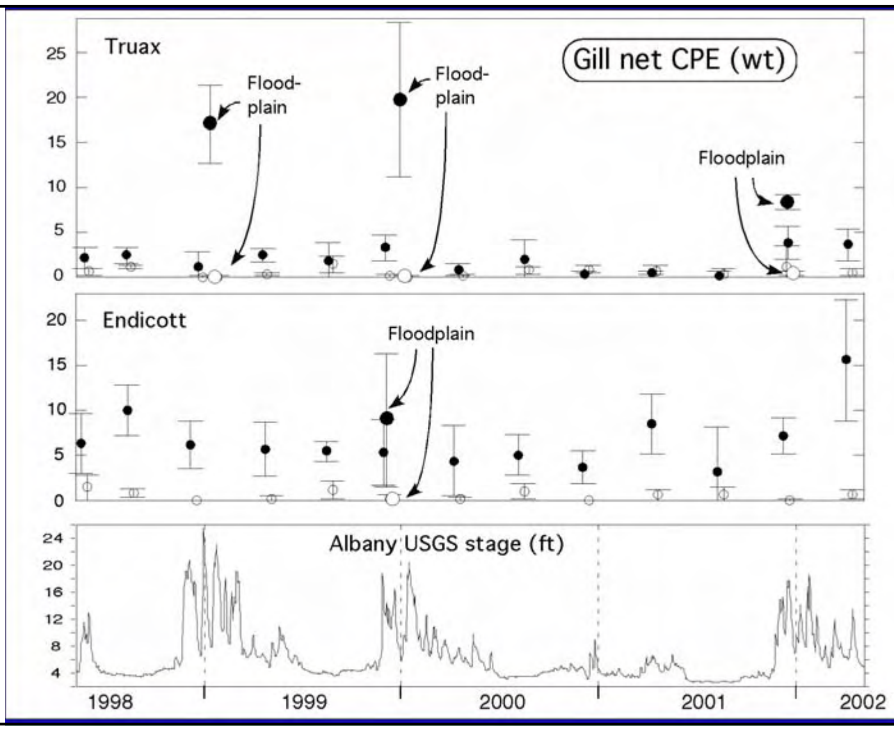
Fish assemblages in intermittent ag-streams and ditches also dominated by native species (out of 14 only 4 non-native)

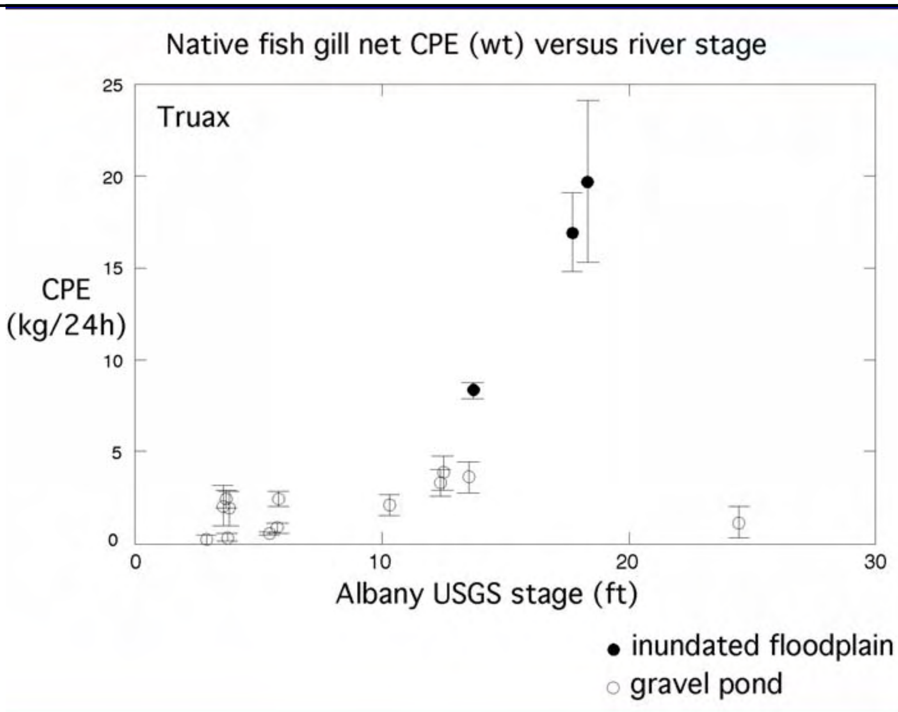




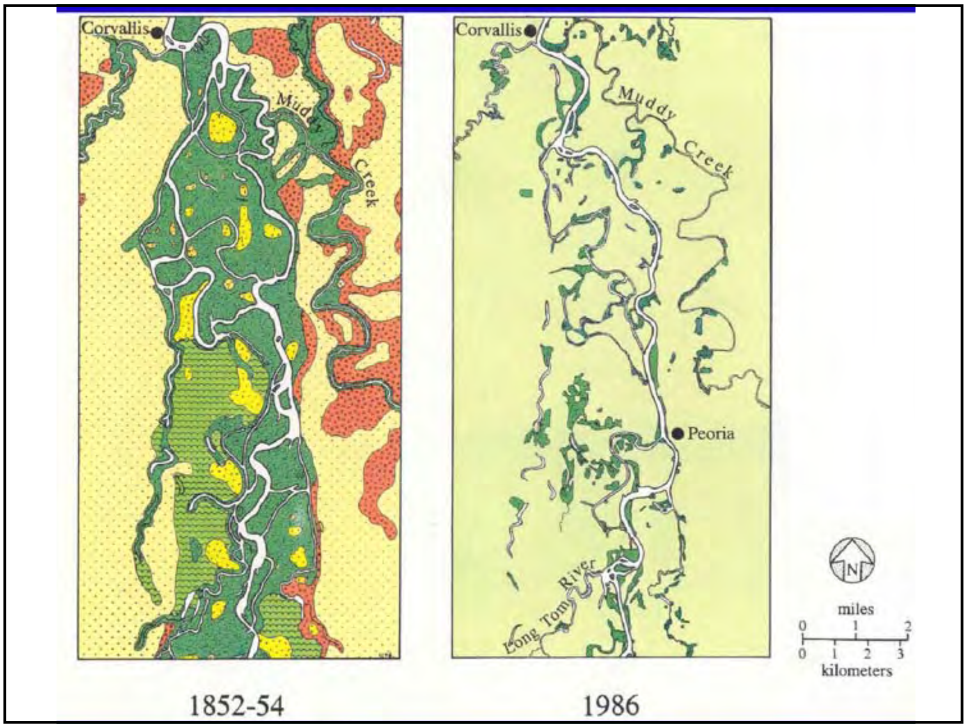
Summer and Winter Conditions at Truax Restoration Site

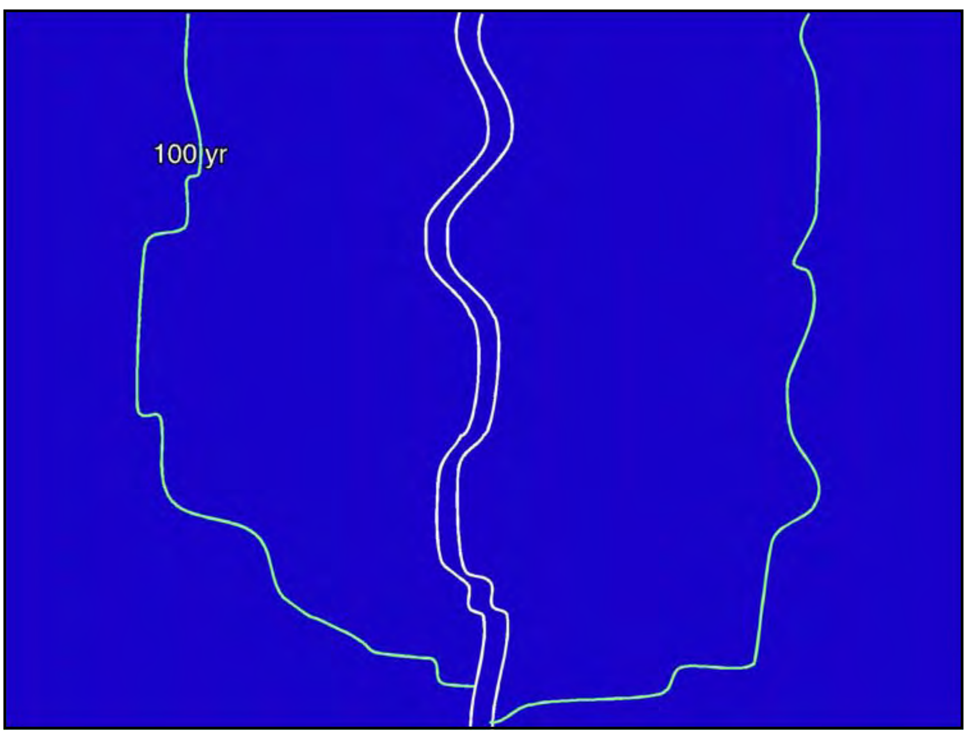


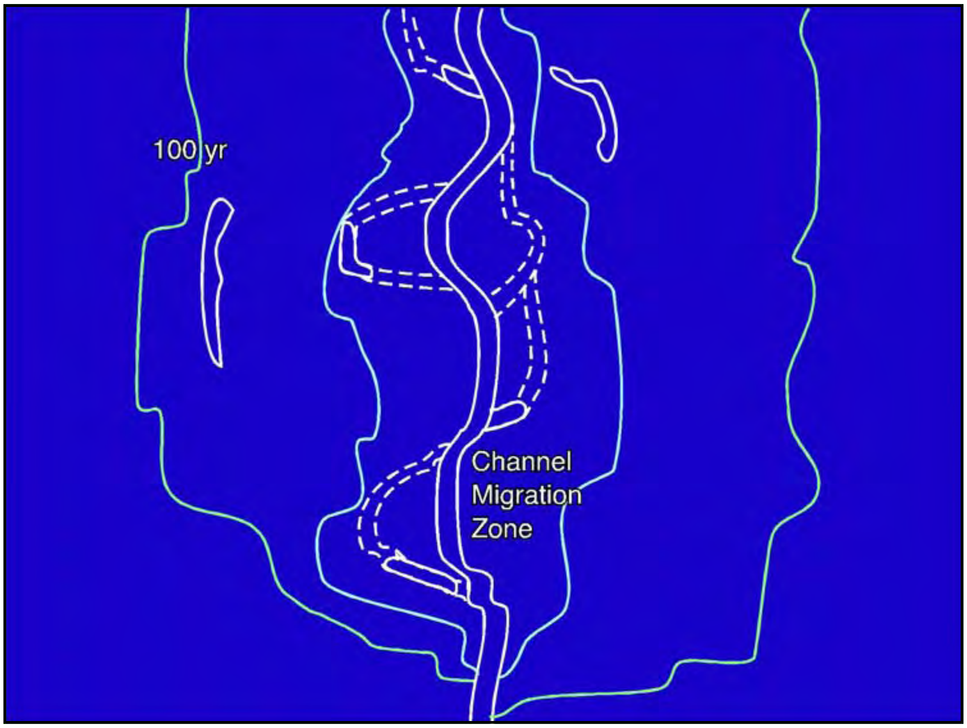


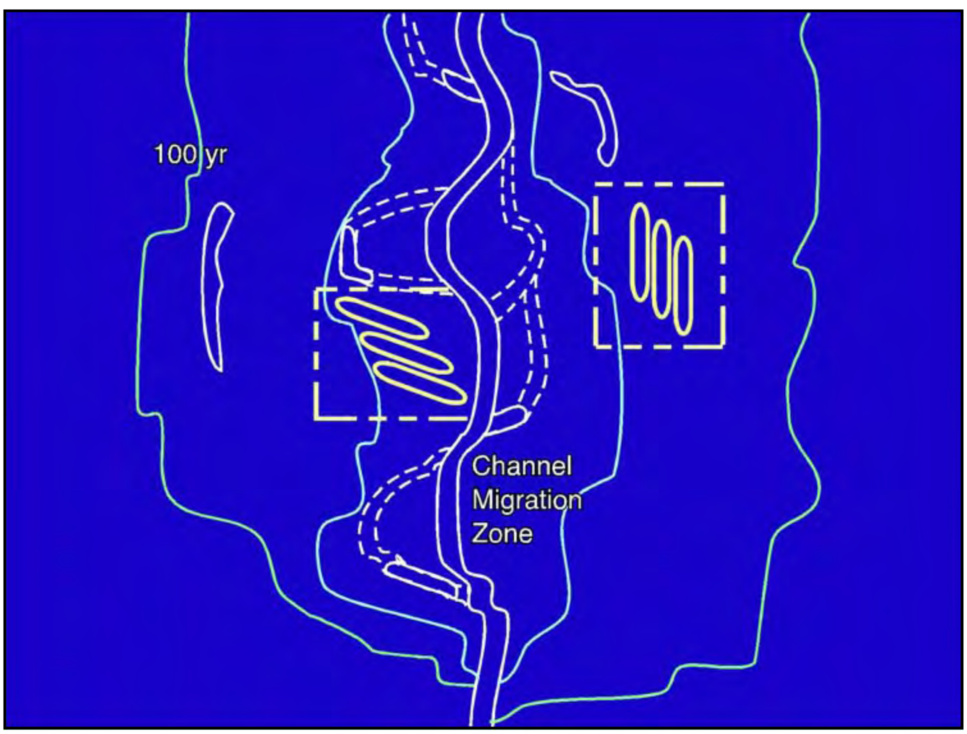
- Periodically inundated floodplain areas are at least as important as ponds that simulate oxbow lakes

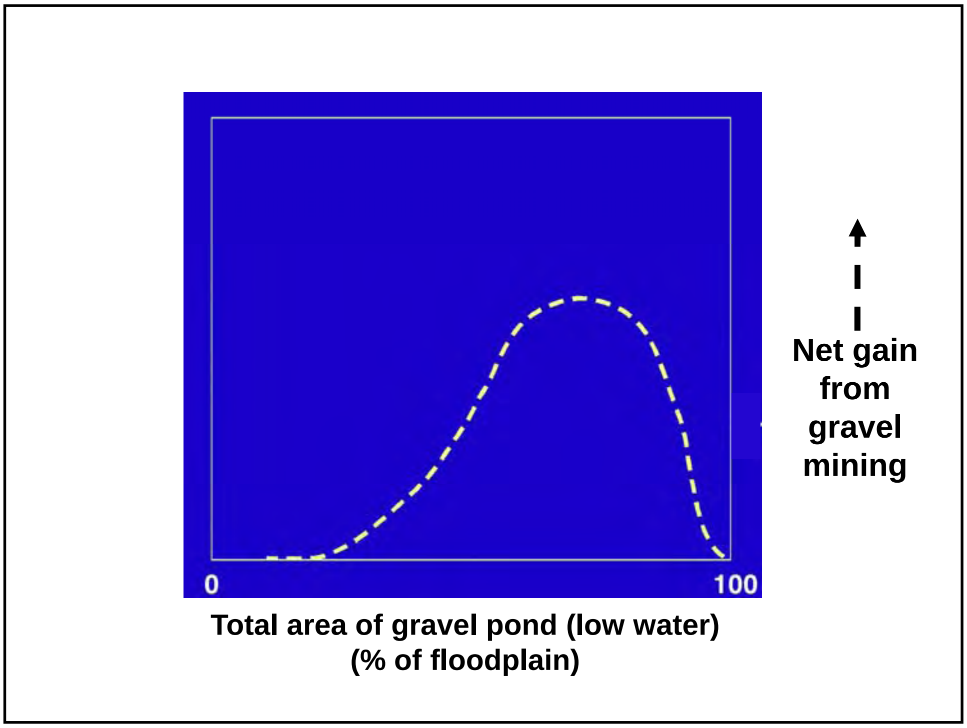
- Therefore, if agricultural land is being converted to aggregate mining use, where and how much of the property should be converted to permanent ponds?

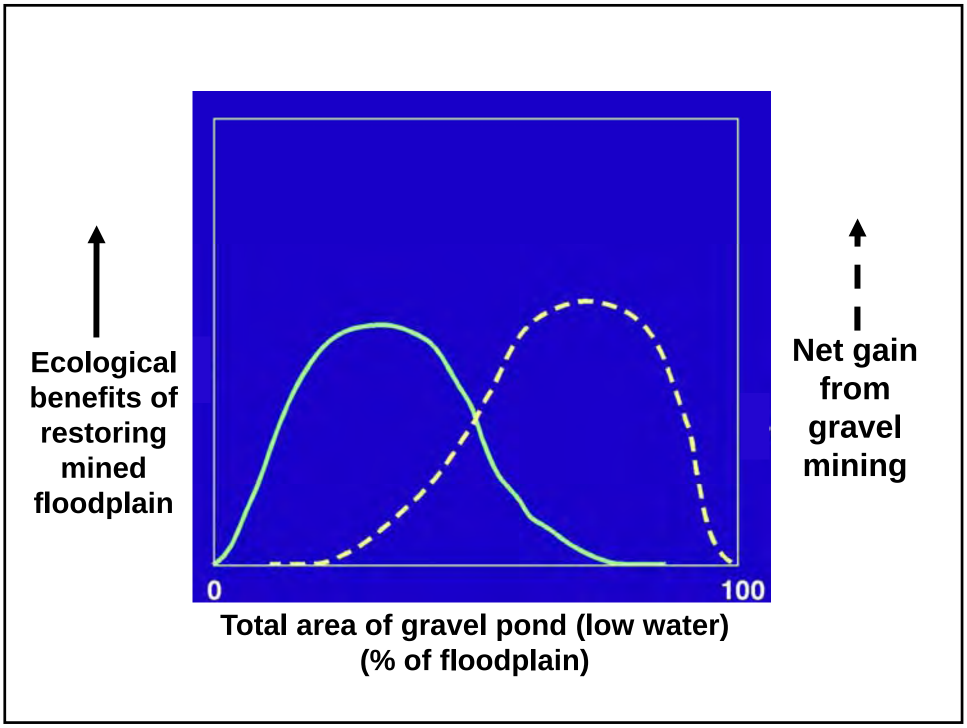

Corvallis
Muddy Creek
1852-54
Corvallis
Muddy Creek
Peoria
Long Tom River
N
miles
0 1 2
0 1 2 3
kilometers
1986


100 yr

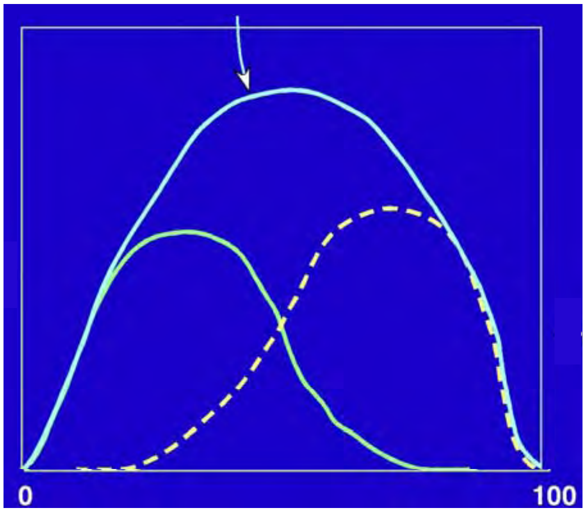

100 yr
Channel
Migration
Zone


100 yr
Channel
Migration
Zone


Net gain from gravel mining
0
100
Total area of gravel pond (low water) (% of floodplain)


Ecological benefits of restoring mined floodplain
Net gain from gravel mining
0
100
Total area of gravel pond (low water) (% of floodplain)

Total gain after mining and restoration/reclamation



Ecological benefits of restoring mined floodplain

Net gain from gravel mining

Total area of gravel pond (low water) (% of floodplain)

Is Aggregate Mining in Willamette Floodplains a Good Thing?

"NO"

- If floodplain retains some natural functions and is protected from intensive land-use development
- If site conditions indicate high risk of premature avulsion
- If existing toxic materials could be released
- If there has been an excess of sediment removal in basin that will affect recruitment

Is Aggregate Mining in Willamette Floodplains a Good Thing?

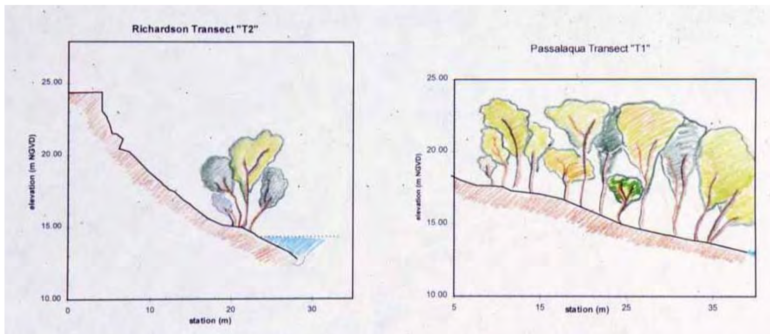
"YES"

- If within area already altered by other land use
- If gravel ponds are similar to river pools at low water
- If ponds have seasonal surface connection to the river
- If there is protection from premature avulsion by river channel
- If sufficient floodplain area is not mined

Funding for this work provided by Morse Brothers and The Oregon Watershed Enhancement Board

Presentation 6: Matt Kondolf

Habitat Potential in Former Gravel Pits
A Case Study on the Russian River



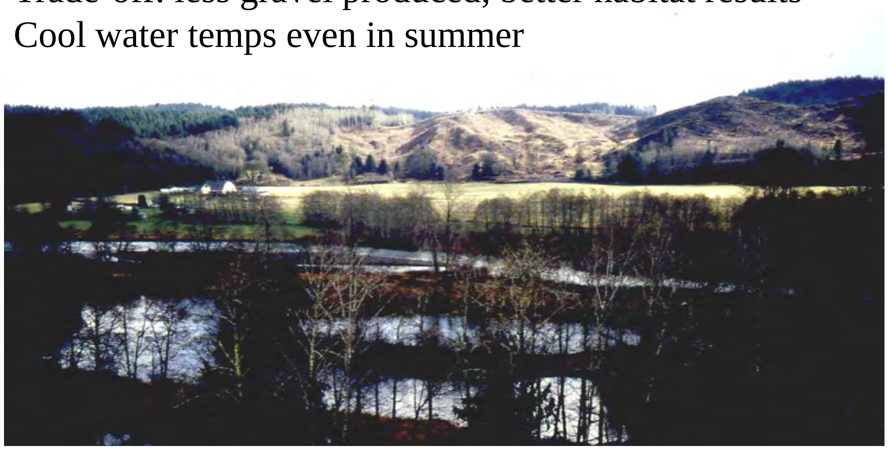
Matt Kondolf, University of California

Presented to the symposium Ecological Opportunities for Gravel Pit Reclamation on the Russian River

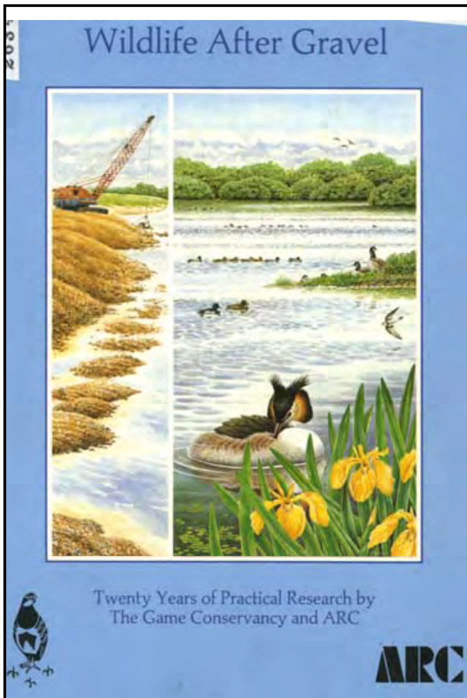
Massive transformation of floodplains worldwide to abandoned gravel pits: potential to create wetland habitat

A Bavarian pit to be reclaimed to wildlife habitat

Off-channel spawning/rearing habitat created in
the Olympic Peninsula (eg Weyco Pits)
Deliberately excavated to create suitable habitat:
shallow, multiple channels
Trade-off: less gravel produced, better habitat results
Cool water temps even in summer

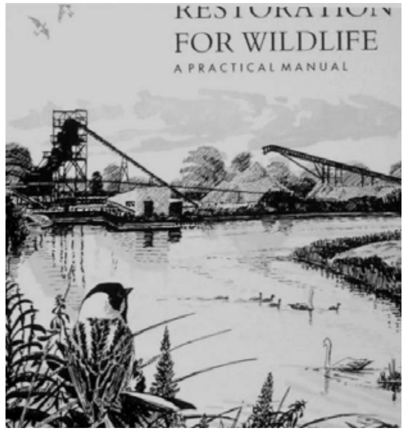


Trench excavations along the Big Quilcene River, WA
designed to 'trap' gravel upstream of urban reach
Such excavations can also provide slough habitat



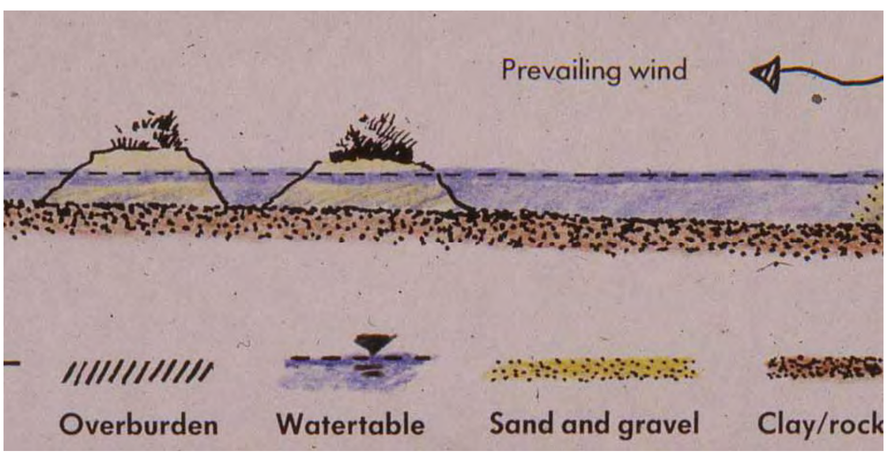
Tremendous interest in habitat potential of gravel pits in UK

A pit Milton Keynes managed by wildlife NGO, with blinds, fees. But shallow - gravel <2m deep.

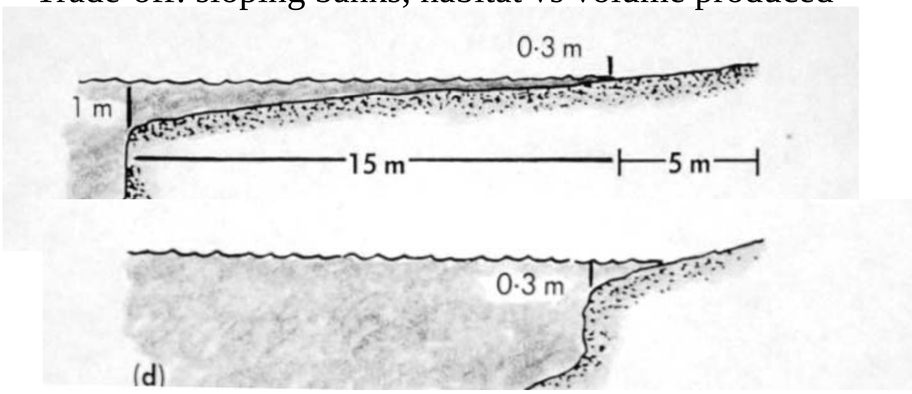


Some key recommendations from UK research:

-Build 'bunds' (islands) to minimize wind fetch and provide protected habitats for nesting, etc



Shallow excavation to produce shallow water habitat,
even with fluctuations in water level.
Trade-off: sloping banks, habitat vs volume produced

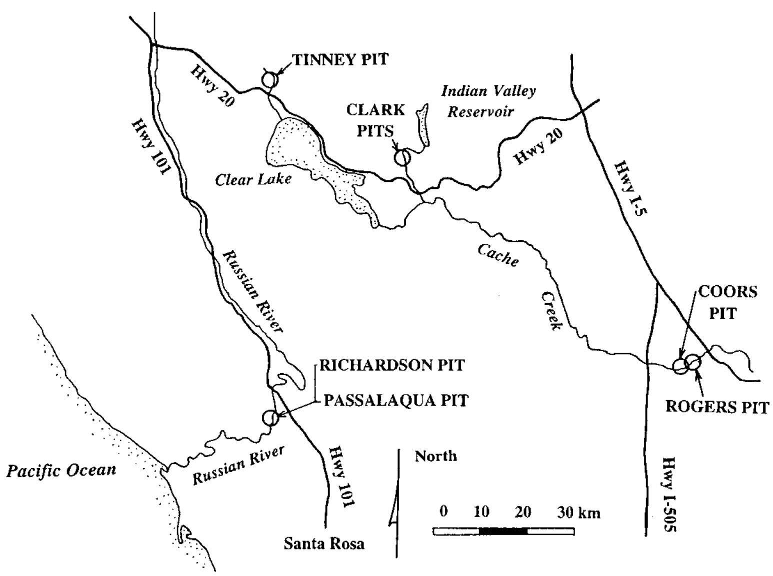


Greater seasonal water level fluctuations in
Med-climate California

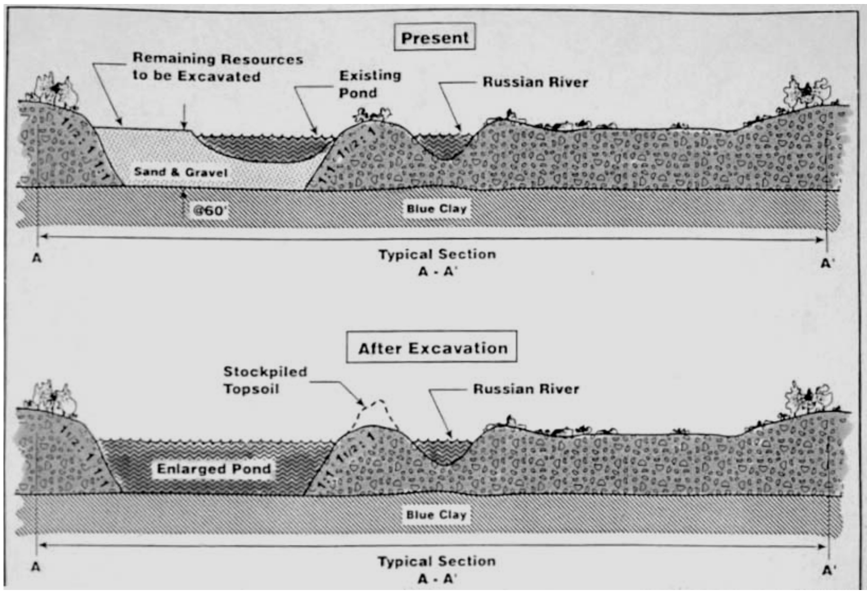
Clark Pits, N Fk Cache Creek
- regulated flow limits seasonal water level fluctuations

Contrast to pits on Middle Creek (trib to Clear Lake)
- seasonal water table fluctuations > 20 ft

Study of Gravel-Pit Re-Vegetation
effect of water-level fluctuation and pit geometry



As reviewed by Mitch Swanson, formerly meandering river was channelized in late 1950s, cut-off bends mined



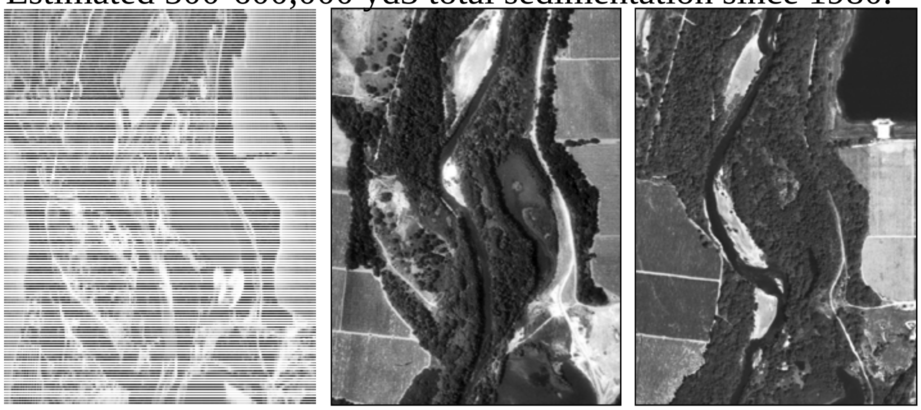
Scale of the pits is impressive (compared to channel).

Concerns over pit capture - but has not occurred because
- capturing pits is not a short-cut
- backwater effects of Wohler Narrows limits shear stress

1995 flood breached, but river did not adopt course through the gravel pit

Passalaqua Pit functioned like a side channel, overtopping several times/year, rapid sedimentation - now filled.

Estimated 500-600,000 yd3 total sedimentation since 1980.



1986 *1995* *2005*

This was the idea behind the original Sonoma County ARM Plan - but abandoned due to concerns about predation and trapping

Vegetation transects

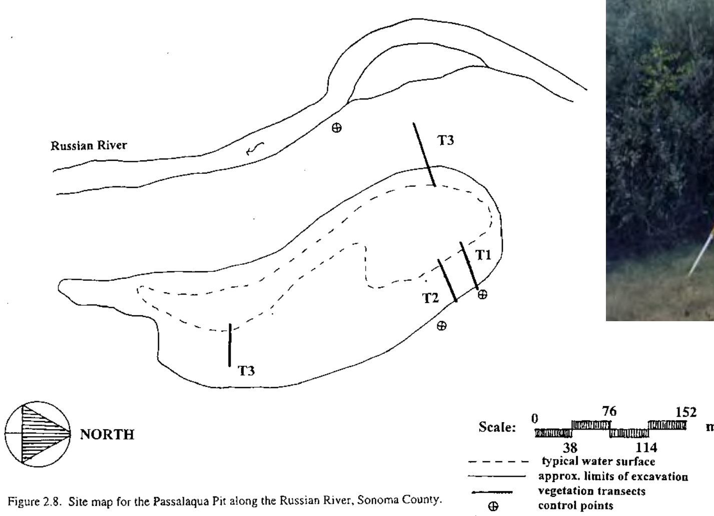
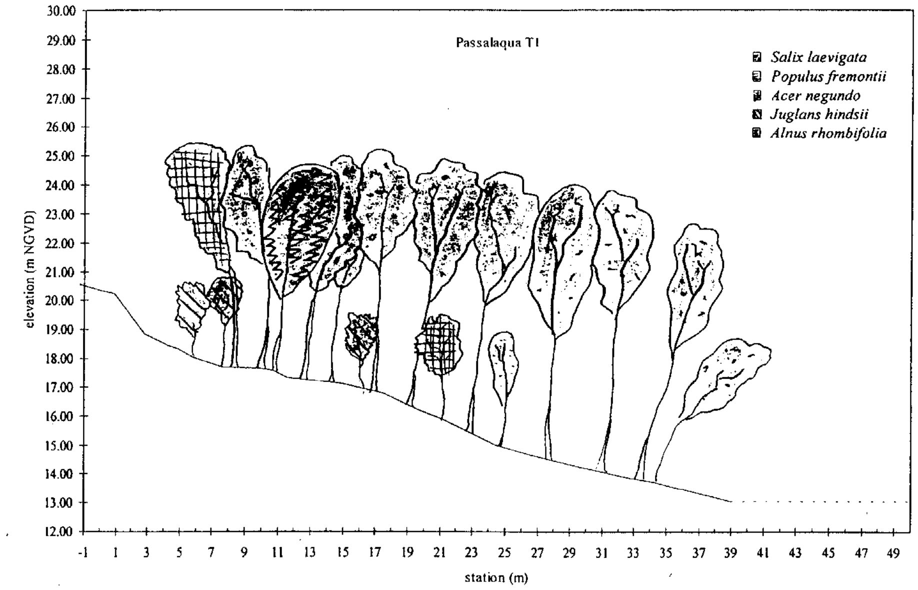


Figure 2.8. Site map for the Passalaqua Pit along the Russian River, Sonoma County.

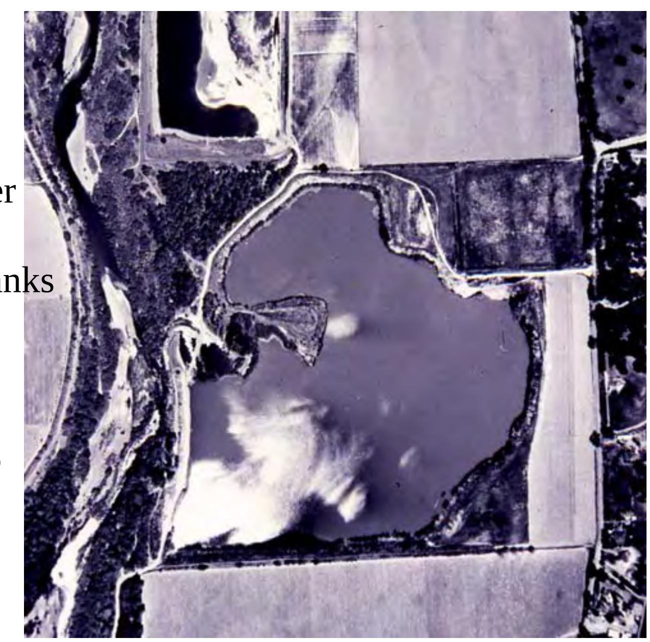
Riparian bands typically 100 ft wide



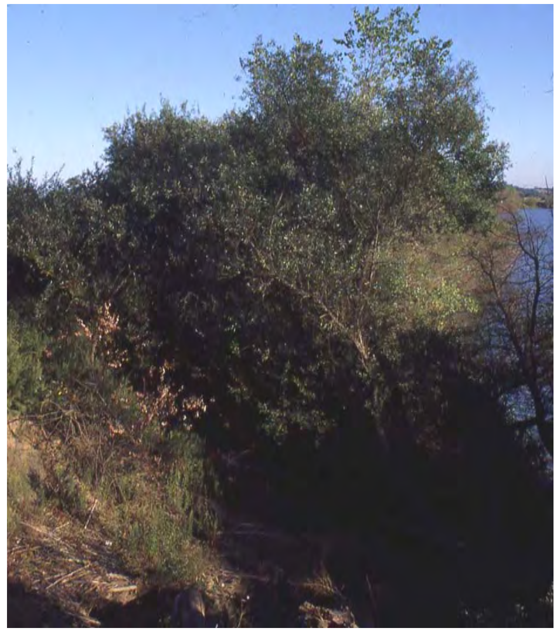
Just upstream
Richarson Pit

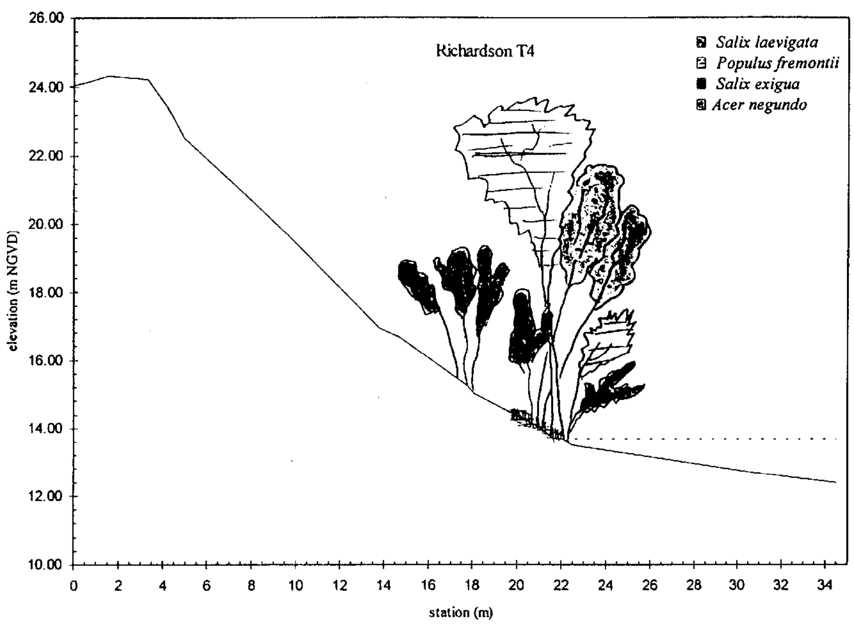
Isolated from river
by high berm
Steeply-sloped banks

Berm breached at
mid-point,
Delta deposit into
pit (flat surface)

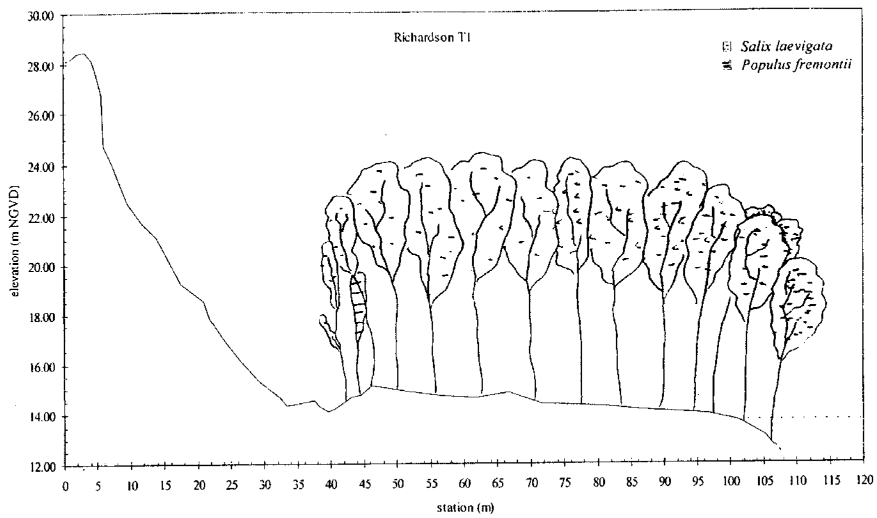


Steep banks result in narrow bands of riparian vegetation, Typically <20ft wide





Narrow riparian band along steep margins of Richardson Pit



The exception: the flat delta deposit in Richardson has a wide riparian forest

Vegetation Transects

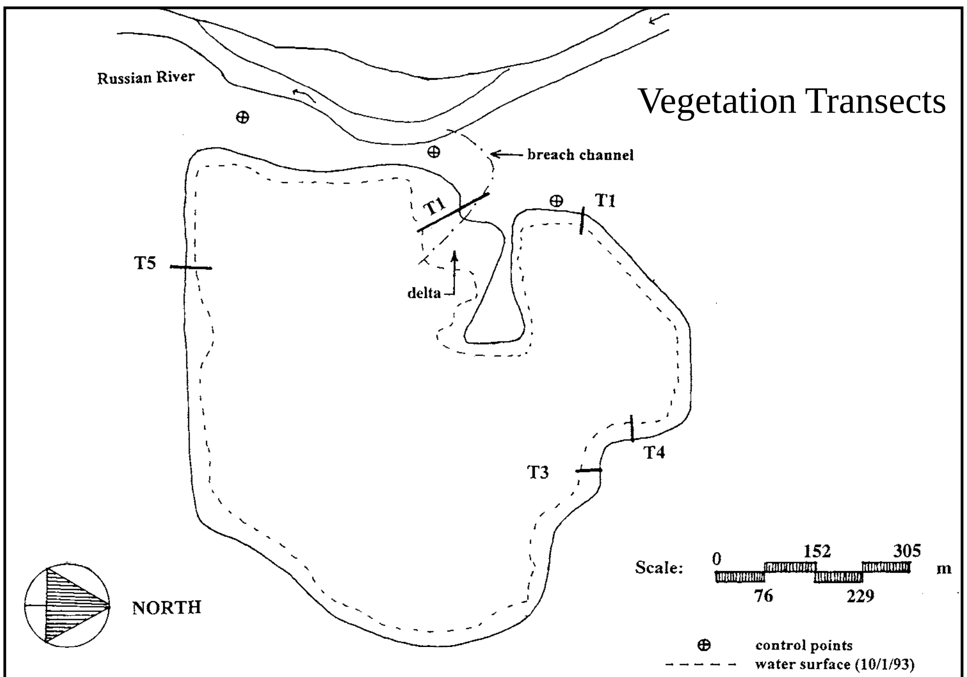
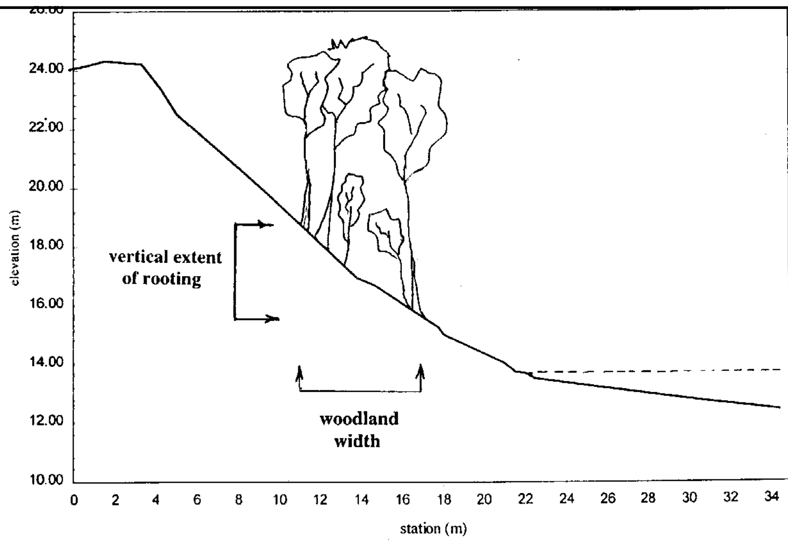
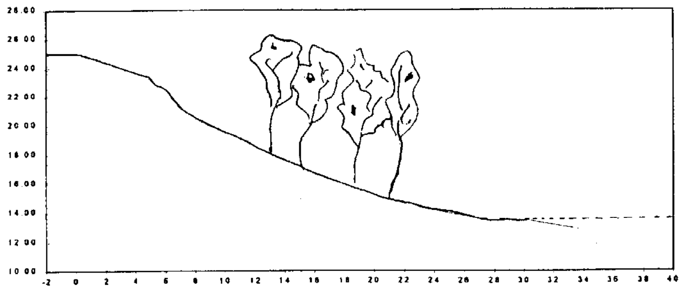


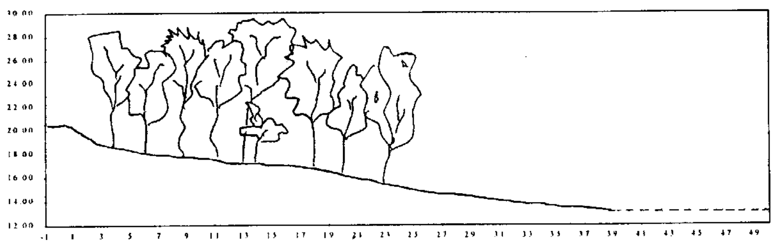
Figure 2.9. Site map for the Richardson Pit along the Russian River, Sonoma County.



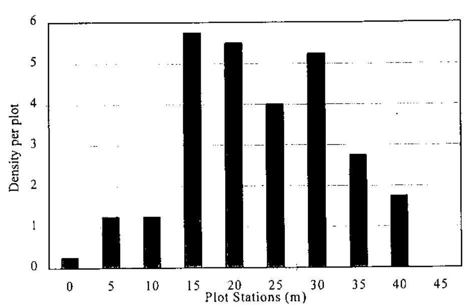
Access to shallow water table is key constraint:
Woodland width is controlled largely by bank slope

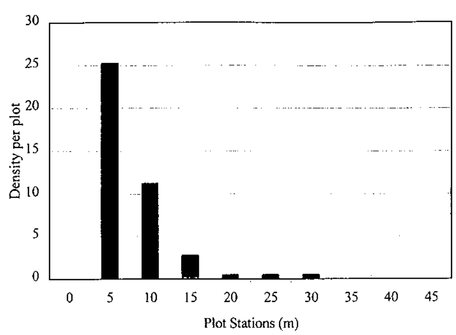
Another key factor: Fine-grained substrate from
fresh sedimentation (or overburden deposition)
Ideal conditions to establish woody riparian vegetation
at Passalaqua





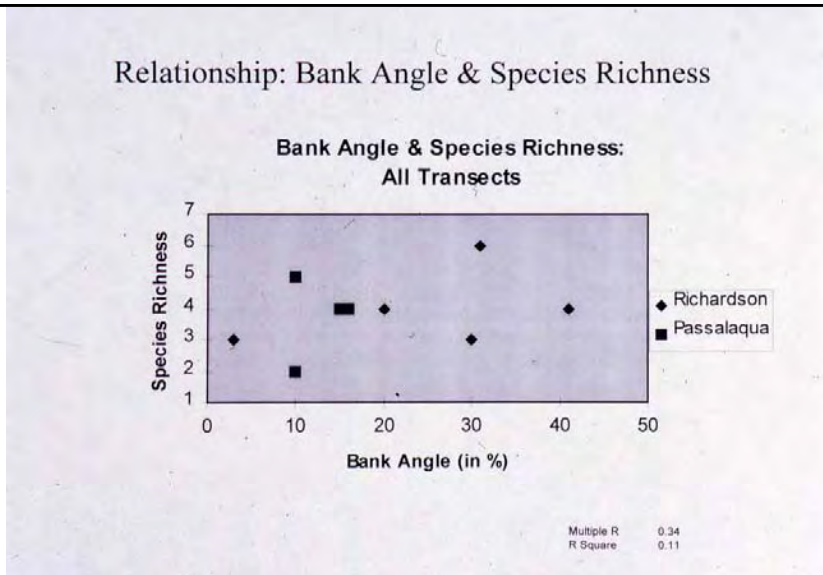
Passalaqua Pit with its gentle slopes, shallow water table, and fine-grained substrate = ideal conditions



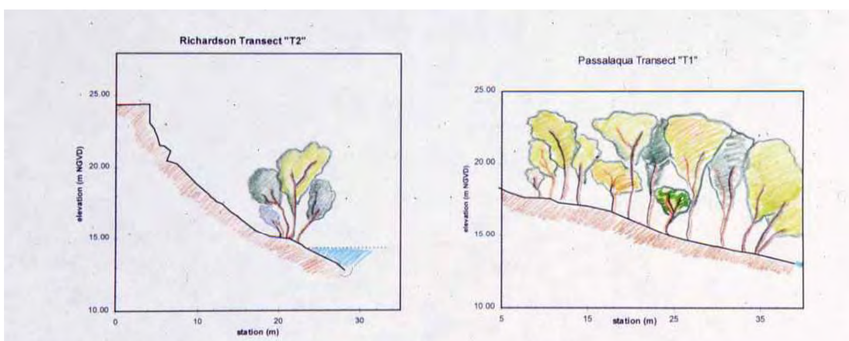


Passalaqua Pit *Richardson Pit*

However, tree density was actually higher in narrower riparian bands of Richardson -



Species richness did not vary by bank angle



To maximize post-mining habitat:
- shallow sloping banks
- account for water-table fluctuations
- fine-grained substrate: fresh deposition or overburden

Other issues: temperature, predation, stranding?

Pit capture: serious issue many places, but not Middle Reach Russian River