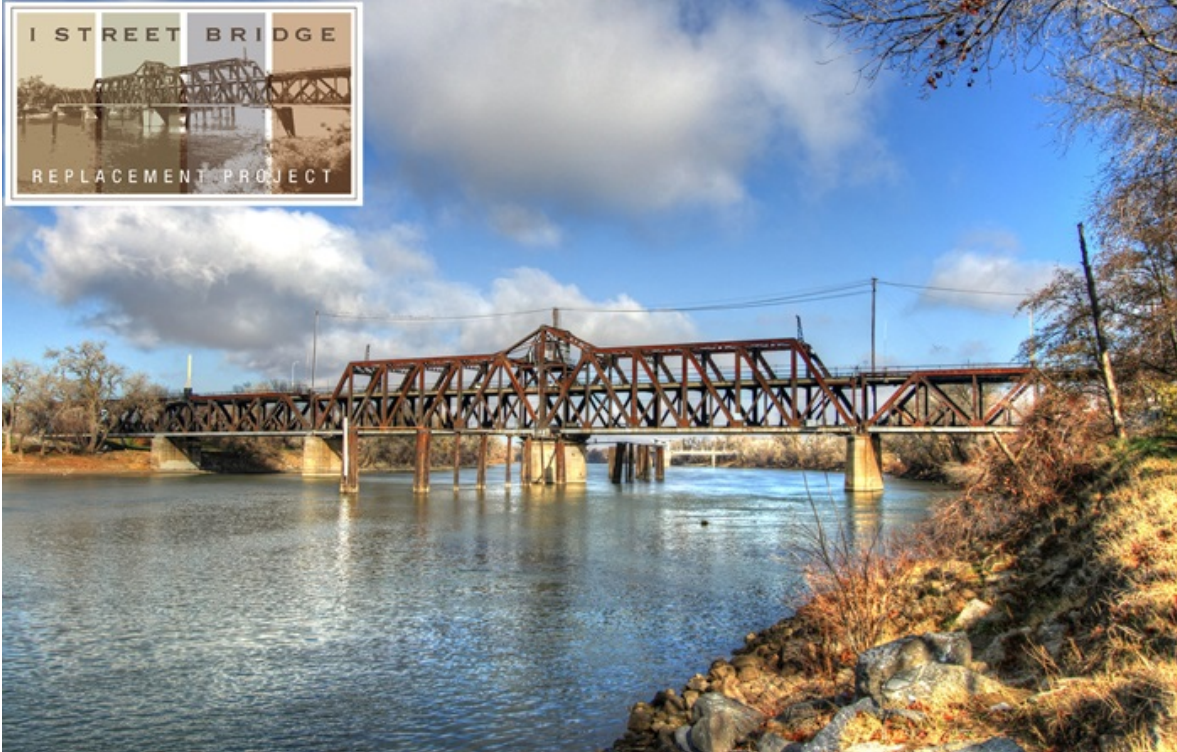


# VOLUME 2

## I Street Bridge Replacement Project



### Draft Environmental Impact Report/ Environmental Assessment

Sacramento and Yolo Counties

Federal Project No.: BRLS 5002(164)

**Prepared by the  
City of Sacramento and the  
State of California Department of Transportation**

The environmental review, consultation, and any other actions required by applicable Federal environmental laws for this project are being, or have been, carried out by Caltrans pursuant to 23 U.S.C. 327 and the Memorandum of Understanding dated December 23, 2016 and executed by FHWA and Caltrans.



September 2017

## Volume 2 **Appendices**

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<b>Appendix A</b>	<b>Section 4(f) De Minimis Determination and Section 6(f) Assessment</b>
<b>Appendix B</b>	<b>Title VI Policy Statement</b>
<b>Appendix C</b>	<b>Summary of Relocation Benefits</b>
<b>Appendix D</b>	<b>Avoidance, Minimization, and/or Mitigation Summary</b>
<b>Appendix E</b>	<b>Incomplete or Unavailable Information for Project-Specific MSAT Health Impacts Analysis</b>
<b>Appendix F</b>	<b>Sub-Area Travel Forecasting Model Development and Validation</b>
<b>Appendix G</b>	<b>Agency Letters</b>
<b>Appendix H</b>	<b>List of Technical Studies</b>

Appendix A

**Section 4(f) De Minimis Determination and  
Section 6(f) Assessment**

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# **Appendix A** Section 4(f) De Minimis Determination and Section 6(f) Assessment

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## **A.1 Introduction**

This document contains the Section 4(f) evaluation for the I Street Bridge Replacement project. This evaluation will be circulated as part of the EIR/EA to satisfy the requirements of Section 4(f) of the U.S. Department of Transportation (U.S. DOT) Act of 1966.

The environmental review, consultation, and any other action required in accordance with applicable federal laws for this project is being, or has been, carried-out by the California Department of Transportation (Caltrans) under its assumption of responsibility pursuant to 23 United States Code (USC) 327.

Section 4(f) of the Department of Transportation Act of 1966, codified in federal law at 49 USC 303, declares that “it is the policy of the United States government that special effort should be made to preserve the natural beauty of the countryside and public park and recreation lands, wildlife and waterfowl refuges, and historic sites.”

Section 4(f) specifies that the Secretary [of Transportation] may approve a transportation program or project ... requiring the use of publicly owned land of a public park, recreation area, or wildlife and waterfowl refuge of national, state, or local significance or land of a historic site of national, state, or local significance (as determined by the federal, state, or local officials having jurisdiction over the park, area, refuge, or site) only if:

- there is no prudent and feasible alternative to using that land, and
- the program or project includes all possible planning to minimize harm to the park, recreation area, wildlife and waterfowl refuge, or historic site resulting from the use.

As defined in 23 Code of Federal Regulations (CFR) Section 774.17,<sup>1</sup> resources subject to Section 4(f) consideration include publicly owned lands that are considered part of a public park; a recreational area of national, state, or local significance; a wildlife or waterfowl refuge; or a historic site of national, state, or local significance, whether publicly or privately owned.

Section 4(f) further requires consultation with the Department of the Interior and, as appropriate, the involved offices of the Department of Agriculture and the Department of Housing and Urban Development in developing transportation projects and programs that use lands protected by Section 4(f). If historic sites are involved, then coordination with the State Historic Preservation Officer (SHPO) is also needed.

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<sup>1</sup> 49 USC Section 303 is the code (law) passed by the U.S. Congress in 1966 that serves as the basis for U.S. DOT to develop the rules for implementing the law which is defined in 23 CFR 774.17.

This document also assesses the project against the requirements of Section 6(f)(3) of the Land and Water Conservation Fund Act (LWCF Act) (16 USC Section 4601-4), which contains provisions to protect federal investments in park and recreational resources and the quality of those assisted resources.

## A.2 Description of Proposed Project

The City of Sacramento, in cooperation with the City of West Sacramento and Caltrans, proposes to construct a new bridge over the Sacramento River to replace the vehicle crossing that is currently accommodated by the existing I Street Bridge in order to remove a series of functionally obsolete or structurally deficient bridges (i.e., approach structures). The new connection also would reduce future traffic congestion, improve operations and safety, serve multiple modes of transportation, and comply with current American Association of State Highway and Transportation Officials, Caltrans, and local agency design standards.

The build alternatives under consideration are one bridge alignment for the new bridge over the Sacramento River and two alternatives for portions of the roadway design in Sacramento.

- City of Sacramento Railyards Boulevard/Jibboom Street/Bercut Drive Intersection
  - Alternative 1—Signalized Intersection at Jibboom Street and Bercut Drive
  - Alternative 2—Roundabout Intersection at Jibboom Street and Bercut Drive
- No-Build (No-Project) Alternative

The proposed project would be located in Sacramento and Yolo Counties, over the Sacramento River and between the cities of Sacramento and West Sacramento. The project site is approximately 1,000 feet north of the existing I Street Bridge (Figures 1-1 and 1-2 of the EIR/EA). The total length of the project would be approximately 0.42 mile along C Street and Railyards Boulevard. The purpose of the project is to construct a new public crossing of the Sacramento River north of the Union Pacific Railroad (UPRR)-owned I Street Bridge from C Street in West Sacramento to Railyards Boulevard in Sacramento in order to remove a series of functionally obsolete or structurally deficient bridges, consistent with the adopted findings of the Sacramento River Crossings Alternatives Study for Bridge Location 2 in the North Market Area.

The project is subject to state and federal environmental review requirements because of use of federal Highway Bridge Program (HBP) funds from the Federal Highway Administration (FHWA). Accordingly, project documentation is being prepared in compliance with both the California Environmental Quality Act (CEQA) and the National Environmental Policy Act (NEPA). The City of Sacramento is the lead agency under CEQA, with the City of West Sacramento as a responsible agency, and Caltrans is the lead agency under NEPA. The FHWA's other responsibilities for environmental review, consultation, and any other action required in accordance with applicable federal laws for this project will be carried out by Caltrans under its assumption of responsibility pursuant to 23 USC 327.

This project is included in the Sacramento Area Council of Governments 2035 *Metropolitan Transportation Plan/Sustainable Communities Strategy*.

## **A.3 Section 4(f) Properties**

### **A.3.1 Study Area**

Two study area limits were used as part of the identification of Section 4(f) properties. Parks and recreational areas were evaluated using a different study area than that used for the cultural resources analysis because the evaluation of cultural resources as defined in Section 106 requires identification of an Area of Potential Effects (APE). Accordingly, the study area for the Section 4(f) analysis comprises the two study areas described below, which may or may not overlap.

#### **A.3.1.1 Study Area for Historic Properties**

The study area for historic sites is the APE developed for this project in accordance with 36 CFR 800.4(a)(1), plus the boundary of the Old Sacramento State Historic Park. The APE is the geographic area or areas within which an undertaking may directly or indirectly cause alterations in the character or use of historic properties or archaeological sites. Old Sacramento State Historic Park, a California Historic Landmark, is outside of the APE but is being addressed in this document as an historic property as well as a recreational area.

#### **A.3.1.2 Study Area for Public Parks and Recreational Areas**

The study area for public parks and recreation areas is a 0.5 mile buffer around the project site. The study area is shown in Figure 1 (Attachment A). There are no wildlife refuges in the study area; therefore, refuges are not discussed further.

### **A.3.2 Description of Section 4(f) Properties**

#### **A.3.2.1 Historic Properties**

Table 1 provides a list of historic and cultural resources within the study area for historic properties that have been considered as potential Section 4(f) properties.

In accordance with the requirements of Section 4(f) and Section 106 of the National Historic Preservation Act, Caltrans has consulted with the SHPO regarding determinations of eligibility for two properties identified in the APE and shown below in Table 1. Caltrans received concurrence with its determination of eligibility in a letter from the SHPO dated February 7, 2017. In addition, a third historic property that was not included in the project APE is considered a Section 4(f) property, Old Sacramento State Historic Park. As shown in Table 1, these three properties are eligible for or listed on the National Register of Historic Places (NRHP) and therefore are considered Section 4(f) resources.

**Table 1. Historic Properties Listed or Eligible for the NRHP**

Name	Address	NRHP Eligibility	Section 4(f) Resource?
I Street Bridge (P-34-002349)	I Street/State Route (SR) 16	Listed in the NRHP in 1982	Yes
Sacramento River East Levee (P-34-00490)	Sacramento	Found eligible for listing	Yes
Old Sacramento State Historic Park	Sacramento	Found eligible for listing	Yes

There are no NRHP-listed archaeological properties identified within the APE (refer to Archaeological Survey Report prepared for the project [ICF International 2015]). Therefore, there are no Section 4(f) archaeological properties that require consideration.

### A.3.2.2 Public Parks and Recreation Areas

Table 2 provides a list of the parks, recreational facilities, and other public spaces with recreational use within the study area that have been considered as potential Section 4(f) properties. These properties are shown in Figure 1 (Attachment A) using the map identification numbers in Table 2.

In accordance with the coordination requirements of Section 4(f), letters will be sent to each of the jurisdictions along the study area requesting feedback and confirmation on the locations, primary purpose, and attributes of the parks and recreational areas within their respective jurisdictions.

**Table 2. Potential Section 4(f) Properties (Parks and Recreation Areas)**

Map ID	Name	Description	Approximate Distance from Project Footprint	Section 4(f) Resource?
<b>City of West Sacramento</b>				
1	Elkhorn Plaza	<b>Size:</b> 5.2 acres <b>Features:</b> One backstop, half soccer field, picnic area with BBQs, horseshoe pits, and play structure. <b>Agency with Jurisdiction:</b> City of West Sacramento	0.6 mile	Yes
2	Heritage Green (proposed)	<b>Size:</b> 0.75 acres <b>Features:</b> Future park site with lawn space, picnic area, play structure, and community garden. <b>Agency with Jurisdiction:</b> City of West Sacramento	0.2 mile	Yes
3	Raley Field	<b>Size:</b> Approximately 14.3 acres <b>Features:</b> Triple-A Baseball field for the Sacramento River Cats minor league baseball team. Also a venue for concerts, community events, and private events. <b>Agency with Jurisdiction:</b> Privately owned	0.45 mile	No
4	Washington Plaza (proposed)	<b>Size:</b> 0.38 acres <b>Features:</b> Future park site with urban plaza, interactive water feature, picnic area, and game tables. <b>Agency with Jurisdiction:</b> City of West Sacramento	0.2 mile	Yes

Map ID	Name	Description	Approximate Distance from Project Footprint	Section 4(f) Resource?
5	Crossings Yard (proposed)	<b>Size:</b> 0.69 acres <b>Features:</b> Future park site with lawn space, picnic area, and play structure. <b>Agency with Jurisdiction:</b> City of West Sacramento	Adjacent	Yes
6	Governor's Residence State Park	<b>Size:</b> Approximately 38.25 acres <b>Features:</b> Future regional park, with 11–12 acres potentially dedicated to the Governor's Residence and the remaining 31–33 acres dedicated to state park land, with waterfront access. <b>Agency with Jurisdiction:</b> City of West Sacramento	0.3 mile	Yes
7	Broderick Boat Ramp	<b>Size:</b> Approximately 8.87 acres <b>Features:</b> Boat ramp and launching dock, parking for trailers, restroom facilities. <b>Agency with Jurisdiction:</b> City of West Sacramento	Adjacent	Yes
8	Off-Leash Dog Park (proposed)	<b>Size:</b> Approximately 1.5 acres <b>Features:</b> Future off-leash dog park with access to Broderick Boat Ramp. <b>Agency with Jurisdiction:</b> City of West Sacramento	Adjacent	Yes
9	River Walk Park	<b>Size:</b> 7.5 acres <b>Features:</b> Riverfront park that contains a paved trail along the west bank of the Sacramento River. Picnic areas are located between the trail and the river. Along the trail itself are many educational signs that talk about the settlement of Sacramento, as well as the natural habitat of the river. <b>Agency with Jurisdiction:</b> City of West Sacramento	Adjacent	Yes
10	Riverfront Park (proposed)	<b>Size:</b> 0.71 acres <b>Features:</b> Future riverfront park with half basketball court, children's play area, and picnic areas. <b>Agency with Jurisdiction:</b> City of West Sacramento	Adjacent	Yes
11	River Walk Park (proposed)	<b>Size:</b> TBD <b>Features:</b> Proposed extension of existing River Walk Park. <b>Agency with Jurisdiction:</b> City of West Sacramento	Adjacent	Yes
12	Access Corridor (proposed)	<b>Size:</b> 0.75 acres <b>Features:</b> Future promenade with fitness stations and public seating. <b>Agency with Jurisdiction:</b> City of West Sacramento	0.3 miles	Yes
13	River Walk Park (proposed)	<b>Size:</b> TBD <b>Features:</b> Proposed extension of existing River Walk Park. <b>Agency with Jurisdiction:</b> City of West Sacramento	1 mile	Yes
<b>City of Sacramento</b>				
14	Tiscornia Park	<b>Size:</b> Approximately 14.36 acres <b>Features:</b> River access at the confluence of the Sacramento and American Rivers, beach, picnic and BBQ areas, parking, restroom facilities. <b>Agency with Jurisdiction:</b> City of Sacramento	0.4 miles	Yes
15	Sacramento River Parkway Trail	<b>Size:</b> 9.3 miles <b>Features:</b> Consists of two disconnected segments. The north segment in the project area starts at Jiboom Street Bridge in Tiscornia Park and connects to the American River Parkway Trail. <b>Agency with Jurisdiction:</b> City of Sacramento	Adjacent	Yes



Map ID	Name	Description	Approximate Distance from Project Footprint	Section 4(f) Resource?
16	Robert T. Matsui Waterfront Park	<b>Size:</b> 6.5 acres (Phase I) <b>Features:</b> Public area that contains paved bike path (Sacramento River Bike Trail) adjacent to the west bank of the Sacramento River. Second phase of development will include shade structure, and picnic and BBQ areas. <b>Agency with Jurisdiction:</b> City of Sacramento	Adjacent	Yes
17	Sacramento River Parkway (Central Area)	<b>Size:</b> Approximately 11.52 acres <b>Features:</b> Parkway along the east bank of the Sacramento River between Discovery Park and the Pocket Area of Sacramento. Contains the paved Sacramento River Parkway Trail and provides connection to the American River Bike Trail. <b>Agency with Jurisdiction:</b> City of Sacramento	Adjacent	Yes
18	Riverfront Park (proposed)	<b>Size:</b> Approximately 0.04 acres <b>Features:</b> Future linear park consisting of passive and active uses, with riparian planting, river access, and small gathering spaces. <b>Agency with Jurisdiction:</b> City of Sacramento	Adjacent	Yes
19	Old Sacramento State Historic Park	<b>Size:</b> Approximately 6.2 acres <b>Features:</b> Sacramento Railroad Museum and other historic buildings, picnic areas, and walking tours through Old Sacramento. <b>Agency with Jurisdiction:</b> California Department of Parks and Recreation	Adjacent	Yes
20	Sacramento River Parkway (Future)	<b>Size:</b> Approximately 16 miles <b>Features:</b> Proposed extension of existing Sacramento River Parkway that would require many public right-of-way acquisitions. <b>Agency with Jurisdiction:</b> City of Sacramento	Adjacent	Yes
21	Crocker Park	<b>Size:</b> Approximately 3.62 acres <b>Features:</b> Picnic area adjacent to Crocker Art Museum. <b>Agency with Jurisdiction:</b> City of Sacramento	0.4 mile	Yes
22	Central Shops Plazas (proposed)	<b>Size:</b> Approximately 12.53 acres <b>Features:</b> Future urban plazas that will connect the Central Shops buildings of the Railyards site. <b>Agency with Jurisdiction:</b> City of Sacramento	0.6 mile	Yes
23	Depot Park (proposed)	<b>Size:</b> Approximately 1.49 acres <b>Features:</b> Planned park that will serve as entry way to "Depot" District of the Sacramento Railyards <b>Agency with Jurisdiction:</b> City of Sacramento	0.1 mile	Yes
24	Vista Park (proposed)	<b>Size:</b> Approximately 10.54 acres <b>Features:</b> Planned park that would contain a playing field and amphitheater. <b>Agency with Jurisdiction:</b> City of Sacramento	0.15 mile	Yes
25	Stanford Walk (proposed)	<b>Size:</b> Approximately 0.77 acre <b>Features:</b> Future urban linear plaza intended for pedestrians and bicyclists. Will connect Vista Park to the Central Shops District. <b>Agency with Jurisdiction:</b> City of Sacramento	0.2 mile	Yes

Map ID	Name	Description	Approximate Distance from Project Footprint	Section 4(f) Resource?
26	Neighborhood Parks (proposed)	<b>Size:</b> Approximately 2.88 acres <b>Features:</b> Five open space areas for active and passive community activities including play structures, gardens, and gathering spaces. <b>Agency with Jurisdiction:</b> City of Sacramento	0.3 mile	Yes
27	Saint Rose of Lima Park	<b>Size:</b> 0.51 acre <b>Features:</b> Public square with benches, a stage, and seasonal ice rink. <b>Agency with Jurisdiction:</b> City of Sacramento	0.3 mile	Yes
28	Leland Stanford Mansion State Historic Park	<b>Size:</b> 0.6 acre <b>Features:</b> Historic mansion and gardens. A museum with daily tours. <b>Agency with Jurisdiction:</b> California Department of Parks and Recreation	0.5 mile	Yes
29	Caesar Chavez Plaza	<b>Size:</b> 3.05 acres <b>Features:</b> Café, fountain, picnic area, stage, seasonal events including farmers market and summer concerts <b>Agency with Jurisdiction:</b> City of Sacramento	0.3 mile	Yes
30	Capitol Park	<b>Size:</b> Approximately 36 acres <b>Features:</b> California State Capitol, gardens, memorial, walking paths, seating, guided daily tours. <b>Agency with Jurisdiction:</b> California Department of Parks and Recreation	0.5 mile	Yes
31	Zapata Park	<b>Size:</b> 0.95 acre <b>Features:</b> Neighborhood park with play structure and basketball court. Master Plan includes community garden. <b>Agency with Jurisdiction:</b> City of Sacramento	0.45 mile	Yes
32	J. Neely Johnson Park	<b>Size:</b> 0.96 acre <b>Features:</b> Community garden <b>Agency with Jurisdiction:</b> City of Sacramento	0.5 mile	Yes

### A.3.3 Section 4(f) De Minimis Determination

Section 6009(a) of the Safe Accountable Flexible Efficient Transportation Equity Act: A Legacy for Users amended Section 4(f) legislation at 23 USC 138 and 49 USC 303 to simplify the processing and approval of projects that have only *de minimis* impacts on lands protected by Section 4(f). This revision provides that once U.S. DOT determines that a transportation use of Section 4(f) property, after consideration of any impact avoidance, minimization, and mitigation or enhancement measures, results in a *de minimis* impact on that property, an analysis of avoidance alternatives is not required and the Section 4(f) evaluation process is complete. FHWA's final rule on Section 4(f) *de minimis* findings is codified in 23 CFR 774.3 and CFR 774.17.

Responsibility for compliance with Section 4(f) has been assigned to Caltrans pursuant to 23 USC 326 and 327, including determinations and approval of Section 4(f) evaluations, as well as coordination with those agencies that have jurisdiction over a Section 4(f) resource that may be affected by a project action.

Table 3 summarizes the use determination for the recreational resources in the study area, including proposed parks. There are no differences in acquisition impacts proposed as part of the City of Sacramento roadway design alternatives. Areas of permanent acquisition are shown in Figure 2 (Attachment A). The remainder of the resources are discussed in Section A.3.4, *Other Resources Evaluated Relative to the Requirements of Section 4(f)*.

**Table 3. Section 4(f) Parks and Recreation Properties Use Determination Summary**

Map ID	Name	Use?	Constructive Use?	Temporary Occupancy?	Explanation
<b>City of West Sacramento</b>					
1	Elkhorn Plaza	No	No	No	0.6 mile away from project footprint, no potential for impact.
2	Heritage Green (proposed)	No	No	No	0.2 mile away from project footprint, no potential for impact.
3	Raley Field	No	No	No	0.45 mile away from project footprint, no potential for impact.
4	Washington Plaza (proposed)	No	No	No	0.2 mile away from project footprint, no potential for impact.
5	Crossings Yard (proposed)	No	No	No	0.69 mile away from project footprint, no potential for impact.
6	Governor's Residence State Park (proposed)	No	No	No	0.3 mile away from project footprint, no potential for impact.
7	<b>Broderick Boat Ramp</b>	<b>Yes</b>	No	No	<b>Permanently incorporate 0.135 acre of the park.</b>
8	Off-Leash Dog Park (proposed)	No	No	No	Adjacent to project footprint, but no temporary occupancy or acquisitions required.
9	River Walk Park	No	No	No	Adjacent to project footprint, but no temporary occupancy or acquisitions required.
10	Riverfront Park (proposed)	No	No	No	Adjacent to project footprint, but no temporary occupancy or acquisitions required.
11	River Walk Park (proposed)	No	No	No	City of West Sacramento will coordinate design and construction of the two projects. No acquisition of land would occur.
12	Access Corridor (proposed)	No	No	No	0.3 mile away from project footprint, no potential for impact.
13	River Walk Park (proposed)	No	No	No	1 mile away from the project footprint, no potential for impact.
<b>City of Sacramento</b>					
14	Tiscornia Park	No	No	No	0.4 mile away from project footprint, no potential for impact.
15	<b>Sacramento River Parkway Trail</b>	No	No	<b>Yes</b>	<b>Project would require temporary rerouting and detour of trail for approximately 2 years.</b>
16	Robert T. Matsui Waterfront Park	No	No	No	Adjacent to project footprint, but no construction staging or acquisitions required.
17	<b>Sacramento River Parkway (Central Area)</b>	<b>Yes</b>	No	No	<b>Permanently incorporate 2.155 acres of the park.</b>

Map ID	Name	Use?	Constructive Use?	Temporary Occupancy?	Explanation
18	Riverfront Park (proposed)	No	No	No	City of Sacramento will coordinate design and construction of the two projects. No acquisition of land would occur.
19	<b>Old Sacramento State Historic Park</b>	No	No	<b>Yes</b>	<b>Temporary occupancy at back of property when existing I Street Bridge approach ramp structures are decommissioned.</b>
20	Sacramento River Parkway (future)	No	No	No	Adjacent to project footprint, but no construction staging or acquisitions required.
21	Crocker Park	No	No	No	0.5 mile away from project footprint, no potential for impact.
22	Central Shops Plaza (proposed)	No	No	No	0.6 mile away from project footprint, no potential for impact.
23	Depot Park (proposed)	No	No	No	0.15 mile away from project footprint, no potential for impact.
24	Vista Park (proposed)	No	No	No	0.15 mile away from project footprint, no potential for impact.
25	Stanford Walk (proposed)	No	No	No	0.2 mile away from project footprint, no potential for impact.
26	Neighborhood Parks (proposed)	No	No	No	0.5 mile away from project footprint, no potential for impact.
27	Saint Rose of Lima Park	No	No	No	0.2 mile away from project footprint, no potential for impact.
28	Leland Stanford Mansion State Historic Park	No	No	No	0.4 mile away from project footprint, no potential for impact.
29	Caesar Chavez Plaza	No	No	No	0.3 mile away from project footprint, no potential for impact.
30	Capitol Park	No	No	No	0.5 mile away from project footprint, no potential for impact.
31	Zapata Park	No	No	No	0.45 mile away from project footprint, no potential for impact.
32	J. Neely Johnson Park	No	No	No	0.5 mile away from project footprint, no potential for impact.

As Table 3 demonstrates, the proposed project would result in a Section 4(f) use of two recreational resources: Broderick Boat Ramp and the Sacramento River Parkway (Central Area). The project would also result in a temporary occupancy of the Sacramento River Parkway Trail and Old Sacramento State Historic Park. The temporary occupancy of Old Sacramento State Historic Park is discussed in Section A.3.4.1, *Historic Properties*. The boat ramp, parkway, and trail are discussed further below.

### A.3.3.1 Broderick Boat Ramp

Broderick Boat Ramp is a public park that primarily provides boating access to both the Sacramento and American Rivers. Boats of many sizes may be launched from the boat ramp. It is located on the west bank of the Sacramento River at 103 4<sup>th</sup> Street. It contains a boat ramp and launching dock, parking for trailers, and restroom facilities. The park is approximately 8.87 acres. The majority of the park is undeveloped and does not contain any public facilities or structures. There is no entrance fee to the park.

### **Impacts on Broderick Boat Ramp**

A permanent incorporation of 0.135 acre from the resource would be necessary, which is approximately 1.2 percent of the entire park. The portion of the park that would be acquired is along the southern boundary of the park near B Street along a levee road. This section of the park contains trees and grassy areas, but no park facilities or active recreation areas. The boat ramp, parking lot, and restrooms are all located on the northern portion of the property. Visitors would not experience any loss of access or use of active recreational or parking facilities after construction of the proposed project.

### **De Minimis Determination for Broderick Boat Ramp**

Although a use of 0.135 acre of the park would occur, the impact would be minor. In terms of recreational value, the affected area of this park does not contain developed recreational facilities. Access to the park, public facilities, and boat ramp would all be maintained. The transportation use of the Section 4(f) resource, together with any impact avoidance, minimization, and mitigation or enhancement measures incorporated into the project, would not adversely affect the activities, features, and attributes that qualify the resource for protection under Section 4(f) and would qualify as a *de minimis* impact.

### **Measures to Minimize Harm for Broderick Boat Ramp**

Measures necessary to minimize harm (such as any avoidance, minimization, mitigation, or enhancement measures) are considered prior to determining an impact to be *de minimis*. The project includes the following elements to reduce impacts on the Broderick Boat Ramp. Additional minimization measures may be added in coordination with the City of West Sacramento Parks and Recreation Department.

- Maintain safe access to Broderick Boat Ramp at all times.
- Ensure that construction equipment in the Broderick Boat Ramp park and other potential impediments to recreation is equipped with required safety markings (e.g., lights).
- Coordinate construction activities with the City of West Sacramento Department of Parks and Recreation at least 10 days in advance of start of construction and regularly while construction activities are ongoing in the Broderick Boat Ramp park.
- Post written notices in the Broderick Boat Ramp park regarding construction activities.
- Restore any areas within the Broderick Boat Ramp park disturbed by construction activities to preconstruction or better conditions.
- Compensate for loss of 0.135 acre of parkland. In accordance with Section 5404 of the California Public Park Preservation Act, the loss of acreage at the Broderick Boat Ramp park will be compensated for by either providing new acreage at a suitable location or improving the unacquired portion of the parkland and facilities. The project proponents will work with the City of West Sacramento to identify sites that are considered suitable as replacement land or to identify appropriate park improvements following the steps listed below.
  - Conduct a fair-market value assessment of the value of the land being acquired.

- Coordinate with the City of West Sacramento regarding compensation and appropriate enhancement measures.

### **Coordination for Broderick Boat Ramp**

Prior to making Section 4(f) approvals, coordination with the City of West Sacramento Department of Parks and Recreation is required regarding activities, features, and attributes that qualify Broderick Boat Ramp as a Section 4(f) resource. Caltrans will request of the City of West Sacramento Department of Parks and Recreation concurrence on the *de minimis* finding under Section 4(f) after an opportunity for public review and comment concerning the effects of the project has occurred.

### **Conclusion for Broderick Boat Ramp**

Conversion of a minor portion of the Broderick Boat Ramp into a transportation use would not adversely affect the activities, features, and attributes that qualify this park for protection under Section 4(f). Accordingly, the project would have a *de minimis* impact on Broderick Boat Ramp. The final determination will be made following the EIR/EA public comment period.

### **A.3.3.2 Sacramento River Parkway Trail**

The Sacramento River Parkway Trail is a recreational land use primarily used by bicyclists, joggers, and pedestrians accessing various parts of Sacramento. It is made up of two disconnected segments. The north segment is along the eastern bank of the Sacramento River, and starts at the northern end of Jibboom Street in Tiscornia Park and ends in Old Sacramento in the south, passing under the existing I Street Bridge. Portions of the trail are paved, and portions are considered off road. All portions are designated for recreational use. On Front Street in Old Sacramento, pedestrians and bicyclists traverse a cobblestone and gravel street. The trail starts again in Miller Park, outside of the study area. Parking for the Sacramento River Parkway Trail is available at its northern end at Tiscornia Park.

There are no developed facilities that are a part of the trail. Rather, the trail passes through various parks that contain facilities, such as Tiscornia Park, the Sacramento River Parkway, Old Sacramento State Historic Park, and Miller Park.

### **Use of Sacramento River Parkway Trail**

No permanent acquisition or easement would be required for the project. However, construction of the project would close the trail in the area between Matsui Waterfront Park and Old Sacramento and would necessitate a temporary detour. As described below, the temporary use of Sacramento River Parkway Trail during the construction period would satisfy the requirements of 23 CFR Section 774.13(d) for a “minimal” temporary occupancy.

- **The duration of the occupancy must be temporary (i.e., less than the time needed for construction of the project), and there should be no change in ownership of the land.**

The Sacramento River Parkway Trail along Jibboom Street passes directly under the existing I Street Bridge, and continues north under the location of the proposed new bridge.

Consequently, the trail would require temporary rerouting during construction. The detour would be in place for approximately 2 years and would ensure uninterrupted use of the trail. The total project construction schedule is approximately 30 months. Given that the length of occupancy would be 6 months less than the total construction period and no changes in ownership would take place, the occupancy is considered temporary.

- **The scope of work must be minor (i.e., both the nature and magnitude of changes to the Section 4[f] resource are minimal).**

Construction activities would require a temporary rerouting of the trail. A detour (described below) would be provided for the closed section of trail to ensure safety of pedestrians and cyclists during construction. The detour would be in place for approximately 2 years, and would be approximately 0.2 mile longer than the existing route. Once constructed, the trail would be returned to pre-construction conditions. The trail would remain accessible throughout the construction period and would be restored after approximately 24 months.

- **There are no anticipated permanent adverse physical impacts, and there will be no interference with the activities or purpose of the resource, on either a temporary or permanent basis.**

No permanent physical impacts on the trail are proposed as part of the project. The trail would continue to function in its current purpose. During construction of the project, a portion of the northern segment of the trail would be rerouted. To the south of Railyards Boulevard the detour would follow the temporary Jibboom Street alignment. To the north of Railyards Boulevard cyclists and pedestrians would then continue following a detour north along Bercut Drive to Richards Boulevard, where they could then connect back to the Parkway on the west side of Interstate 5 (I-5). Uninterrupted use of the trail would be maintained throughout the construction period. The existing trail passes through a busy area of Sacramento that includes various developed areas and busy intersections, and is near a major freeways. A temporary rerouting of the trail would not adversely impact pedestrians and bicyclists using the trail.

- **The land being used must be fully restored (i.e., the resource must be returned to a condition that is at least as good as that which existed prior to the project).**

Following construction, all equipment and construction debris would be removed from the site. The affected portion of the trail would again be located within the Sacramento River Parkway, in as good or better than current conditions and on its original alignment with the addition of the new connections to Railyards Boulevard that the proposed project would provide.

- **There must be documented agreement of the appropriate officials having jurisdiction over the resource regarding the foregoing requirements.**

Prior to making Section 4(f) approvals, coordination with the City of Sacramento Department of Parks and Recreation, the agency having jurisdiction over this resource, is required in order to obtain concurrence on the temporary occupancy finding. After an opportunity for public review and comment concerning the effects of the project has occurred, Caltrans will request concurrence on the temporary occupancy finding from the City of Sacramento Department of Parks and Recreation.

### **Measures to Minimize Harm for Sacramento River Parkway Trail**

The following measures to minimize harm will be incorporated into the project to reduce the effects of the temporary occupancy.

- Provide advance notice regarding project-related construction activities at Sacramento River Parkway Trail. At least 10 days advance notice will be provided regarding trail closure and detour at all trailheads and parking lots at Tiscornia Park and Matsui Waterfront Park.
- Coordinate construction activities with the City of Sacramento Department of Parks and Recreation so that trail users can be informed of construction activities.

### **Conclusion for Sacramento River Parkway Trail**

Implementation of the project would not require a Section 4(f) use of the Sacramento River Parkway Trail because it would not require permanent closure of the trail. The temporary occupancy of the Sacramento River Parkway Trail meets the criteria outlined in 23 CFR 774.13(d); therefore, the temporary occupancy would not constitute a use under Section 4(f).

#### **A.3.3.3 Sacramento River Parkway (Central Area)**

The Sacramento River Parkway plan area is located along the east bank of the Sacramento River within the city limits. It is approximately 17 miles long and 820 acres in area (City of Sacramento 1997). The Sacramento River Parkway Plan has the primary objective of preserving riparian habitat while providing public access to recreational opportunities along the Parkway. It is envisioned as a recreational resource that links with the American River Parkway, and eventually connecting with the Laguna Area. Part of the Parkway Plan includes acquiring more public access to areas that are currently blocked to the public.

The Sacramento River Parkway Central Area, where the project would be located, is between Jibboom Street and Old Sacramento. The Parkway contains a strip of land adjacent to the river, and the paved Sacramento River Parkway Trail, which provides connection to the American River Bike Trail. This portion of the Sacramento River Parkway is primarily used by pedestrians. It provides riverfront views and other forms of passive recreation. The Central Area of the parkway does not contain developed public facilities other than the Sacramento River Parkway Trail, which is analyzed as a separate resource above.

#### **Use of Sacramento River Parkway (Central Area)**

The project would require acquisition of 2.155 acres from the Sacramento River Parkway. The same amount would be necessary for either of the two City of Sacramento roadway design alternatives. The area that would be acquired is a strip of land on the eastern portion of the parkway's Central Area, adjacent to I-5 and away from the riverbank. Acquiring 2.155 acres constitutes a loss of 0.26 percent (total) of the Sacramento River Parkway. Such acquisition constitutes permanent incorporation of land from a Section 4(f) resource into a transportation use. This acquisition would be a minimal impact because there are no developed facilities or other resources in this portion of the parkway. The Sacramento River Parkway Trail would be temporarily rerouted away from this area, and is discussed as a separate resource. The



construction period is anticipated to last approximately 2 years. Impacts on recreation during construction would be minimized by maintaining access to the Parkway at all times, including the Sacramento River Parkway Trail via a detour. Construction equipment in the Parkway during construction activities and other potential impediments to recreation would be equipped with required safety markings (e.g., lights).

### ***De Minimis Determination for Sacramento River Parkway (Central Area)***

Although a use of 2.155 acre of the Sacramento River Parkway would occur, the impact would be minor and would qualify as a *de minimis* impact. In terms of recreational value, this area does not include any recreational areas or features other than the Sacramento River Parkway Trail, which is analyzed as a separate resource in Section A.3.3.2. The rest of this portion of the parkway is mainly open space used for passive recreation. After construction, pedestrian use of this area for walking and river views would be restored.

### ***Measures to Minimize Harm for Sacramento River Parkway (Central Area)***

Measures necessary to minimize harm (such as any avoidance, minimization, mitigation, or enhancement measures) are considered prior to determining an impact to be *de minimis*. The project includes the following elements to reduce impacts.

- Maintain safe access to the Sacramento River Parkway Trail at all times.
- Ensure that project construction equipment in the Sacramento River Parkway, and other potential impediments to recreation, is equipped with required safety markings (e.g., lights).
- Coordinate construction activities with the City of Sacramento Department of Parks and Recreation at least 10 days in advance of start of construction and regularly while construction activities are ongoing in the Parkway.
- Post written notices in the Sacramento River Parkway regarding construction activities.
- Return construction staging or any areas within the Sacramento River Parkway disturbed by construction activities to preconstruction or better conditions.

Additional minimization measures may be added in coordination with the City of Sacramento Department of Parks and Recreation.

### ***Coordination for Sacramento River Parkway (Central Area)***

Prior to making Section 4(f) approvals, coordination with the City of Sacramento Department of Parks and Recreation is required regarding activities, features, and attributes that qualify Sacramento River Parkway (Central Area) as a Section 4(f) resource. Caltrans will request of the City of Sacramento Department of Parks and Recreation concurrence on the *de minimis* finding under Section 4(f) after an opportunity for public review and comment concerning the effects of the project has occurred.

## **Conclusion for Sacramento River Parkway (Central Area)**

The transportation use of Sacramento River Parkway Trail, together with measures to minimize harm incorporated into the project, would not adversely affect the activities, features, and attributes that qualify this park for protection under Section 4(f). Accordingly, the project would have a *de minimis* impact on Sacramento River Parkway Trail. As stated above, this acquisition would constitute 0.26 percent of the entire parkway, a minor area. This portion of the parkway does not contain any developed public facilities, other than the Sacramento River Parkway Trail, which is analyzed separately. Once construction is complete, pedestrians would be able to access this portion of the parkway. Furthermore, the portion of the parkway that would be acquired is a strip of land adjacent to I-5, not the riverfront. The final determination will be made following the EIR/EA public comment period.

### **A.3.4 Other Resources Evaluated Relative to the Requirements of Section 4(f)**

This section discusses parks, recreational facilities, wildlife refuges, and historic properties found within or next to the project area that do not trigger Section 4(f) protection because either: 1) they are not publicly owned, 2) they are not open to the public, 3) they are not eligible historic properties, 4) the project would not permanently use the property and would not hinder the preservation of the property, or 5) the proximity impacts would not result in constructive use.

#### **A.3.4.1 Historic Properties**

Based on the analysis conducted as part of the Section 106 of the National Historic Preservation Act, three historic properties qualified as Section 4(f) resources. Two of these properties, (I Street Bridge and Sacramento River East Levee, described below) are within the project APE. No adverse effects under Section 106 were identified for these properties. SHPO's concurrence with the No Adverse Effect determination is necessary before Caltrans can make a Section 4(f) approval. Old Sacramento State Historic Park is not within the project APE but is within the Section 4(f) study limits. Old Sacramento State Historic Park is included in Table 4 and described below.

As shown in Table 4, no use of any cultural resources protected by the provisions of Section 4(f) would occur.

**Table 4. Section 4(f) Historic Property Use Determination Summary**

<b>Name</b>	<b>Use?</b>	<b>Constructive Use?</b>	<b>Temporary Occupancy?</b>	<b>Explanation</b>
I Street Bridge (P-34-002349)	No	No	No	No physical destruction of the bridge would occur and, therefore, no adverse effect under Section 106.
Sacramento River East Levee (P-34-00490)	No	No	No	No adverse effect finding under Section 106. No land or portion of the resource would be permanently incorporated or temporarily occupied. Proximity impacts to the resource would not be of a severity such that the protected activities, features, or attributes that qualify the property for protection under Section 4(f) are substantially impaired.
Old Sacramento State Historic Park	No	No	Yes	<b>Temporary occupancy at back of property when existing I Street Bridge approach ramp structures are decommissioned.</b>

The proposed project would not adversely affect the activities, features, or attributes that qualify these historic resources for protection under Section 4(f); therefore, no use of historic properties would result from the project. The temporary occupancy of Old Sacramento State Historic Park is discussed below.

### ***Old Sacramento State Historic Park***

Old Sacramento State Historic Park is a public park and a historic part of the City of Sacramento located along the east bank of the Sacramento River, between Tower Bridge and I Street Bridge. The park area is a California Historic Landmark and is eligible for listing in the NRHP. The park contains many historic buildings, as well as the Sacramento Railroad Museum. It is accessible via the Capitol Mall/Lincoln Highway and J Street. There are two public parking garages as well as on-street parking along most of the streets in Old Sacramento. This state park is popular in the region and is frequented by both locals and tourists. Pedestrians shop, dine, and sightsee throughout the park, and there are views of and access to the Sacramento River. The park is also a popular location for school field trips and holiday events, such as parades and other gatherings, which typically draw large crowds to the park. Public facilities are prominent throughout the park, including public restrooms, drinking fountains, and benches.

Old Sacramento State Historic Park is not located within the architectural APE of the project. However, it is a California Historic Landmark eligible for listing in the NRHP and a public recreational resource; therefore, the park is included within the Section 4(f) study area. Within the jurisdiction of the state park is a parking lot just east of the Sacramento Railroad museum. This lot is located under the location where the existing I Street Bridge approach structures would be decommissioned.

### ***Temporary Occupancy of Old Sacramento State Historic Park***

As described below, the temporary use of Old Sacramento State Historic Park during the construction period would satisfy the requirements of 23 CFR Section 771.135(p)(7) for a “minimal” temporary occupancy. Construction activities in the park would last approximately 4

months. The portion of the park that would be affected is the parking area under the approaches to the existing I Street Bridge. Parking would be maintained throughout the construction period, as would access to the state park. Recreational activities would not be impeded during construction.

- **The duration of the occupancy must be temporary (i.e., less than the time needed for construction of the project), and there should be no change in ownership of the land.**

Construction activities at the park, primarily demolition of the bridge approaches, would last approximately 4 months. The total construction period for the project would be 30 months. No permanent acquisition or easement would be required, so no change in ownership is proposed.

- **The scope of work must be minor (i.e., both the nature and magnitude of changes to the Section 4[f] resource are minimal).**

Demolition of the bridge approaches would result in minor impacts on this resource. Demolition activities would require temporary closure of a small portion of the parking lot for safety purposes. As such, there would be no active recreational uses allowed in the area of demolition during the duration of the work.

- **There are no anticipated permanent adverse physical impacts, and there will be no interference with the activities or purpose of the resource, on either a temporary or permanent basis.**

The portion of the Old Sacramento State Historic Park underneath and around the existing I Street Bridge approach structures contains parking for cars, buses, and RVs, pedestrian walkways, and some vegetation. Parking would remain available in the two public parking garages at the park entrances and on streets throughout the park. Safe access to Old Sacramento State Historic Park and the Sacramento Railroad Museum, including the parking garages, would also be maintained during the demolition period.

- **The land being used must be fully restored (i.e., the resource must be returned to a condition that is at least as good as that which existed prior to the project).**

Following removal of the bridge approach structures, the site would be returned to a condition as good as or better than current conditions. All equipment and construction debris would be removed from the site.

- **There must be documented agreement of the appropriate officials having jurisdiction over the resource regarding the foregoing requirements.**

Prior to making Section 4(f) approvals, coordination with the California Department of Parks and Recreation, the agency having jurisdiction over this resource, is required in order to obtain concurrence on the temporary occupancy finding. After an opportunity for public review and comment concerning the effects of the project has occurred, Caltrans will request concurrence on the temporary occupancy finding from the California Department of Parks and Recreation.

### Measures to Minimize Harm for Old Sacramento State Historic Park

- Provide advance notice regarding project-related construction activities at Old Sacramento State Historic Park. At least 10 days advance notice will be provided regarding construction activity near the parking lots at Old Sacramento State Historic Park.
- Coordinate construction activities with the California Department of Parks and Recreation, so that the agency can inform users regarding construction activities.

### Conclusion for Old Sacramento Historic Park

Implementation of the project would not constitute a Section 4(f) use of the Old Sacramento State Historic Park because it would not require acquisition of permanent right-of-way (ROW) from the park. The portion of the park that would be affected is currently used for parking, not recreational activities. There are two parking garages as well as on-street parking that would be available as alternative parking areas during the 4 months that project construction activities would occur in the parking area. Park activities and facilities would not be affected during construction. Access to the park, museum, riverfront, and other public recreational facilities would be fully available during construction. The temporary occupancy of the Old Sacramento Historic Park meets the criteria outlined in 23 CFR 774.13(d); therefore, the project would not constitute as a use under Section 4(f).

### **A.3.4.2 Parks and Recreational Areas**

#### ***City of West Sacramento***

Three public parks (Elkhorn Plaza, Raley Field and River Walk Park) are located within the study area in the city of West Sacramento but would not be affected by the proposed project.

Elkhorn Plaza is located within the study area, approximately 0.6 mile west of the project boundary. Access to Elkhorn Plaza is through Sacramento Avenue and Elkhorn Plaza.

Raley Field is located within the study area, approximately 0.45 mile west of the project boundary. Access to Raley Field is through 5th Street, the Tower Bridge Gateway, and Ballpark Drive. Parking for Raley Field is located between 5th Street and South River Road.

River Walk Park is located along the west bank of the Sacramento River between the Tower Bridge and existing I Street Bridge. The park has views of the Sacramento River, Old Sacramento, and the Sacramento Skyline. There are picnic areas, as well as an area for special events available for rent. There is also a restroom facility.

No ROW would be acquired from these parks and recreational areas and no temporary construction easement would be required for staging or other construction activities. Visitors would not experience any loss of access or use of recreational or parking facilities. Therefore, there would be no use of these properties under Section 4(f). No further study is required.

### River Walk Park-Proposed Extension

A proposed extension of the Sacramento River Walk Park is described in the City of West Sacramento Parks Master Plan (2003).

Development of these parcels has not yet occurred. The extensions of the River Walk north and south of the existing River Walk Park are not yet constructed, and a temporary construction easement would not be required for staging or other construction activities associated with the proposed project. The City of West Sacramento, as both one of the project proponents and the agency with jurisdiction over this resource, will assist with coordination of the design and construction of the two projects. Therefore there will be no acquisition of land from this proposed resource.

### Other City of West Sacramento Proposed Parks

Other proposed parks are identified in Figure 1 (Attachment A) and described in Table 2 above. These parks are not yet constructed. There would be no direct use and temporary construction easements would not be required for staging or other construction activities. Therefore, there would be no use of these properties under Section 4(f). No further study is required.

## **City of Sacramento**

### Downtown Sacramento Parks

Crocker Park, Leland Stanford Mansion State Historic Park, Capitol Park, Saint Rose of Lima Square, Caesar Chavez Park, J. Neely Johnson Park, and Zapata Park are all located in downtown Sacramento. These parks are accessible via local streets and are far enough away from the project boundary that access to these parks would not be affected. No ROW would be acquired from any of these parks on a permanent basis, and temporary construction easements would not be required for staging or other construction activities. These parks are far enough away from the project boundary that visitors would not have views of construction equipment, nor would they experience temporary construction-related noise effects. There would not be any loss of access or use of recreational or parking facilities. Therefore, there would be no use of these properties under Section 4(f). No further study is required.

### Tiscornia Park

Tiscornia Park is located north of the project at the confluence of the Sacramento and American Rivers. It contains beach and river access and picnic areas. This park is accessible from Jibboom Street. No ROW would be acquired from this park on a permanent basis, and a temporary construction easement would not be required for staging or other construction activities. Visitors may have intermittent and temporary views of construction equipment and may also experience temporary construction-related noise effects, but they would not experience any loss of access or use of recreational or parking facilities.

### *Proposed Riverfront Park*

A proposed public Riverfront Park is part of the planned Sacramento Railyards development. The Sacramento Railyards Specific Plan (City of Sacramento 2016) identifies Open Space areas that are intended to create a framework for linking the different districts within the Railyards development. The portion of the proposed Riverfront Park along the riverfront between Tiscornia Park and Old Sacramento would contain a segment of the Sacramento River Parkway (Central Area). It would primarily consist of passive open space, and no developed facilities are currently planned. Another portion of the park along and just east of the riverfront would surround a river-adjacent mixed-use residential/hotel with green and park-like public space. The parks within the Sacramento Railyards would be privately developed, but under jurisdiction of the City of Sacramento. They would also be maintained by the City of Sacramento (Rich pers. comm.).

This park is not yet constructed. As currently designed, the proposed project would not require either temporary construction easements or permanent ROW acquisition in the park; therefore, there would be no use of this property under Section 4(f). No further study is required.

### *Other City of Sacramento Proposed Parks*

Other proposed parks include other parcels identified in the Sacramento Railyards Specific Plan as open space (shown in Figure 1 [Attachment A]). These parks are not yet constructed. There would be no direct use and temporary construction easements would not be required for staging or other construction activities. Therefore, there would be no use of these properties under Section 4(f). No further study is required.

## **A.4 Section 6(f) Assessment**

Section 6(f)(3) of the LWCF Act (16 USC Section 4601-4) contains provisions to protect federal investments in park and recreational resources and the quality of those assisted resources. The law recognizes the likelihood that changes in land use or development may make park use of some areas purchased with LWCF funds obsolete over time, particularly in rapidly changing urban areas, and provides for conversion to other use pursuant to certain specific conditions.

Section 6(f)(3): No property acquired or developed with assistance under this section shall, without the approval of the Secretary, be converted to other than public outdoor recreation uses. The Secretary shall approve such conversion only if he finds it to be in accord with the then existing comprehensive statewide outdoor recreation plan and only upon such conditions as he deems necessary to assure the substitution of other recreation properties of at least equal fair market value and of reasonably equivalent usefulness and location.

This requirement applies to all parks and other sites that have been the subject of LWCF grants of any type and includes acquisition of park land and development or rehabilitation of park facilities.

A review of the LWCF listing of grants for Sacramento and Yolo Counties revealed that several grants have been allotted to the Sacramento River Parkway (project numbers BG-34-321 and SL-

34-001) and one grant has been allotted to the Sacramento River Parkway Trail (project number 06-00679). Further consultation with the California Department of Parks and Recreation confirmed that LWCF funds were used to construct the Sacramento River Parkway Trail in the vicinity of the project (Attachment B). The trail would be temporarily rerouted during construction, and the detour would be in place for approximately 2 years. However, the trail would remain in use during construction, and would be reestablished in its original location to a condition as good as or better than current conditions. Therefore, there would be no conversion of any LWCF-funded recreational areas to a non-recreational use, and protection under Section 6(f) would not apply.

## **A.5 References Cited**

### **A.5.1 Printed References**

City of Sacramento. 2016. *Sacramento Railyards Specific Plan*. October. Approved by the City of Sacramento on November 10, 2016.

City of Sacramento. 1997. Sacramento River Parkway Plan. Available: [http://www.sacramentoriverparkway.org/The\\_Parkway\\_Story/Sac-River-Parkway-Plan.1997.pdf](http://www.sacramentoriverparkway.org/The_Parkway_Story/Sac-River-Parkway-Plan.1997.pdf). Accessed June 22, 2015.

City of West Sacramento. 2003. City of West Sacramento Parks Master Plan. September 2003. Available: <https://www.cityofwestsacramento.org/civica/filebank/blobdload.asp?BlobID=3628>. Accessed April 29, 2016.

Federal Highway Administration (FHWA). 2012. *Section 4(f) Policy Paper*. Available: <http://www.environment.fhwa.dot.gov/4f/4fpolicy.asp>. Accessed August 4, 2014.

ICF International. 2015. *Archaeological Survey Report for the I Street Bridge Replacement Project, City of Sacramento, Sacramento County and City of West Sacramento, Yolo County, California*. July 2015.

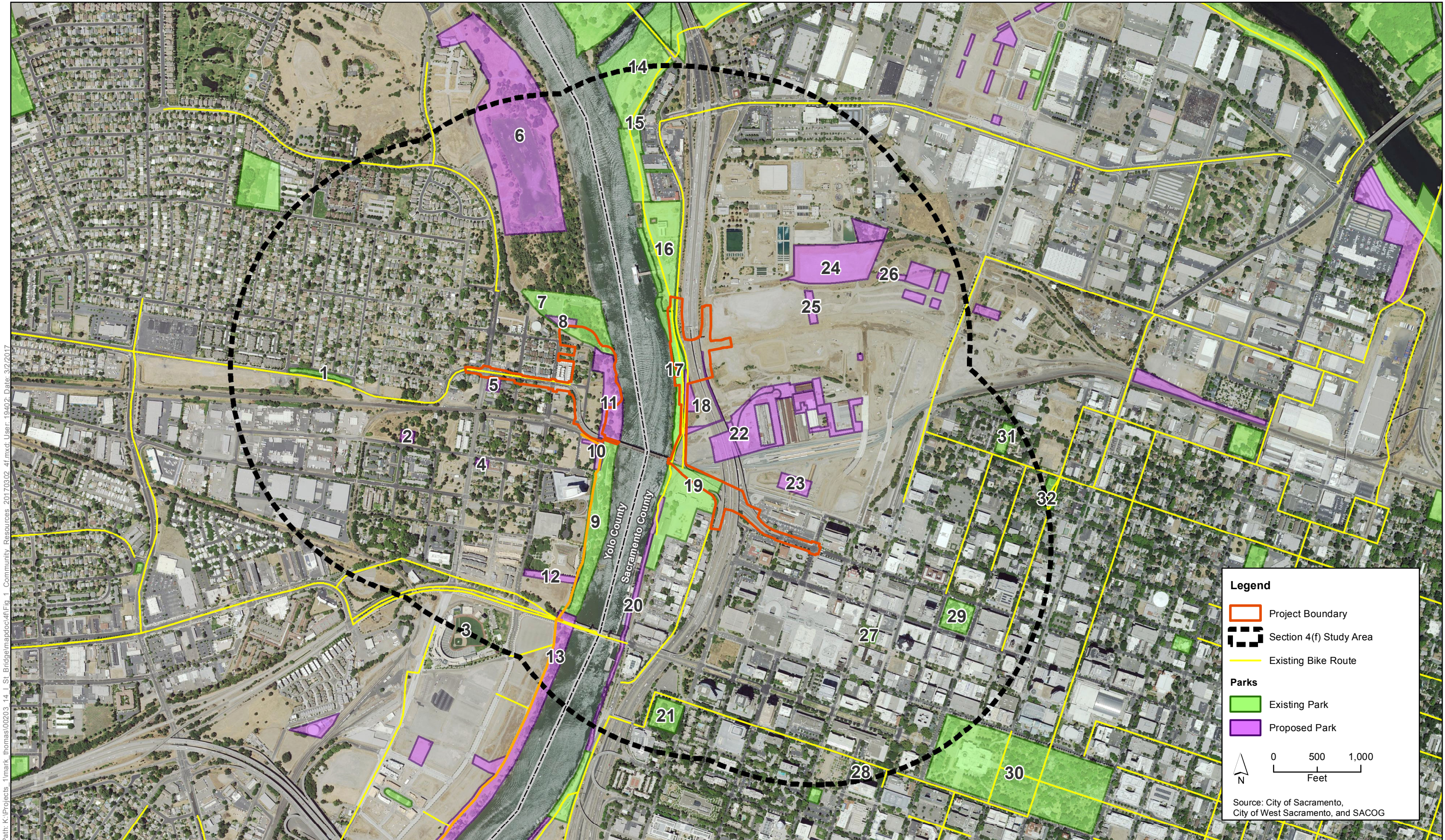
### **A.5.2 Personal References**

Rich, Richard. City of Sacramento. Project Manager, Railyards Project Entitlements and Environmental Review. September 8, 2016—Phone conversation with Lindsay Christensen, ICF International.



Attachment A  
**Figures**

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Path: K:\Projects\1\mark\_thomas\0203\_14\_I\_1\_1\_St\_Bridgelmapdoc\4\Fig\_1\_Community\_Resources\_20170302\_41.mxd, User: 19402, Date: 3/2/2017

**Legend**

- Project Boundary
- Section 4(f) Study Area
- Existing Bike Route

**Parks**

- Existing Park
- Proposed Park

0 500 1,000  
Feet

Source: City of Sacramento, City of West Sacramento, and SACOG

**Figure 1**  
**Section 4(f) Study Area**

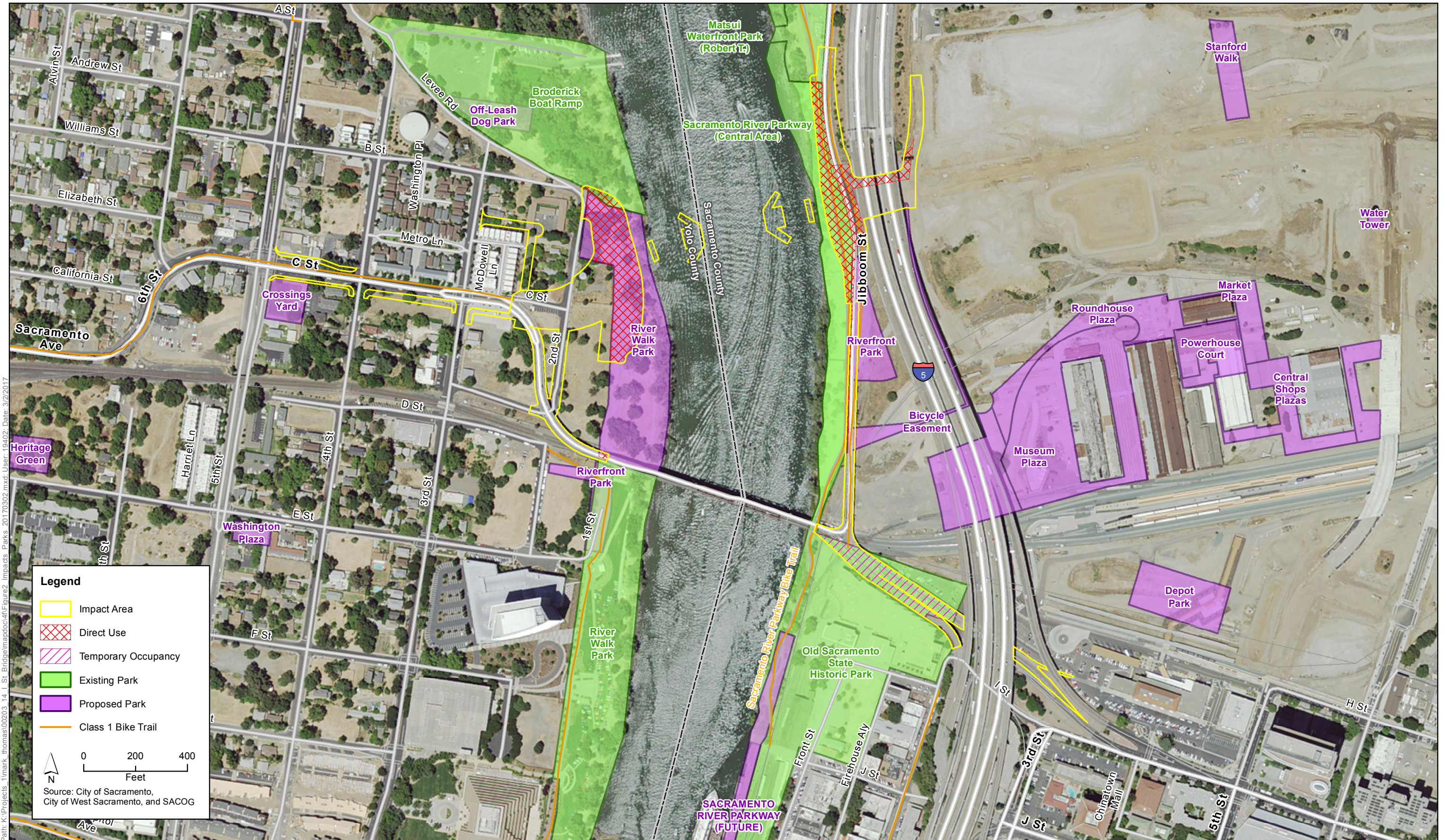


Figure 2  
Proposed Project Impacts to Parks

Attachment B  
**Correspondence**

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**From:** Bee, Natalie@Parks <Natalie.Bee@parks.ca.gov>  
**Sent:** Wednesday, July 08, 2015 1:16 PM  
**To:** Christensen, Lindsay  
**Subject:** RE: Sacramento I Street Bridge Replacement project  
**Attachments:** Scanned from OGALS Xerox.pdf

Hi Lindsay,

I've attached the map for the Sacramento River Trail that was funded through LWCF from Old Sac to Discovery, project number 06-00679. Is the City looking to replace the I Street bridge using the existing footprint or is an additional bridge being installed that would impact the current trail?

*Natalie Bee*

Associate Park and Recreation Specialist  
California State Parks  
Office of Grants and Local Services  
1416 9<sup>th</sup> Street, Rm 918  
Sacramento, CA 94296-0001

(916) 651-0564 *phone*

(916) 653-6511 *fax*



---

**From:** Christensen, Lindsay [<mailto:Lindsay.Christensen@icfi.com>]  
**Sent:** Wednesday, July 08, 2015 12:34 PM  
**To:** Bee, Natalie@Parks  
**Subject:** Sacramento I Street Bridge Replacement project

Hi Natalie,

Per our phone conversation, I'm looking to see if any LWCF grants were used in the project area for the I Street Bridge Replacement Project. I am attaching a draft figure that shows where potential park impacts could occur. Any information you can provide would be very helpful.

Thank you so much!

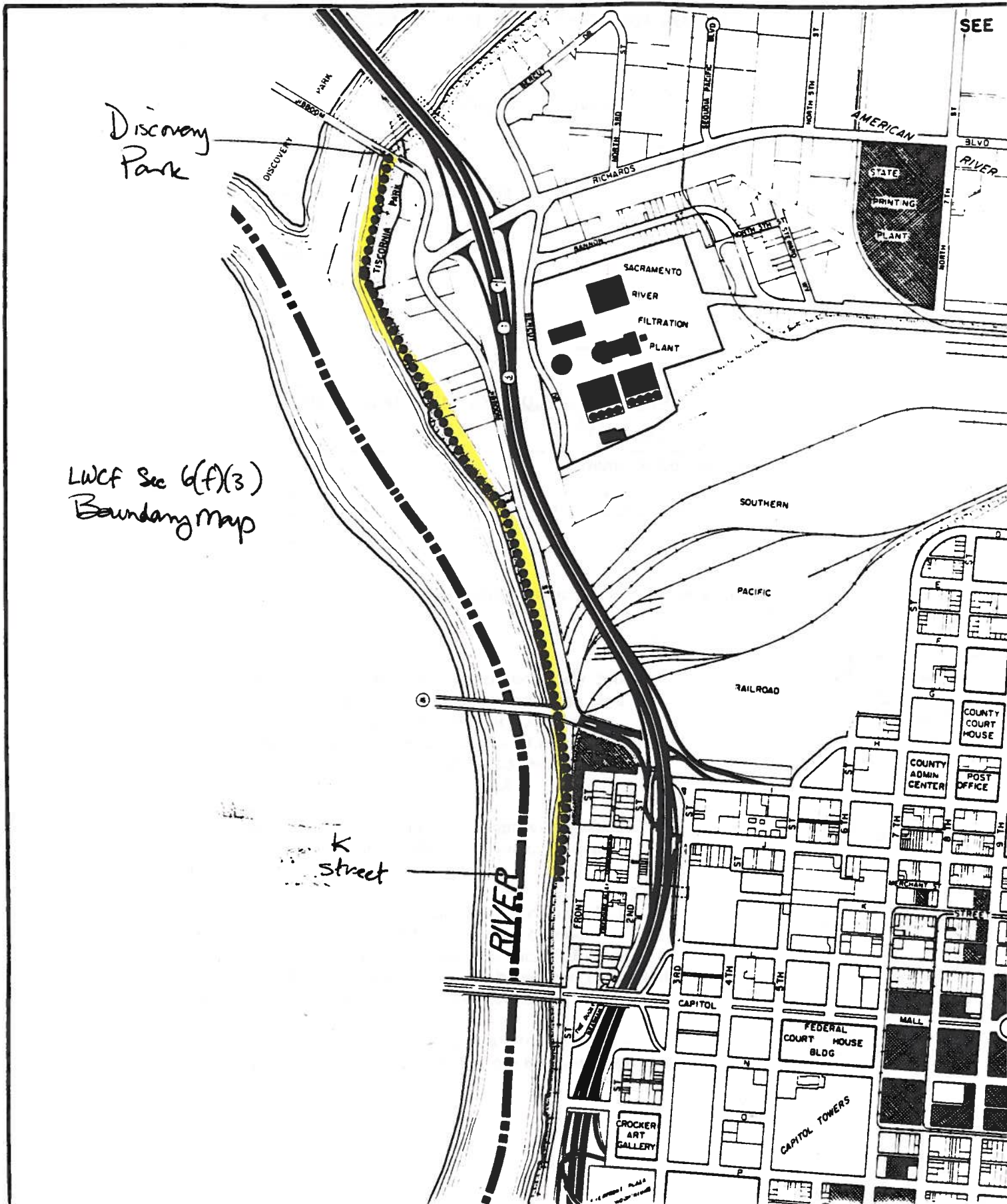
LINDSAY CHRISTENSEN | Project Coordinator, Environment & Planning  
Division | 916.231.7614 | [lindsay.christensen@icfi.com](mailto:lindsay.christensen@icfi.com) | [icfi.com](http://icfi.com)

ICF INTERNATIONAL | 630 K Street, Suite 400, Sacramento, CA 95814 | 916.737.3000



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# SACRAMENTO RIVER BIKE TRAIL



Appendix B  
**Title VI Policy Statement**

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# Appendix B Title VI Policy Statement

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**DEPARTMENT OF TRANSPORTATION**  
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March 2013

## **NON-DISCRIMINATION POLICY STATEMENT**

The California Department of Transportation, under Title VI of the Civil Rights Act of 1964 and related statutes, ensures that no person in the State of California shall, on the grounds of race, color, national origin, sex, disability, religion, sexual orientation, or age, be excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity it administers.

For information or guidance on how to file a complaint based on the grounds of race, color, national origin, sex, disability, religion, sexual orientation, or age, please visit the following web page: [http://www.dot.ca.gov/hq/bep/title\\_vi/t6\\_violated.htm](http://www.dot.ca.gov/hq/bep/title_vi/t6_violated.htm).

Additionally, if you need this information in an alternate format, such as in Braille or in a language other than English, please contact the California Department of Transportation, Office of Business and Economic Opportunity, 1823 14<sup>th</sup> Street, MS-79, Sacramento, CA 95811. Telephone: (916) 324-0449, TTY: 711, or via Fax: (916) 324-1949.

A handwritten signature in blue ink, appearing to read "Malcolm Dougherty".

MALCOLM DOUGHERTY  
Director

*"Caltrans improves mobility across California"*



Appendix C

## **Summary of Relocation Benefits**

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# Appendix C Summary of Relocation Benefits

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## C.1 California Department of Transportation Relocation Assistance Program

### C.1.1 Declaration of Policy

“The purpose of this title is to establish a *uniform policy for fair and equitable treatment* of persons displaced as a result of federal and federally assisted programs in order that such persons *shall not suffer disproportionate injuries* as a result of programs designed for the benefit of the public as a whole.”

The Fifth Amendment to the U.S. Constitution states, “No Person shall...be deprived of life, liberty, or property, without due process of law, nor shall private property be taken for public use without just compensation.” The Uniform Act sets forth in statute the due process that must be followed in Real Property acquisitions involving federal funds. Supplementing the Uniform Act is the government-wide single rule for all agencies to follow, set forth in 49 Code of Federal Regulations (CFR) Part 24. Displaced individuals, families, businesses, farms, and nonprofit organizations may be eligible for relocation advisory services and payments, as discussed below.

### C.1.2 Fair Housing

The Fair Housing Law (Title VIII of the Civil Rights Act of 1968) sets forth the policy of the United States to provide, within constitutional limitations, for fair housing. This act, and as amended, makes discriminatory practices in the purchase and rental of most residential units illegal. Whenever possible, minority persons shall be given reasonable opportunities to relocate to any available housing regardless of neighborhood, as long as the replacement dwellings are decent, safe, and sanitary and are within their financial means. This policy, however, does not require the Department to provide a person a larger payment than is necessary to enable a person to relocate to a comparable replacement dwelling.

Any persons to be displaced will be assigned to a relocation advisor, who will work closely with each displacee in order to see that all payments and benefits are fully utilized and that all regulations are observed, thereby avoiding the possibility of displacees jeopardizing or forfeiting any of their benefits or payments. At the time of the initiation of negotiations (usually the first written offer to purchase), owner-occupants are given a detailed explanation of the state’s relocation services. Tenant occupants of properties to be acquired are contacted soon after the initiation of negotiations and also are given a detailed explanation of the Caltrans Relocation Assistance Program. To avoid loss of possible benefits, no individual, family, business, farm, or nonprofit organization should commit to purchase or rent a replacement property without first contacting a Department relocation advisor.

### **C.1.3 Relocation Assistance Advisory Services**

In accordance with the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, as amended, the Department will provide relocation advisory assistance to any person, business, farm or nonprofit organization displaced as a result of the acquisition of real property for public use, so long as they are legally present in the United States. The Department will assist eligible displacees in obtaining comparable replacement housing by providing current and continuing information on the availability and prices of both houses for sale and rental units that are “decent, safe and sanitary.” Nonresidential displacees will receive information on comparable properties for lease or purchase (for business, farm and nonprofit organization relocation services, see below).

Residential replacement dwellings will be in a location generally not less desirable than the displacement neighborhood at prices or rents within the financial ability of the individuals and families displaced, and reasonably accessible to their places of employment. Before any displacement occurs, comparable replacement dwellings will be offered to displacees that are open to all persons regardless of race, color, religion, sex, national origin, and consistent with the requirements of Title VIII of the Civil Rights Act of 1968. This assistance will also include the supplying of information concerning federal and state assisted housing programs and any other known services being offered by public and private agencies in the area.

Persons who are eligible for relocation payments and who are legally occupying the property required for the project will not be asked to move without first being given at least 90 days written notice.

#### **C.1.3.1 Residential Relocation Payments**

The Relocation Assistance Program will help eligible residential occupants by paying certain costs and expenses. These costs are limited to those necessary for or incidental to the purchase or rental of a replacement dwelling and actual reasonable moving expenses to a new location within 50 miles of the displacement property. Any actual moving costs in excess of the 50 miles are the responsibility of the displacee. The Residential Relocation Assistance Program can be summarized as follows:

##### ***Moving Costs***

Any displaced person, who lawfully occupied the acquired property, regardless of the length of occupancy in the property acquired, will be eligible for reimbursement of moving costs. Displacees will receive either the actual reasonable costs involved in moving themselves and personal property up to a maximum of 50 miles, or a fixed payment based on a fixed moving cost schedule. Lawful occupants who move into the displacement property after the initiation of negotiations must wait until the Department obtains control of the property in order to be eligible for relocation payments.

### ***Purchase Differential***

In addition to moving and related expense payments, fully eligible homeowners may be entitled to payments for increased costs of replacement housing.

Homeowners who have owned and occupied their property for 180 days or more prior to the date of the initiation of negotiations (usually the first written offer to purchase the property), may qualify to receive a price differential payment and may qualify to receive reimbursement for certain nonrecurring costs incidental to the purchase of the replacement property. An interest differential payment is also available if the interest rate for the loan on the replacement dwelling is higher than the loan rate on the displacement dwelling, subject to certain limitations on reimbursement based upon the replacement property interest rate. The maximum combination of these three supplemental payments that the owner-occupant can receive is \$22,500. If the total entitlement (without the moving payments) is in excess of \$22,500, the Last Resort Housing Program will be used (see the explanation of the Last Resort Housing Program below).

### ***Rent Differential***

Tenants and certain owner-occupants (based on length of ownership) who have occupied the property to be acquired by the Department prior to the date of the initiation of negotiations may qualify to receive a rent differential payment. This payment is made when the Department determines that the cost to rent a comparable “decent, safe and sanitary” replacement dwelling will be more than the present rent of the displacement dwelling. As an alternative, the tenant may qualify for a down payment benefit designed to assist in the purchase of a replacement property and the payment of certain costs incidental to the purchase, subject to certain limitations noted under the Down Payment section below. The maximum amount payable to any eligible tenant and any owner-occupant of less than 180 days, in addition to moving expenses, is \$5,250. If the total entitlement for rent supplement exceeds \$5,250, the Last Resort Housing Program will be used.

To receive any relocation benefits, the displaced person must buy or rent and occupy a “decent, safe and sanitary” replacement dwelling within one year from the date the Department takes legal possession of the property, or from the date the displacee vacates the displacement property, whichever is later.

### ***Down Payment***

The down payment option has been designed to aid owner-occupants of less than 180 days and tenants in legal occupancy prior to Caltrans’ initiation of negotiations. The down payment and incidental expenses cannot exceed the maximum payment of \$5,250. The one-year eligibility period in which to purchase and occupy a “decent, safe and sanitary” replacement dwelling will apply.

### ***Last Resort Housing***

Federal regulations (49 CFR 24) contain the policy and procedure for implementing the Last Resort Housing Program on federal-aid projects. Last Resort Housing benefits are, except for the

amounts of payments and the methods in making them, the same as those benefits for standard residential relocation as explained above. Last Resort Housing has been designed primarily to cover situations where a displacee cannot be relocated because of lack of available comparable replacement housing, or when the anticipated replacement housing payments exceed the \$22,500 and \$5,250 limits of the standard relocation procedure, because either the displacee lacks the financial ability or other valid circumstances.

After the initiation of negotiations, the Department will within a reasonable length of time, personally contact the displacees to gather important information, including the following:

- Number of people to be displaced.
- Specific arrangements needed to accommodate any family member(s) with special needs.
- Financial ability to relocate into comparable replacement dwelling which will adequately house all members of the family.
- Preferences in area of relocation.
- Location of employment or school.

#### **C.1.4 Nonresidential Relocation Assistance**

The Nonresidential Relocation Assistance Program provides assistance to businesses, farms and nonprofit organizations in locating suitable replacement property, and reimbursement for certain costs involved in relocation. The Relocation Advisory Assistance Program will provide current lists of properties offered for sale or rent, suitable for a particular business's specific relocation needs. The types of payments available to eligible businesses, farms and nonprofit organizations are: searching and moving expenses, and possibly reestablishment expenses; or a fixed in lieu payment instead of any moving, searching and reestablishment expenses. The payment types can be summarized as follows:

##### **C.1.4.1 Moving Expenses**

Moving expenses may include the following actual, reasonable costs:

- The moving of inventory, machinery, equipment and similar business-related property, including: dismantling, disconnecting, crating, packing, loading, insuring, transporting, unloading, unpacking, and reconnecting of personal property. Items acquired in the right-of-way contract may not be moved under the Relocation Assistance Program. If the displacee buys an Item Pertaining to the Realty back at salvage value, the cost to move that item is borne by the displacee.
- Loss of tangible personal property provides payment for actual, direct loss of personal property that the owner is permitted not to move.
- Expenses related to searching for a new business site, up to \$2,500, for reasonable expenses actually incurred.

#### **C.1.4.2 Reestablishment Expenses**

Reestablishment expenses related to the operation of the business at the new location, up to \$10,000 for reasonable expenses actually incurred.

#### **C.1.4.3 Fixed In Lieu Payment**

A fixed payment in lieu of moving, searching, and reestablishment payments may be available to businesses that meet certain eligibility requirements. This payment is an amount equal to half the average annual net earnings for the last two taxable years prior to the relocation and may not be less than \$1,000 nor more than \$20,000.

#### **C.1.5 Additional Information**

Reimbursement for moving costs and replacement housing payments are not considered income for the purpose of the Internal Revenue Code of 1954, or for the purpose of determining the extent of eligibility of a displacee for assistance under the Social Security Act, or any other law, *except* for any federal law providing local “Section 8” Housing Programs.

Any person, business, farm or nonprofit organization that has been refused a relocation payment by the Department relocation advisor or believes that the payment(s) offered by the agency are inadequate may appeal for a special hearing of the complaint. No legal assistance is required. Information about the appeal procedure is available from the relocation advisor.

California law allows for the payment for lost goodwill that arises from the displacement for a public project. A list of ineligible expenses can be obtained from Caltrans Right-of-Way. California’s law and the federal regulations covering relocation assistance provide that no payment shall be duplicated by other payments being made by the displacing agency.

**Avoidance, Minimization and/or Mitigation Summary**

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# Appendix D Avoidance, Minimization and/or Mitigation Summary

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## **D.1 Land Use**

### **D.1.1 Avoidance and Minimization Measures**

No measures are necessary.

### **D.1.2 CEQA Mitigation Measures**

#### **Restore Sacramento River Parkway Trail after Construction**

In the event that any inadvertent damage occurs to the Sacramento River Parkway Trail, the area affected will be restored to the condition that existed prior to construction activities or better.

#### **Provide Advance Notification of Sacramento River Parkway Trail Closures**

The City of Sacramento will provide advance notification of the Sacramento River Parkway Trail closure on its websites and trailheads. Notices will include trail closure dates, approximate duration, and a description of the detour available during closure.

## **D.2 Growth**

### **D.2.1 Avoidance and Minimization Measures**

No measures are necessary.

### **D.2.2 CEQA Mitigation Measures**

No measures are necessary.



## **D.3 Community Impacts**

### **D.3.1 Avoidance and Minimization Measures**

#### **Prepare a Transportation Management Plan**

Prior to construction, the project proponent will prepare a Transportation Management Plan (TMP). Implementation of a TMP would minimize disruptions to traffic and to emergency services during construction and ensure that construction would not create major delays. A TMP is a program of activities for alleviating or minimizing work-related traffic delays by applying traditional traffic handling practices as well as innovative strategies. A TMP program includes public awareness campaigns, motorist information, demand management, incident management, system management, construction methods and staging, and alternate route planning. TMP strategies also strive to reduce the overall duration of work activities where appropriate. Typical components of a TMP can include measures such as implementation of staging, traffic handling, and detour plans; restricting construction work to certain days and/or hours to minimize impacts on traffic and pedestrians; coordination with other construction projects to avoid conflicts; and the use of portable changeable message signs to inform the public of construction activities.

Implementation of the measures in the TMP would reduce the temporary access and circulation impacts of the project that would be caused by potentially lengthy construction delays. In addition to the measures described above, the TMP will include the following measures.

- Any emergency service agency whose ability to respond to incidents will be affected by any lane closure must be notified prior to that closure.
- Work will be coordinated with the local busing system (including school buses and public systems) to minimize impacts on their bus schedules.

The project proponent will provide information to residents and businesses before and during project work that may represent a negative impact on commerce and travel surrounding the zone of construction.

#### **Construct Mid-block East West Road**

Construct a new east/west access road south of C Street, just south of the Washington Firehouse property, to restore on-street parking, emergency access, and circulation to parcels currently served by 2nd Street, and prevent creation of a cul-de-sac inconsistent with West Sacramento's Standard Specifications. The roadway will restore circulation that will be impaired or unusable due to bridge impacts on the parking lot and the adjacency of the new location of the southeast corner of 3rd and C Street to the driveway or curb cut into the Washington Firehouse parking. The roadway will be consistent with the 2nd Street reconfiguration shown in Figure 2.81 and Figure 2.85 of *Washington Realized* (City of West Sacramento 2015). Implementation of this measure will occur concurrent with project construction.

The new access road will provide access to private parcels between 3rd Street and the Sacramento River and will accommodate pedestrian and bicycle use as well as provide limited

vehicular access within the same street space. It will be designed to enhance and visually communicate the shared nature of the street. It may be a “Stubbed” access street connected to 3rd Street, then terminating in a hammer head or parking lot. Or it may be a “Connecting” access street connected to the existing 2nd Street and 3rd Street. The new access road will be a minimum of 60 feet wide with a 20-foot right-of-way for vehicles and a 20-foot “no structure” zone on each side which may accommodate semi-private uses or parking.

### **D.3.2 CEQA Mitigation Measures**

No measures are necessary.

## **D.4 Utilities/Emergency Services**

### **D.4.1 Avoidance and Minimization Measures**

#### **Provide Advance Notice to Utility Service Providers**

The project proponent will provide advance notification and coordinate with utility service providers prior to and during construction to avoid or minimize potential service disruptions.

#### **Prepare a Transportation Management Plan**

Please refer to the discussion of this measure in Section D.3.1.

#### **Construct 2nd Street Reconfiguration**

Please refer to the discussion of this measure in Section D.3.1.

### **D.4.2 CEQA Mitigation Measures**

No measures are necessary.

## **D.5 Traffic and Transportation/Pedestrian and Bicycle Facilities**

### **D.5.1 Avoidance and Minimization Measures**

No measures are necessary.

## D.5.2 CEQA Mitigation Measures

### Prepare a Transportation Management Plan

Please refer to the discussion of this measure in Section D.3.1.

### Construct Mid-block East West Road

Please refer to the discussion of this measure in Section D.3.1.

### Implement Roadway and Freeway Improvements

**5th Street/E Street, West Sacramento** – Under 2040 conditions, construct westbound and eastbound left-turn lanes with at least 75 feet of storage. Install a traffic signal when warranted, due to increases in peak-hour volumes or to accommodate the planned streetcar. Implementation of this measure would result in the following.

2040 operations after mitigation = LOS C or better.

This mitigation would increase crossing lengths for pedestrians and bicyclists, which would increase their exposure time to vehicles.

**5th Street/F Street, West Sacramento** – Under 2040 conditions, construct westbound and eastbound left-turn lanes with at least 75 feet of storage. Install a traffic signal when warranted, which was previously identified as mitigation for the Raley's Landing project. Implementation of this measure would result in the following.

2040 operations after mitigation = LOS C or better.

This mitigation would increase crossing lengths for pedestrians and bicyclists, which would increase their exposure time to vehicles.

**5th Street/Tower Bridge Gateway, West Sacramento** – Implement the planned modification of the 5th Street/West Capitol Avenue intersection, which would eliminate the vehicle connection to West Capitol Avenue. The proximity of this intersection to 5th Street/Tower Bridge Gateway creates inefficient signal operations at 5th Street/Tower Bridge Gateway and 3rd Street/Tower Bridge Gateway. Implementation of this measure would result in the following.

2020 operations after mitigation = LOS D or better based on 2040 conditions that reflect this configuration with higher peak hour volumes.

**North 7th Street/B Street, Sacramento** – Under 2020 conditions, widen North 7th Street to four lanes through the intersection. This capacity expansion is part of the *Sacramento Railyards Specific Plan Update*. Implementation of this measure would result in the following.

2020 operations after modification = LOS B in the a.m. peak hour.

Modifications that require construction of additional lanes would increase crossing length for pedestrians and bicyclists, which would increase their exposure time to vehicles.

**Bercut Drive/Richards Boulevard, Sacramento** – Under 2040 conditions, extend the southbound right-turn lane to provide 200 feet of storage. Implementation of this measure would result in the following.

2040 operations after modification = LOS F (72 seconds of delay) in the p.m. peak hour.

This modification may take away on-street parking spots.

**North 3rd Street/Richards Boulevard, Sacramento** – Under 2040 conditions, operation of this intersection is constrained by the downstream intersection of I-5 northbound ramps/Richards Boulevard and Bercut Drive/Richards Boulevard. Providing additional capacity for motorists heading northbound onto I-5 would improve operations along the corridor, including at North 3rd Street/Richard Boulevard. This could be addressed by providing a second right-turn lane from Richards Boulevard westbound onto I-5 northbound through converting a westbound through lane to a through-right shared lane. This modification is consistent with the I-5/Richards Boulevard Interchange Project Study Report improvement alternatives but would require ramp modifications that are subject to Caltrans approval and may create a more hazardous conflict zone between bicyclists and vehicles. Implementation of this measure would result in the following.

2040 operations after mitigation = LOS F (104 seconds of delay) in the p.m. peak hour.

**North 12th Street/North B Street, Sacramento** – Under 2040 conditions, the vehicle traffic operations at this intersection are constrained by multimodal modifications planned for the intersection to better accommodate bicycle and pedestrian travel through the intersection, including a cycle track, bulb outs, and vehicle turn-movement restrictions. These modifications are consistent with the *Sacramento 2035 General Plan* for this area, where bicycle and pedestrian travel have high priorities. Physical mitigation to reduce vehicle delays would require taking space away from bicycles and pedestrians or from adjacent property to accommodate more vehicle lanes, which may not be feasible.

**I-5 Southbound Weaving Segment between Garden Highway and Richards Boulevard** – Modify ramp meter signal timings at the Garden Highway and West El Camino Avenue southbound I-5 on-ramps to reduce a.m. peak-hour flows onto the mainline such that mainline flows in the weaving segment are no higher than under 2020 no build conditions. Implementation of this measure would result in the following.

2020 operations after mitigation = a.m. peak hour LOS F (maximum service volume = 2,185)

Changing the ramp meter timing could cause queues to lengthen at the on-ramps, potentially affecting upstream arterial traffic operations on Garden Highway and West El Camino Avenue.

## **D.6 Visual/Aesthetics**

### **D.6.1 Avoidance and Minimization Measures**

No measures are necessary.

### **D.6.2 CEQA Mitigation Measures**

#### **Compensate for Temporary Effects on and Permanent Loss of Cottonwood Riparian Forest (including SRA Cover)**

Please refer to the discussion of this measure in Section D.16.2.

#### **Work with Stakeholders to Determine Bridge Aesthetics**

The project proponent will conduct a focused outreach effort and will conduct a public meeting or charrette session with public stakeholders to develop an aesthetic design approach to aid in reducing the visual impact of the proposed bridge. This measure will allow concerned viewers to contribute to creating a bridge that is visually appealing to the general public, while balancing the need for increased circulation access at this location. Affected stakeholders will be able to provide input on the preferred architectural style and coloring of the proposed bridge.

#### **Implement Project Landscaping**

The project proponent will install landscaping where space and safety considerations allow. This will improve the visual quality of the project corridor by improving corridor aesthetics and helping to reduce the apparent scale of new and reconfigured intersections, in addition to replacing some of the vegetation lost through construction. Prior to approval of the roadway design, the City of Sacramento and /or City of West Sacramento project landscape architect will review project designs to ensure that the following elements are implemented in the project landscaping plan.

- Design and implement low-impact development (LID) measures that disperse and reduce runoff by using such features as vegetated buffer strips/medians between paved areas that catch and infiltrate runoff. In addition, pervious paving will be evaluated for use in the proposed project to improve infiltration and to reduce the amount of surface runoff from entering waterways and the storm water system. LID measures will not be used where infiltration could result in adverse environmental effects. LID measures, such as cobbled swales and aggregate mulching, can be used as an aesthetic design element to create an attractive view while reducing water use.
- Require construction contractors to incorporate native grass and wildflower seed to standard seed mixes, which may be non-native, for erosion control measures that will be applied to all exposed slopes. Wildflowers will provide seasonal interest to areas where trees and shrubs are removed and grasslands are disturbed. Only wildflower and grass species that are native will be incorporated into the seed mix, and under no circumstances will any invasive grass or

wildflower plant species be used as any component in any erosion control measures. Species will be chosen that are indigenous to the area and for their appropriateness to the surrounding habitat. For example, upland grass and wildflower species will be chosen for drier, upland areas, and wetter species will be chosen for areas that will receive more moisture. If not appropriate to the surrounding habitat, wildflowers should not be included in the seed mix.

- Require the species list to include trees, shrubs, and an herbaceous understory of varying heights, as well as both evergreen and deciduous types. Plant variety will increase the effectiveness of the roadside planting areas by providing multiple layers, seasonality, diverse habitat, and reduced susceptibility to disease. Evergreen groundcovers or low-growing plants, such as *Ceanothus* spp., should be used in areas where taller vegetation would potentially cause driving hazards by obscuring site distances. Species used will be native and indigenous to the project area and California. Native plant species can be used to create attractive spaces, high in aesthetic quality, that are not only drought-tolerant but also attract more wildlife than traditional landscape plant palettes. Use of native species promotes a visual character of California that is being lost through development and reliance on non-native ornamental plant species.
- Use vegetative accents and screening to reduce the perceived scale and mass of the built features, while accentuating the design treatments that will be applied to built features. Special attention should be paid to plant choices near residences to ensure that species chosen are of an appropriate height, and rely on evergreen species to provide year-round light screening from nuisance light, if applicable.
- Under no circumstances will any invasive plant species be used at any location.
- Plant vegetation within the first 6 months following project completion.
- Implement an irrigation and maintenance program during the plant establishment period and carried on, as needed, to ensure plant survival. However, design of the landscaping plan will try to maximize the use of planting zones that are water efficient. The design also may incorporate aesthetic features, such as cobbling swales or shallow detention areas, which can reduce or eliminate the need for irrigation in certain areas.
- If an irrigation system is required, use a smart watering system in areas that are irrigated to evaluate the existing site conditions and plant material against weather conditions to avoid overwatering of such areas. To avoid undue water flows, manage the irrigation system in such a manner that any broken spray heads, pipes, or other components are fixed within 1-2 days, or the zone or system will be shut down until it can be repaired.

### **Apply Minimum Lighting Standards**

- All artificial outdoor lighting and overhead street lighting is to be limited to safety and security requirements and the minimum required for driver safety. Lighting will be designed using Illuminating Engineering Society's design guidelines and in compliance with International Dark-Sky Association-approved fixtures. All lighting will be designed to have minimum impact on the surrounding environment and will use downcast, cut-off type fixtures that are shielded and direct the light only toward objects requiring illumination. Therefore, lights will be installed at the lowest allowable height and cast low-angle illumination while minimizing incidental light spill onto adjacent properties or open spaces,

or backscatter into the nighttime sky. The lowest allowable wattage will be used for all lighted areas, and the amount of nighttime lights needed to light an area will be minimized to the highest degree possible. Light fixtures will have non-glare finishes that will not cause reflective daytime glare. Lighting will be designed for energy efficiency, with daylight sensors or timers with an on/off program. Lights will provide good color rendering with natural light qualities, with the minimum intensity feasible for security, safety, and personnel access. Lighting, including light color rendering and fixture types, will be designed to be aesthetically pleasing.

- LED lighting will avoid the use of blue-rich white light lamps and use a correlated color temperature that is no higher than 3,000 Kelvin, consistent with the International Dark-Sky Associations Fixture Seal of Approval Program (International Dark-Sky Association 2010a, 2010b, 2015). In addition, LED lights will use shielding to ensure that nuisance glare and that light spill does not affect sensitive residential viewers.
- Lights along pathways and bridge safety lighting will use shielding to minimize offsite light spill and glare, and will be screened and directed away from adjacent uses to the highest degree possible. The amount of nighttime lights used along pathways will be minimized to the highest degree possible to ensure that spaces are not unnecessarily over-lit. For example, the amount of light can be reduced by limiting the amount of ornamental light posts to higher use areas and by using bollard lighting on travel way portions of pathways.
- Technologies to reduce light pollution evolve over time; design measures that are currently available may help but may not be the most effective means of controlling light pollution once the project is designed. Therefore, all design measures used to reduce light pollution will use the technologies available at the time of project design to allow for the highest potential reduction in light pollution.

## **D.7 Cultural Resources**

### **D.7.1 Avoidance and Minimization Measures**

No measures are necessary.

### **D.7.2 CEQA Mitigation Measures**

#### **Conduct Mandatory Cultural Resources Awareness Training for Construction Personnel**

Before any ground-disturbing work occurs in the project area, a qualified archaeologist will be retained to conduct mandatory contractor/worker cultural resources awareness training for construction personnel. The awareness training will be provided to all construction personnel (contractors and subcontractors), to brief them on the need to avoid effects on cultural resources adjacent to and within construction areas and the penalties for not complying with applicable state and federal laws and permit requirements.

### **Develop Interpretative Display for the I Street Bridge**

The project proponent will develop an interpretive display and erect the display in Old Sacramento at a site within clear view of the I Street Bridge. The display will focus on the removal of vehicular uses from the I Street Bridge, to interpret for future generations the vehicular uses of the bridge. The project proponents will also assemble a freestanding interpretive panel that documents the history of the joint railroad-automobile use of the I Street Bridge, emphasizing the non-rail uses. Details on the implementation on the interpretive display will be coordinated through Caltrans in consultation with SHPO.

### **Establish an Environmental Sensitive Area for Resource CA-SAC-658H**

An Environmentally Sensitive Area (ESA) will be established to ensure that resource CA-SAC-658H is not affected during project implementation. Prior to construction, the construction contractor will install high-visibility orange construction fencing and/or flagging, as appropriate, along the perimeter of the area of direct impact (ADI) located within the APE to restrict access to the portion of CA-SAC-658H outside the ADI. Prior to installation of the ESA fencing, an Environmentally Sensitive Area Action Plan will be prepared as a stipulation of the Programmatic Agreement (PA) prepared for the project.

### **Develop a Programmatic Agreement for the Project**

A project-specific PA between Caltrans, the City of Sacramento and the SHPO will be developed for the project. The PA will assure fulfillment of the NHPA requirements of Section 106 and will ensure proper evaluation and treatment of any previously unknown archaeological resources uncovered during ground-disturbing construction activities. Additionally, the PA will establish responsibilities for the treatment of historic properties, the implementation of mitigation measures, and ongoing consultation efforts with Native American groups.

The PA will include development of a plan for archaeological test trenching within the APE on the West Sacramento side of the river, since this area has a high archaeological sensitivity for both historic-period and prehistoric material. A plan will be prepared for this work similar to a Caltrans Extended Phase I (XPI) Plan. Excavations will be conducted prior to construction, and will aid in the identification of unknown subsurface archaeological deposits that may be present within the APE.

The PA will also require preparation of Environmentally Sensitive Area Action Plan, as discussed above, for CA-SAC-658H. The PA will require preparation of an Archaeological Resource Management Plan (ARMP), prepared to Caltrans and City of Sacramento and City of West Sacramento standards. The ARMP will designate procedures for treatment of previously unidentified cultural resources encountered during test trenching or construction, including steps for the mitigation of resources that are determined eligible for the NRHP.

The ARMP will specify that a qualified archaeologist and a Native American monitor will be retained to monitor all initial ground disturbing activities (e.g., vegetation removal, grading,



excavation, bridge construction). The purpose of the monitoring is to ensure that measures identified in the environmental document are properly implemented to avoid and minimize effects to cultural resources and to ensure that the project complies with all applicable permit requirements and agency conditions of approval. Conditions for monitoring and project reporting will be specified.

### **Implement Avoidance and Notification Procedures for Cultural Resources Discovered during Construction**

It is Caltrans' and the City of Sacramento's policy to avoid cultural resources whenever possible. If cultural materials are discovered during construction, all earthmoving activity within and around the immediate discovery area will be diverted until a qualified archaeologist can assess the nature and significance of the find. All reasonable measures will be implemented to avoid, minimize, or mitigate further harm to the resource. If appropriate, the project proponent will notify Indian tribes or Native American groups that may attach religious or cultural significance to the affected resource.

If human remains are discovered, State Health and Safety Code Section 7050.5 states that further disturbances and activities shall cease in any area or nearby area suspected to overlie remains, and the county coroner shall be contacted. Pursuant to PRC Section 5097.98, if the remains are thought to be Native American, the coroner will notify the NAHC, which will then notify the Most Likely Descendent (MLD). The project proponent will work with the MLD to avoid the remains and, if avoidance is not feasible, to determine the respectful treatment of the remains. Further provisions of PRC Section 5097.98 are to be followed as applicable.

## **D.8 Hydrology and Floodplain**

### **D.8.1 Avoidance and Minimization Measures**

No measures are necessary.

### **D.8.2 CEQA Mitigation Measures**

No measures are necessary.

## **D.9 Water Quality**

### **D.9.1 Avoidance and Minimization Measures**

#### **Implement Measures to Protect Water Quality during Construction**

Impacts from the staging and storage areas would be avoided or minimized because all construction activities, including disturbed soil areas in staging areas, would comply with a variety of permits, requirements and agencies. As required in the Storm Water Pollution Prevention Plan (SWPPP), staging areas must be sufficiently stabilized and returned to their pre-project conditions for final Regional Water Quality Control Board approval. The CGP (Order No. 2009-0009-DWQ, as amended by Order Nos. 2010-0014-DWQ and 2012-0006-DWQ) is applicable to all entities disturbing more than an acre of soil. By law, all storm water discharges associated with construction activity where clearing, grading, and excavation results in soil disturbance of at least 1 acre of total land area (such as this project) must comply with the provisions of the CGP and develop and implement an effective SWPPP. As required by the Construction General Permit, the project proponent will prepare the SWPPP prior to the beginning of construction. Implementation of the SWPPP starts with the commencement of construction and continues through the completion of the project.

The SWPPP would include the following elements.

- **Project Description** – The Project description includes maps and other information related to construction activities and potential sources of pollutants.
- **Minimum Construction Control Measures** – These measures may include limiting construction access routes, stabilizing areas denuded by construction, and using sediment controls and filtration.
- **Erosion and Sediment Control** – The SWPPP is required to contain a description of soil stabilization practices, control measures to prevent a net increase in sediment load in storm water, controls to reduce tracking sediment onto roads, and controls to reduce wind erosion.
- **Non-Storm Water Management** – The SWPPP includes provisions to reduce and control discharges other than storm water.
- **Post-Construction Storm Water Management** – The SWPPP includes a list of storm water control measures that provide ongoing (permanent) protection for water resources.
- **Waste Management and Disposal** – The SWPPP includes a waste management section, including, for example, equipment maintenance waste, used oil, and batteries. All waste must be disposed of as required by state and federal law.
- **Maintenance, Inspection, and Repair** – The SWPPP requires an ongoing program to ensure that all controls are in place and operating as designed.
- **Monitoring** – This provision requires documented inspections of the control measures.

- Reports – The contractor will prepare an annual report on the construction project and submit this report on July 15 each year. This report will be submitted to the State Water Board on the Storm Water Multiple Application and Report Tracking System website.
- Training – The SWPPP provides documentation on the training and qualifications of the designated Qualified SWPPP Developer and Qualified SWPPP Practitioner. Trained personnel must perform inspections, maintenance, and repair of construction site BMPs.
- Construction Site Monitoring Program – The SWPPP includes a Construction Site Monitoring Program detailing the procedures and methods related to the visual monitoring and sampling and analysis plans for non-visible pollutants, sediment and turbidity, and pH and bioassessment.

The following minimum BMPs would be necessary for the project to comply with the CGP.

- Soil stabilization
  - Hydroseeding
  - Geotextiles, mats, plastic covers, and erosion control blankets
  - Hydraulic mulch
- Sediment control
  - Fiber rolls
  - Silt fence
  - Sediment trap
  - Gravel bag berm
  - Check dams
  - Storm drain inlet protection
- Tracking control practices
  - Temporary construction entrance
- Non-storm water controls
  - Dewatering operations
  - Material and equipment use over water
  - Clear water diversion
  - Temporary stream crossing
  - Potable water/irrigation
- Water management and materials pollution control
  - Concrete waste management
  - Hazardous waste management and contaminated soil management

Because the project proponent and the construction contractor must comply with conditions stipulated in water quality permits for the project, no additional measures are required during construction.

### **Implement Measures to Protect Water Quality during Project Operation and Maintenance**

The project design will incorporate Construction General Permit SWPPP post-construction measures, site design measures, LID measures, and other permanent erosion control elements found in Sacramento Stormwater Quality Partnership's SQIP, the City of West Sacramento's SWMP, and Caltrans' MS4 program guidance documents. The NPDES MS4 permits contains provisions to reduce, to the maximum extent practicable, pollutant loadings from the facility once construction is complete. Thus, design features or BMPs would be developed and incorporated into the project design and operations prior to project construction. These measures would reduce the suspended particulate loads, and thus pollutants associated with the particles, from entering waterways. Under the Sacramento County MS4 Permit, storm water mitigation measures are required to be incorporated into project design plans for Planning Priority Projects. These include development projects or land-disturbing activity that results in the creation, addition, or replacement of 5,000 square feet or more of impervious surface area on an already developed site. Traditional permittees, such as City of West Sacramento, are required to comply with Section E of the Statewide Phase II MS4 Permit, which specifies requirements for site design measures<sup>1</sup>, LID design standards, alternative post-construction stormwater management program, and operations and management requirements for post construction stormwater management. Additionally, an operation and maintenance program would be implemented for permanent control measures.

Low-impact development measures are proposed to reduce the rate of runoff, filter pollutants, and allow infiltration into the ground. The proposed measures would address peak-flow attenuation impacts and can include structural measures, such as detention, underground storage, and non-structural measures, through the modification of proposed treatment BMPs to accommodate flow and volume control.

Caltrans-approved treatment BMPs/low-impact development measures that have been studied and verified to remove targeted design constituents and provide general pollutant removal include the following.

- Biofiltration systems
- Infiltration devices
- Detention devices
- Dry weather flow diversion
- Gross solids removal devices (GSRDs)
- Media filters

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<sup>1</sup> Site design measures are implemented to reduce site runoff. Examples of these measures include stream setbacks and buffers, soil quality improvement and maintenance, tree planting and preservation, rooftop and impervious area disconnection, porous pavement, green roofs, vegetated swales, and rain barrels and cisterns.

- Multi-chamber treatment train
- Wet basins

The project proponent would be responsible for maintaining the treatment BMPs discussed above. The Maintenance Stormwater Coordinator would be involved in the design review of any permanent storm water treatment BMPs and would need to approve any such devices at the end of the plans, specifications, and estimate phase. The Caltrans Maintenance Unit would be able to provide guidance on the following project-related issues to ensure that BMPs function as needed.

- Drainage patterns (particularly known areas of flooding and debris)
- Stability of slopes and roadbed (help to determine whether the Project can be built and maintained economically)
- Possible material borrow or spoil sites
- Concerns of the local residents
- Existing and potential erosion problems
- Facilities within the right-of-way that will affect design
- Special problems such as deer crossings and endangered species
- Whether facilities are safe to maintain
- Known environmentally sensitive areas
- Frequency of traction sand use and estimate of sand quantity applied annually

BMPs will address soil stabilization, sediment control, wind-erosion control, non-storm water management, vehicle tracking control, and waste management practices and will be based on the best available technology. Implementation of these measures will ensure that storm water runoff would reduce or avoid permanent impacts on water quality. Because project proponent and the construction contractor must comply with conditions stipulated in the MS4 permit for the project, and an operation and maintenance program would be implemented for permanent control measures, no additional measures are required during operation and maintenance.

### **D.9.2 CEQA Mitigation Measures**

No measures are necessary.

## **D.10 Geology/Soils/Seismic/Topography**

### **D.10.1 Avoidance and Minimization Measures**

No measures are necessary.

## **D.10.2 CEQA Mitigation Measures**

No measures are necessary.

## **D.11 Paleontology**

### **D.11.1 Avoidance and Minimization Measures**

No measures are necessary.

### **D.11.2 CEQA Mitigation Measures**

#### **Educate Construction Personnel in Recognizing Fossil Material**

All construction personnel will receive training provided by a qualified professional paleontologist experienced in teaching non-specialists to ensure that construction personnel can recognize fossil materials in the event that any are discovered during construction.

#### **Stop Work if Substantial Fossil Remains Are Encountered during Construction**

If substantial fossil remains (particularly vertebrate remains) are discovered during earth-disturbing activities, activities will stop immediately until a State-registered professional geologist or qualified professional paleontologist can assess the nature and importance of the find and a qualified professional paleontologist can recommend appropriate treatment. Treatment may include preparation and recovery of fossil materials so that they can be housed in an appropriate museum or university collection, and may include preparation of a report for publication describing the finds. The project proponent will ensure that recommendations regarding treatment and reporting are implemented.

#### **Include Resource Stewardship Measures in Standard Specifications for the Project**

The following measures will be added to the standard specifications for the project.

If paleontological resources are discovered at the job site, do not disturb the material and immediately:

1. Stop all work within a 60-foot radius of the discovery
2. Protect the area
3. Notify the Resident Engineer

The project proponent will investigate and modify the dimensions of the protected area if necessary.

Do not take paleontological resources from the job site. Do not resume work within the specified radius of the discovery until authorized.

The project proponent will alert the construction contractor that paleontological monitoring will occur during activities that will disturb native sediments.

## **D.12 Hazardous Waste/Materials**

### **D.12.1 Avoidance and Minimization Measures**

#### **Conduct Phase II Site Assessments**

The project proponent will conduct a Phase II assessment within the proposed acquisition area of the parcels described below.

- APNs 010-371-005 and 010-371-006 to assess the site for possible soil/groundwater contamination.
- Existing Caltrans right-of-way and C Street Site Y for previous ADL impacts and metals within the depth of construction as metals could potentially originate from historical Capitol Plating operations.
- APNs 001-019-017, 001-210-018, and 002-010-023 to evaluate the site's potential for metals, TPH, and PCB impacts for all construction activities that will result in soil excavation within the proposed right-of-way adjacent to Jibboom Street at these parcels. Based on the findings of the Phase II investigation, a soils management plan and health and safety plan may be necessary.

The Phase II assessment will include sampling and laboratory analysis to confirm the presence of hazardous materials and may include the following.

- Surficial soil and water samples
- Testing of underground storage tanks
- Subsurface soil borings
- Groundwater monitoring well installation, sampling, and analysis (may be appropriate on neighboring properties as well to determine the presence of contamination)
- Asbestos, lead, and other regulated material testing

#### **Conduct a Detailed Review of Existing Records**

To determine the site history for APN 010-482-011, the project proponent will conduct a detailed review of existing records at Yolo County Environmental Health Services and the Central Valley RWQCB and conduct an owner/tenant interview, if possible. If additional information is not available, the project proponent will conduct a Phase II assessment within the proposed acquisition area.

### **Develop and Implement Plans to Address Worker Health and Safety**

The project proponent will develop and implement the necessary plans and measures required by Caltrans and federal and state regulations, including a health and safety plan, BMPs, and/or an injury and illness prevention plan. The plans will be prepared and implemented to address worker safety when working with potentially hazardous materials, including potential ACMs, LCPs, lead or chromium in traffic stripes, ADL, and other construction-related materials within the right-of-way during any soil-disturbing activity.

### **Conduct Sampling, Testing, Removal, Storage, Transportation, and Disposal of Yellow/White Traffic Striping**

As required by Caltrans' standard special provisions, the construction contractor will sample and test yellow/white traffic striping scheduled for removal to determine whether lead or chromium is present. All aspects of the project associated with removal, storage, transportation, and disposal will be in strict accordance with appropriate regulations of the California Health and Safety Code. The stripes will be disposed of at a Class 1 disposal facility. The responsibility of implementing this measure will be outlined in the contract between the project proponent and the construction contractor. Implementing this measure will minimize potential effects from these hazardous materials.

### **Perform Soil Testing and Appropriately Dispose of Soils Contaminated with ADL**

The project proponent will conduct soil testing for ADL contamination in the project area along C Street, 2nd Street, and at the bridge approach/viaduct leading from C Street in West Sacramento; and within the proposed project limits in Sacramento at the bridge approach/viaduct leading from I Street, and along Jibboom Street and Bercut Drive.

Soils in the project limits identified as having hazardous levels of ADL will be disposed of or reused according to federal and state regulations. Soils within the right-of-way that contain hazardous waste concentrations of ADL may be reused under the authority of variances issued by DTSC. These variances include stockpiling, transporting, and reusing soils with concentrations of lead below maximum allowable levels in the project right-of-way. Stockpiling, transporting, and reusing of soil will also be conducted following Caltrans' standard special provisions.

### **Develop a Lead and Asbestos Abatement Plan**

For the structures proposed to be removed or renovated as part of the project, a hazardous materials survey will be conducted prior to demolition or significant renovation. If lead or asbestos is found in these structures, an abatement plan will be developed prior to removal or renovation. The abatement plan will provide for a California-certified asbestos consultant and California Department of Health Services–certified lead project designer to prepare hazardous materials specifications for abatement of the ACM and LCP. This specification should be the basis for selecting qualified contractors to perform the proposed asbestos and lead abatement work. The project proponent will retain a California-licensed asbestos abatement contractor to perform the abatement of any asbestos-containing construction materials and LCP deemed



potentially hazardous. Abatement of hazardous building materials will be completed prior to any work on these structures.

### **Comply with the Land Use Covenant for the Northern Shops and Sacramento Station Study Areas**

The land use covenant (LUC) outlines approved land use and provisions for soil, soil vapor, and groundwater management. These provisions include the Northern Shops study area and Sacramento Station study area sites. The project proponent will comply with the provisions of the LUC, including the following.

1. No activities that will disturb the soil shall be allowed on the property without a soil management plan (SMP) approved in writing by the Department of Toxic Substances Control (DTSC).
2. Any soil brought to the surface shall be managed in compliance with all applicable provisions of state and federal law and a SMP approved in writing by DTSC.
3. No groundwater will be extracted, except as approved of in advance in writing by DTSC in a groundwater management plan.
4. Vapor intrusion mitigation management is required for enclosed structures or buildings.

### **Comply with the Land Use Covenant or Guidance Documents for the Manufactured Gas Plant Study Area**

If soil remedy is complete and soils are certified prior to construction in the Manufactured Gas Plant study area, the project proponent will comply with the resulting LUC and/or guidance documents. If site characterization is not complete, the project proponent will conduct a Phase II assessment within the depth and area of construction improvements.

## **D.12.2 CEQA Mitigation Measures**

No measures are necessary.

## **D.13 Air Quality**

### **D.13.1 Avoidance and Minimization Measures**

#### **Develop a Lead and Asbestos Abatement Plan**

Please refer to the discussion of this measure in Section D.12.1.

## D.13.2 CEQA Mitigation Measures

### Implement Control Measures for Construction Emissions of Fugitive Dust

Caltrans' Standard Specification Section 14, "Environmental Stewardship" addresses the construction contractor's responsibility on many items of concern, such as air pollution; protection of lakes, streams, reservoirs, and other waterbodies; use of pesticides; safety; sanitation; convenience for the public; and damage or injury to any person or property as a result of any construction operation. Section 14-9.02 includes specifications relating to air pollution control for work performed under a contract, including compliance with air pollution control rules, regulations, ordinances, and statutes provided in Government Code Section 11017 (Public Contract Code Section 10231). Section 14-9.03 is directed at controlling dust. Caltrans' Standard Specifications are incorporated into all Caltrans' construction contracts.

#### Sacramento Metro Air Quality Management District

Additional measures to control dust in Sacramento County will be borrowed from SMAQMD's recommended list of dust control measures and implemented to the extent practicable when the measures have not already been incorporated in, and do not conflict with, the requirements of Caltrans' Standard Specifications, special provisions, the NPDES permit, the Biological Opinions, the CWA Section 404 permit, CWA Section 401 Certification, and other permits issued for the project. The following measures are taken from SMAQMD's (2016) CEQA Guide and represent their basic control measures for fugitive dust.

- Water all exposed surfaces two times daily. Exposed surfaces include, but are not limited to soil piles, graded areas, unpaved parking areas, staging areas, and access roads.
- Cover or maintain at least two feet of free board space on haul trucks transporting soil, sand, or other loose material on the site. Any haul trucks that would be traveling along freeways or major roadways should be covered.
- Use wet power vacuum street sweepers to remove any visible trackout mud or dirt onto adjacent public roads at least once a day. Use of dry power sweeping is prohibited.
- Limit vehicle speeds on unpaved roads to 15 mph.
- All roadways, driveways, sidewalks, parking lots to be paved should be completed as soon as possible. In addition, building pads should be laid as soon as possible after grading unless seeding or soil binders are used.

#### Yolo Solano Air Quality Management District

Additional measures to control dust in Yolo County will be borrowed from YSAQMD's recommended list of dust control measures and implemented to the extent practicable when the measures have not already been incorporated in, and do not conflict with, the requirements of Caltrans' Standard Specifications, special provisions, the NPDES permit, the Biological Opinions, the CWA Section 404 permit, CWA Section 401 Certification, and other permits issued for the project. The following measures are taken from YSAQMD's Construction Dust Mitigation Measures (Yolo Solano Air Quality Management District 2007).

- Water all active construction sites at least twice daily. Frequency should be based on the type of operation, soil, and wind exposure.
- Haul trucks shall maintain at least 2 feet of freeboard.
- Cover all trucks hauling dirt, sand, or loose materials.
- Apply non-toxic binders (e.g., latex acrylic copolymer) to exposed areas after cut and fill operations and hydroseed area.
- Apply chemical soil stabilizers on inactive construction areas (disturbed lands within construction projects that are unused for at least four consecutive days).
- Plant tree windbreaks on the windward perimeter of construction projects if adjacent to open land.
- Plant vegetative ground cover in disturbed areas as soon as possible.
- Cover inactive storage piles.
- Sweep streets if visible soil material is carried out from the construction site.
- Treat accesses to a distance of 100 feet from the paved road with a 6- to 12-inch layer of wood chips or mulch.
- Treat accesses to a distance of 100 feet from the paved road with a 6-inch layer of gravel.

#### Sacramento Railyards Specific Plan

Construction activity within the *Sacramento Railyards Specific Plan* area will comply with the mitigation measures contained in the adopted *Mitigation Monitoring Plan* for the Railyards development (City of Sacramento 2016). Wet suppression and wind speed reduction are the two most common methods used to control open dust sources at construction sites because a source of water and material for wind barriers tend to be readily available on a construction site.

#### **Implement SMAQMD's Recommended Construction GHG BMPs**

The City will implement the following SMAQMD's recommended GHG reduction measures, to the extent feasible.

- Improve fuel efficiency from construction equipment:
  - Minimize idling time either by shutting equipment off when not in use or reducing the time of idling to no more than 3 minutes (5 minute limit is required by the state airborne toxics control measure [Title 13, sections 2449(d)(3) and 2485 of the California Code of Regulations]). Provide clear signage that posts this requirement for workers at the entrances to the site.
  - Maintain all construction equipment in proper working condition according to manufacturer's specifications. The equipment must be checked by a certified mechanic and determined to be running in proper condition before it is operated.
  - Train equipment operators in proper use of equipment.
  - Use the proper size of equipment for the job.

- Use equipment with new technologies (repowered engines, electric drive trains).
- Perform on-site material hauling with trucks equipped with on-road engines (if determined to be less emissive than the off-road engines).
- Use alternative fuels for generators at construction sites such as propane or solar, or use electrical power.
- Use an ARB-approved low carbon fuel for construction equipment. (NO<sub>x</sub> emissions from the use of low carbon fuel must be reviewed and increases mitigated.)
- Encourage and provide carpools, shuttle vans, transit passes and/or secure bicycle parking for construction worker commutes.
- Reduce electricity use in the construction office by using compact fluorescent bulbs, powering off computers every day, and replacing heating and cooling units with more efficient ones.
- Recycle or salvage non-hazardous construction and demolition debris (goal of at least 75 percent by weight).
- Use locally sourced or recycled materials for construction materials (goal of at least 20 percent based on costs for building materials, and based on volume for roadway, parking lot, sidewalk and curb materials). Wood products utilized should be certified through a sustainable forestry program.
- Minimize the amount of concrete for paved surfaces or utilize a low carbon concrete option.
- Produce concrete on-site if determined to be less emissive than transporting ready mix.
- Use SmartWay certified trucks for deliveries and equipment transport.
- Develop a plan to efficiently use water for adequate dust control.

## **D.14 Noise**

### **D.14.1 Avoidance and Minimization Measures**

#### **Measures to Minimize Noise Effects from Construction**

Standard Caltrans procedures include implementation of the following measures to minimize the temporary noise effects from construction.

- All equipment will have sound-control devices that are no less effective than those provided on the original equipment. No equipment will have an unmuffled exhaust.
- The construction contractor will implement appropriate additional noise measures, including changing the location of stationary construction equipment, turning off idling equipment, rescheduling construction activity, notifying adjacent residents in advance of construction work, and installing acoustic barriers around stationary construction noise sources.

## **D.14.2 CEQA Mitigation Measures**

### **Build Pavement Surface Designed to Reduce Tire-Pavement Noise**

Provide a “quieter pavement” surface on C Street that is designed to reduce noise from the tire-pavement interface. Pavement surfaces such as Open-Graded Asphalt Concrete have been shown to be effective at reducing vehicle noise emissions by 3 dB or more. Once the noise-reducing surface is installed, post-construction noise level testing shall be done at locations in line with building façade locations to determine compliance with City exterior noise limits.

### **Ensure Building Compliance with City Noise Limits for Interior Spaces**

This measure will only be implemented if measured noise level at a residential building façade exceeds 70 Ldn after implementation of quieter pavement. To comply with City noise standards for interior spaces, the Project Proponent shall ensure that building assemblies (composite of window, wall and door assemblies as applicable) provide a composite Outdoor-Indoor Transmission Class (OITC) rating of 29 as a minimum value, in residential facades facing C Street. Since closed windows are implicit in the OITC rating, buildings are required to include ventilation or air-conditioning system to provide adequate ventilation to interior spaces. The composite attenuation from building assemblies rated at OITC 29 or higher is expected to ensure compliance with the 45 Ldn City standard for interior spaces. Documentation of OITC performance of existing buildings may be available in architectural documents. However, in some cases, an acoustical consultant may be retained to determine performance of building assemblies, if architectural plans are not available. Where building assemblies do not meet an OITC value of 29, window, wall and door assemblies will be evaluated and replaced as appropriate. The sound-insulation performance of buildings facing the C Street segment of the project shall be documented in a supplemental report.

### **Use Noise-Reducing Construction Practices**

To the extent feasible, construction contractors will control noise from construction activity such that noise does not exceed applicable noise ordinance standards specified by the City of West Sacramento. Measures that can be implemented to control noise include:

- Locate noise-generating equipment as far away as practical from residences and other noise-sensitive uses.
- Equip all construction equipment with standard noise attenuation devices such as mufflers to reduce noise and equip all internal combustion engines with intake and exhaust silencers in accordance with manufacturer’s standard specifications.
- Establish equipment and material haul routes that avoid residential uses to the extent practical, limit hauling to the hours between 7:00 a.m. and 10:00 p.m., and specify maximum acceptable speeds for each route.
- Use electrically powered equipment in place of equipment with internal combustion engines where practical, where electric equipment is readily available, and where this equipment accomplishes project work as effectively and efficiently as equipment powered with internal combustion engines.

- Restrict the use of audible warning devices such as bells, whistles, and horns to those situations that are required by law for safety purposes.
- Provide noise-reducing enclosure around stationary noise-generating equipment.
- Provide temporary construction noise barriers between active construction sites that are in close proximity to residential and other noise-sensitive uses. Temporary barriers can be constructed or created with parked truck trailers, soil piles, or material stock piles.
- Route haul trucks away from residential areas where practical.

The construction contractor will develop a construction noise control plan which identifies specific feasible noise control measures that will be employed and the extent to which the measure will be able to control noise to specific noise ordinance limits. The plan will identify areas where it not considered feasible to comply with applicable noise ordinance limits. The noise control plan will be submitted to and approved by the project proponent before any noise-generating activity begins.

### **Use Vibration-Reducing Construction Practices**

The construction contractor will, to the extent feasible, maintain the following minimum distances between vibration-generating construction activity and nearby buildings:

Impact pile driving – 200 feet

Sonic pile driving – 125 feet

Vibratory roller – 75 feet

For cases where this is not feasible, the resident or property owner will be notified in writing prior to construction activity that construction may occur within these distances of their building. The project proponent will inspect the potentially affected buildings prior to construction to inventory existing cracks in paint, plaster, concrete, and other building elements. The project proponent will retain a qualified acoustical consultant or engineering firm to conduct vibration monitoring at potentially affected buildings to measure the actual vibration levels during construction and to keep vibration at those buildings below 0.1 in/sec where feasible. Following completion of construction, the City will conduct a second inspection to inventory changes in existing cracks and new cracks or damage, if any that occurred as a result of construction-induced vibration. If new damage is found, then the City will promptly arrange to have the damaged repaired, or will reimburse the property owner for appropriate repairs.

In addition, if construction activity is required within 100 feet of residences or other vibration-sensitive buildings, a designated complaint coordinator will be responsible for handling and responding to any complaints received during such periods of construction. A reporting program will be required that documents complaints received, actions taken, and the effectiveness of these actions in resolving disputes.

## **D.15 Energy**

### **D.15.1 Avoidance and Minimization Measures**

No measures are necessary.

### **D.15.2 CEQA Mitigation Measures**

No measures are necessary.

## **D.16 Natural Communities**

### **D.16.1 Avoidance and Minimization Measures**

No measures are necessary.

### **D.16.2 CEQA Mitigation Measures**

#### **Install Orange Construction Fencing between the Construction Area and Adjacent Sensitive Biological Resources**

The project proponent and/or their contractor will install orange construction fencing between the construction area and adjacent sensitive biological resource areas. Sensitive biological resources that occur adjacent to the construction area that could be directly affected by the project include natural communities of special concern; special-status wildlife habitats for valley elderberry longhorn beetle; nest sites of Swainson's hawk, purple martin, or other migratory birds; roosting bats; and protected trees to be avoided.

Barrier fencing around sensitive areas will be installed as one of the first orders of work and prior to equipment staging. Before construction begins, the construction contractor will work with the project engineer and a resource specialist to identify the locations for the orange construction fencing, and will place stakes around the sensitive resource sites to indicate these locations. The protected areas will be designated as environmentally sensitive areas and clearly identified on the construction plans and described in the specifications. To minimize the potential for snakes and other ground-dwelling animals from being caught in the orange construction fencing, the fencing will be placed with at least a 1-foot gap between the ground and the bottom of the orange construction fencing. The exception to this condition is where construction barrier fencing overlaps with erosion control fencing and must be secured to prevent sediment runoff. Barrier fencing will be installed before construction activities are initiated, maintained throughout the construction period, and removed after completion of construction.

### **Conduct Environmental Awareness Training for Construction Employees**

The project proponent will retain a qualified biologist to conduct environmental awareness training for construction crews before project implementation. The awareness training will be provided to all construction personnel and will brief them on the need to avoid effects on sensitive biological resources (e.g., native trees, natural communities of special concern, and special-status species habitats in and adjacent to the construction area). The education program will include a brief review of the special-status species with the potential to occur in the BSA (including their life history and habitat requirements, and photographs of the species). The training will identify the portions of the BSA in which the species may occur, as well as their legal status and protection. The program also will cover the restrictions and guidelines that must be followed by all construction personnel to reduce or avoid effects on these species during project implementation. This will include the steps to be taken if a sensitive species is found within the construction area (i.e., notifying the crew foreman, who will call a designated biologist). In addition, construction employees will be educated about the importance of controlling and preventing the spread of invasive plant infestations. An environmental awareness handout that describes and illustrates sensitive resources to be avoided during project construction and identifies all relevant permit conditions will be provided to each crew member. The crew foreman will be responsible for ensuring that crew members adhere to the guidelines and restrictions. Education programs will be conducted for appropriate new personnel as they are brought on the job during the construction period.

### **Conduct Periodic Biological Monitoring**

The project proponent will retain a qualified biological monitor for the project who will visit the site a minimum of once per week to ensure that fencing around environmentally sensitive areas is intact and that activities are being conducted in accordance with the agreed upon project schedule and agency conditions of approval. The monitor will provide the project proponent with a monitoring log for each site visit.

Certain activities will require a biological monitor to be present for the duration of the activity or during the initial disturbance of an area to ensure that impacts on special-status species are avoided. The activities that require specific monitoring are identified in Sections 2.17, 2.18, 2.19, and 2.20.

### **Compensate for Temporary Effects on and Permanent Loss of Cottonwood Riparian Forest (including SRA Cover)**

The project proponent will compensate for the permanent loss of up to 1.44 acres of riparian forest. In addition, any unavoidable loss of riparian forest in the temporary work area will be mitigated. The project proponent will implement onsite and, if necessary, offsite compensation measures and/or purchase mitigation bank credits to compensate for losses of cottonwood riparian forest on the waterside slope of the existing levees, including riparian forest supporting SRA cover habitat (as described in Section 2.20, “Threatened and Endangered Species,” portions of the cottonwood riparian forest in the BSA also provide SRA cover habitat for fish). Onsite compensation will be used to the maximum extent practicable. Compliance with the USACE levee vegetation policy (U.S. Army Corps of Engineers 2014), the Urban Levee Design Criteria



(California Department of Water Resources 2012), or other engineering constraints may limit the ability to achieve full onsite compensation. Therefore, offsite compensation and/or purchase of mitigation bank credits may be needed to achieve no net loss of existing in-kind riparian and SRA cover habitat values. Each of these options is discussed below.

**1. Onsite and/or Offsite Restoration and/or Enhancement along the Sacramento River.**

Riparian habitat restoration and/or enhancement onsite or offsite should occur in the same year construction is completed. For onsite or offsite replacement plantings, the project proponent will prepare a mitigation planting plan, including a species list and number of each species, planting locations, and maintenance requirements. Plantings will consist of cuttings taken from local plants or plants grown from local material. Planted species for the mitigation plantings will be similar to those removed from the project area and will include native species, such as Fremont cottonwood, valley oak, black walnut, Oregon ash, boxelder, and black willow. The final planting plan will be developed based on results of the arborist survey for species to be removed (see additional discussion below). All plantings will be fitted with exclusion cages or other suitable protection from herbivory. Plantings will be irrigated for up to 3 years or until established. Plantings will be monitored annually for 3 years or as required in the project permits. If 75 percent of the plants survive at the end of the monitoring period, the revegetation will be considered successful. If the survival criterion is not met at the end of the monitoring period, planting and monitoring will be repeated after mortality causes have been identified and corrected.

- 2. Mitigation Bank Credit Purchase.** If this option is chosen, the project proponent will provide written evidence to the resource agencies that compensation has been established through the purchase of mitigation credits. The amount to be paid will be the fee that is in effect at the time the fee is paid. The mitigation will be approved by CDFW and may be modified during the permitting process. Mitigation can be in the form of creation and/or preservation credits. If mitigation is in the form of restoration/creation credits, the mitigation will be at a minimum ratio of 1:1 (1 acre of restored or created riparian habitat for each acre of riparian habitat removed). If mitigation is in the form of preservation credits, the mitigation will be at a minimum ratio of 2:1 (2 acres of preserved riparian habitat for each acre of riparian habitat removed). The final compensation ratio will be approved by CDFW in order to result in no net loss of riparian habitat. The project proponent will purchase riparian habitat credits from an approved mitigation bank near the project, such as the Cosumnes Floodplain Mitigation Bank, Fremont Landing Conservation Bank, or Elsie Gridley Mitigation Bank. Replacement riparian forest habitat will include trees species that would support nesting Swainson's hawk (i.e., oak, cottonwood) and will occur within the range of nesting Swainson's hawk within the Sacramento Valley.

To provide a more accurate estimate of tree loss, an arborist survey will be conducted upon completion of 90 percent design plans for the project. In addition to a description of the tree, the arborist survey report will include the precise location of the trunk and size of the dripline for all trees whose trunk or canopy overlap with the project footprint. Riparian forest compensation will be consistent with the requirements of the City of West Sacramento and City of Sacramento tree ordinances to ensure compensation for losses of individual protected trees.

In addition to mitigating for the loss of riparian forest habitat, specific measures will be included to satisfy National Marine Fisheries Service requirements and compensate for the loss of SRA

cover (area and linear feet). However, the acreage will not be duplicated, such that the acreage of riparian forest habitat restored for SRA cover mitigation will apply toward riparian forest habitat mitigation requirements. SRA cover mitigation will include the following riparian replacement requirements.

- Replace the 890 linear feet and 0.44 acre of affected SRA cover vegetation (see Section 2.19.3.1, “Loss of Shaded Riverine Aquatic Cover”) at a 3:1 replacement ratio (i.e., 3 linear feet replaced for every 1 foot affected and 3 acres replaced for every acre affected) by planting native riparian trees in temporary impact areas and along existing onsite or offsite unshaded banks along the Sacramento River.
- Plant native riparian trees onsite to the maximum extent practicable, followed by planting on adjacent reaches of the Sacramento River to minimize the need for purchasing offsite mitigation bank credits.
- Plant riparian trees that are intended to provide SRA cover along the water’s edge at summer low flows up to the OHWM and at sufficient densities to provide shade along at least 85 percent of the bank’s length when the trees reach maturity. This will ensure that riparian plantings intended for SRA cover mitigation will contribute to instream SRA cover when they are inundated during winter/spring flows and overhead cover (shade) during summer flows when they approach maturity.
- Monitor and evaluate the revegetation success of riparian plantings intended for SRA cover mitigation as described above.
- If mitigation for SRA cover is in the form of offsite mitigation bank credits, credits will need to be purchased from an approved mitigation bank within the approved service area for the project that provides riparian forest floodplain conservation credits as off-site compensation for impacts on state- and federally listed fish species, designated critical habitat, and essential fish habitat for Pacific salmon.

### **Compensate for Loss of Protected Trees not in Riparian Habitat**

Within 1 year prior to construction, the project proponent will have a certified arborist conduct a preconstruction inventory of all heritage trees to be removed within the areas defined as ruderal woodland and landscaped land cover types. The inventory will include the location, species, and diameter of all trunks; approximate height and canopy diameter; and approximate age, in support of a tree permit for removal of the heritage trees. All conditions of the tree permit will be implemented.

The project proponent will mitigate the loss of protected trees using one or a combination of the two following options.

- Because it is unlikely that adequate space will be available in the project area for tree planting after construction, pay an in-lieu fee to the City of West Sacramento, which would be used to purchase and plant trees elsewhere in West Sacramento. Replacement trees will be required at a ratio of 1:1 (i.e., 1-inch diameter of replacement tree planted for every 1-inch diameter of tree removed). Replacement trees will be of the same species, except for the replacement of tree of heaven and black locust, which are invasive species and will be

replaced with native tree species. Mitigation will be subject to approval by the City's tree administrator and will take into account species affected, replacement species, location, health and vigor, habitat value, and other factors to determine fair compensation for tree loss. Replacement trees will be monitored annually for 3 years to document vigor and survival. If any of the replacement trees die within 3 years of the initial planting, the project proponent will plant additional replacement trees and monitor them until all trees survive for a minimum of 3 years after planting.

- If feasible, plant replacement trees at or near the location of the tree removal, following the same replacement ratio, species, monitoring, and tree survival requirements described for the option above.

## **D.17 Wetlands and Other Waters**

### **D.17.1 Avoidance and Minimization Measures**

No measures are necessary.

### **D.17.2 CEQA Mitigation Measures**

#### **Install Orange Construction Fencing between the Construction Area and Adjacent Sensitive Biological Resources**

Please refer to the discussion of this measure in Section D.16.2.

#### **Conduct Environmental Awareness Training for Construction Employees**

Please refer to the discussion of this measure in Section D.16.2.

#### **Conduct Periodic Biological Monitoring**

Please refer to the discussion of this measure in Section D.16.2.

#### **Protect Water Quality and Prevent Erosion and Sedimentation in Drainages and Wetlands**

The project proponent and/or their construction contractor will comply with all construction site BMPs specified in the *Water Quality Assessment Report* prepared for the project (ICF International 2016b) and the final SWPPP that will be developed for the project, as well as any other permit conditions to minimize introduction of construction-related contaminants and mobilization of sediment in the Sacramento River and the riparian forest/shrub wetland near the construction area. Broadly, these BMPs will address soil stabilization, sediment control, wind erosion control, vehicle tracking control, non-storm water management, and waste management practices. The BMPs will be based on the best conventional and best available technology.

The proposed project is subject to storm water quality regulations established under the NPDES, described in Section 402 of the federal CWA. In California, the NPDES program requires that any construction activity disturbing 1 or more acres comply with the statewide General Permit, as authorized by the State Water Board. The General Permit requires elimination or minimization of non-storm water discharges from construction sites and development and implementation of a SWPPP for the site. The primary elements of the SWPPP include the following.

- Description of site characteristics—including runoff and streamflow characteristics and soil erosion hazard—and construction procedures
- Guidelines for proper application of erosion and sediment control BMPs
- Description of measures to prevent and control toxic materials spills
- Description of construction site housekeeping practices

In addition to these primary elements, the SWPPP specifies that the extent of soil and vegetative disturbance would be minimized by control fencing or other means and that the extent of soil disturbed at any given time would be minimized. The SWPPP must be retained at the construction site.

The BMPs will be selected to achieve maximum sediment removal and represent the best available technology that is economically achievable; they are subject to review and approval by the project proponent. The project proponent will perform routine inspections of the construction area to verify that the BMPs are properly implemented and maintained. The project proponent will notify contractors immediately of a noncompliance issue and will require compliance.

The BMPs will include, but are not limited to, the following.

- All earthwork or foundation activities involving wetlands or the intermittent vegetated stream will occur in the dry season (between May 1 and October 31). All in-water work within the Sacramento River will be conducted between May 1 and November 30 to minimize or avoid potential impacts on sensitive life stages (migration, spawning, egg and embryo incubation, and rearing) of special-status fish species.
- Equipment used in and around drainages and wetlands will be in good working order and free of dripping or leaking engine fluids. All vehicle maintenance will be performed at least 300 feet from all streams. Any necessary equipment washing will be carried out where the water cannot flow into drainages or wetlands.
- Develop a hazardous material spill prevention control and countermeasure plan before construction begins. The plan will include strict onsite handling rules to keep construction and maintenance materials from entering the river, including procedures related to refueling, operating, storing, and staging construction equipment and to preventing and responding to spills. The plan also will identify the parties responsible for monitoring a spill response. During construction, any spills will be cleaned up immediately according to the spill prevention control and countermeasure plan. The project proponent will review and approve

the contractors' spill prevention control and countermeasure plan before allowing construction to begin.

- Prohibit the following types of materials from being rinsed or washed into the streets, shoulder areas, or gutters: concrete, solvents and adhesives, thinners, paints, fuels, sawdust, dirt, gasoline, asphalt and concrete saw slurry, and heavily chlorinated water.
- Take any surplus concrete rubble, asphalt, or other rubble from construction to a local landfill.
- Prepare and implement an erosion and sediment control plan for the proposed project that will include the following provisions and protocols. The SWPPP for the project will detail the applications and type of measures and the allowable exposure of unprotected soils.
  - Discharge from dewatering operations, if needed, and runoff from disturbed areas will be made to conform to the water quality requirements of the waste discharge permit issued by the RWQCB.
  - Apply temporary erosion control measures, such as sandbagged silt fences, throughout construction of the proposed project and remove them after the working area is stabilized or as directed by the engineer. Soil exposure will be minimized through use of temporary BMPs, groundcover, and stabilization measures. Exposed dust-producing surfaces will be sprinkled daily, if necessary, until wet; this measure will be controlled to avoid producing runoff. Paved roads will be swept daily following construction activities.
  - The contractor will conduct periodic maintenance of erosion and sediment control measures.
  - Plant an appropriate seed mix of native species on disturbed areas upon completion of construction.
  - Cover or apply nontoxic soil stabilizers to inactive construction areas (previously graded areas inactive for 10 days or more) that could contribute sediment to waterways.
  - Enclose and cover exposed stockpiles of dirt or other loose, granular construction materials that could contribute sediment to waterways. Material stockpiles will be located in non-traffic areas only. Side slopes will not be steeper than 2:1. All stockpile areas will be surrounded by a filter fabric fence and interceptor dike.
  - Contain soil and filter runoff from disturbed areas by berms, vegetated filters, silt fencing, straw wattle, plastic sheeting, catch basins, or other means necessary to prevent the escape of sediment from the disturbed area.
  - Use other temporary erosion control measures (such as silt fences, staked straw bales/wattles, silt/sediment basins and traps, check dams, geofabric, sandbag dikes, and temporary revegetation or other ground cover) to control erosion from disturbed areas as necessary.
  - Avoid earth or organic material from being deposited or placed where it may be directly carried into the channel.

The project proponent also will obtain a 401 Water Quality Certification from the Central Valley RWQCB, which may contain additional BMPs and water quality measures to ensure the protection of water quality.

### **Compensate for Loss of Perennial Stream**

The project proponent will comply with any regulatory requirements determined as part of the state (Section 401 Water Quality Certification or WDRs, LSAA) and federal (Section 404 and Section 10 permits) processes for the work that would occur in the Sacramento River. The project proponent will compensate for the permanent fill of up to 1.85 acre of other waters of the United States in the Sacramento River by purchasing mitigation bank credits, which can be in the form of preservation and/or creation credits using the following minimum ratios.

- A minimum of 2:1 (2 acres of mitigation for each acre filled), for a total of up to 3.7 acres, if credits are for preservation of habitat; or
- A minimum of 1:1 (1 acre of mitigation for each acre filled), for a total of up to 1.85 acre, if credits are for creation of habitat.

The actual compensation ratios will be determined through coordination with the Central Valley RWQCB and USACE as part of the permitting process. The project proponent will compensate for permanent loss of perennial stream by implementing one or a combination of the following options.

- Purchase credits for created riparian stream channel at a USACE- approved mitigation bank with a service area that encompasses the project area, such as the Cosumnes Floodplain Mitigation Bank, Fremont Landing Conservation Bank, or Elsie Gridley Mitigation Bank. The project proponent will provide written evidence to the resource agencies that compensation has been established through the purchase of mitigation credits.
- Compensate out-of-kind for loss of perennial stream by implementing compensatory mitigation for cottonwood riparian forest impacts described in Section 2.16, “Natural Communities” (*Compensate for Temporary Effects on and Permanent Loss of Cottonwood Riparian Forest [including SRA Cover]*). The acreage restored or created to compensate for loss of perennial stream will be added to the acreage restored or created for loss of riparian habitat.

## **D.18 Plant Species**

### **D.18.1 Avoidance and Minimization Measures**

No measures are necessary.

## **D.18.2 CEQA Mitigation Measures**

No measures are necessary.

## **D.19 Animal Species**

### **D.19.1 Avoidance and Minimization Measures**

No measures are necessary.

### **D.19.2 CEQA Mitigation Measures**

#### **Install Orange Construction Fencing between the Construction Area and Adjacent Sensitive Biological Resources**

Please refer to the discussion of this measure in Section D.16.2.

#### **Conduct Environmental Awareness Training for Construction Employees**

Please refer to the discussion of this measure in Section D.16.2.

#### **Conduct Periodic Biological Monitoring**

Please refer to the discussion of this measure in Section D.16.2.

#### **Compensate for Temporary Effects on and Permanent Loss of Cottonwood Riparian Forest (including SRA Cover)**

Please refer to the discussion of this measure in Section D.16.2.

#### **Protect Water Quality and Prevent Erosion and Sedimentation in Drainages and Wetlands**

Please refer to the discussion of this measure in Section D.17.2.

#### **Compensate for Loss of Perennial Stream**

Please refer to the discussion of this measure in Section D.17.2.

#### **Conduct Preconstruction Surveys for Western Pond Turtle and Allow Turtles to Leave Work Area Unharmed**

To avoid potential injury to or mortality of western pond turtles, the project proponent will retain a qualified biologist to conduct a preconstruction survey for western pond turtles immediately prior to construction activities (including vegetation removal) along the banks of the Sacramento

River. The biologist will survey the aquatic habitat, river banks, and adjacent riparian and ruderal habitat within the construction area immediately prior to disturbance.

If a western pond turtle is found within the immediate work area during the preconstruction survey or during project activities, work shall cease in the area until the turtle is able to move out of the work area on its own. Information about the location of turtles seen during the preconstruction survey will be included in the environmental awareness training (*Conduct Environmental Awareness Training for Construction Employees*) and provided directly to the construction crew working in that area to ensure that areas where turtles were observed are inspected each day prior to the start of work to ensure that no turtles are present.

If a western pond turtle nest is discovered during the preconstruction survey or during project construction, the project proponent will coordinate with CDFW to determine whether additional avoidance measures (e.g., no-disturbance buffer or monitoring) is prudent.

### **Conduct Preconstruction Surveys for Nesting Migratory Birds, Including Special-Status Birds, and Establish Protective Buffers**

The project proponent will retain a qualified wildlife biologist to conduct nesting surveys before the start of construction. These nesting surveys will be conducted in conjunction with the Swainson's hawk nesting surveys (see *Conduct Focused Surveys for Nesting Swainson's Hawk prior to Construction* in Section 2.20) and will include a minimum of three separate surveys to look for active nests of migratory birds, including raptors. Surveys will include a search of all trees and shrubs, ruderal areas, and grassland vegetation that provide suitable nesting habitat within 50 feet of disturbance. In addition, a 0.25-mile area from the river will be surveyed for nesting raptors in order to identify raptors that might be affected by pile driving. Surveys should occur during the height of the breeding season (March 1 to June 1), with one survey occurring in each of the 2 consecutive months within this peak period and the final survey occurring within 1 week of the start of construction. If no active nests are detected during these surveys, no additional measures are required.

If an active nest is found in the survey area, a no-disturbance buffer will be established to avoid disturbance or destruction of the nest site until the end of the breeding season (September 15) or until after a qualified wildlife biologist determines that the young have fledged and moved out of the construction area (this date varies by species). The extent of these buffers will be determined by the biologist in coordination with CDFW and will depend on the level of noise or construction disturbance taking place, line-of-sight between the nest and the disturbance, ambient levels of noise and other non-project disturbances, and other topographical or artificial barriers. Suitable buffer distances may vary between species.

### **Conduct Tree Removal during Non-Sensitive Periods for Wildlife**

The project proponent will remove or trim trees during the non-breeding season for tree-nesting migratory birds and raptors, and prior to periods when bats would be hibernating (generally between September 15 and October 31). If tree removal cannot be confined to this period, the project proponent will retain a qualified wildlife biologist with knowledge of the wildlife species that could occur in the project area to conduct the appropriate preconstruction surveys and



establish no-disturbance buffers for sensitive wildlife species as described under measures for Swainson's hawk (see *Conduct Focused Surveys for Nesting Swainson's Hawk prior to Construction* in Section 2.20), nesting birds, and roosting bats. Implementation of the following measures will avoid and minimize impacts on purple martins, as well as other nesting birds and bats that use the approach structures.

### **Avoid and Minimize Impacts on Purple Martins during Construction Activities**

No construction activity that results in ground disturbance, modification of the I Street Bridge approach structure, loud noises, and/or vibrations will be conducted within 100 feet of the edge of the purple martin colony during the purple martin nesting season (March 15 to August 15). In addition, no construction-related vehicles or machinery shall be operated or stored beneath the colony during this period or until a qualified biologist determines that the purple martins have completed nesting and are no longer occupying the structure.

### **Avoid and Minimize Impacts on Nesting Birds and Roosting Bats from Demolition of Approach Structures**

Because all four of the approach structures that are associated with the I Street Bridge are used by nesting birds (including purple martin) and roosting bats, the removal of these structures will take place outside of the breeding season for migratory birds and bats, and will be conducted in the following manner to avoid and minimize direct harm and temporary disturbance to nesting birds and roosting bats.

#### Timing of Approach Structure Demolition

To avoid and minimize potential impacts on purple martins and bats, the approach structures will not be removed or be altered until after the new I Street Bridge and associated replacement habitat on the bridge and/or elsewhere is in place and available for use by birds and bats for at least one overlapping nesting/maternal season, which generally would be from March 15 to September 15. Exclusion activities will be initiated between September 15 and October 31 to avoid affecting nesting purple martins and other birds, and to avoid affecting maternal and hibernating bat roosts. The exact date of beginning exclusion will be determined based on the results of preconstruction surveys that will be conducted in mid- to late August to document the status of bird nests and bat roosts. Active nests will be periodically monitored until it is verified that they are no longer being used. The non-volant (non-flying) period for most young bats is between April and the beginning of September (Johnston et al. 2004:26).

To avoid and minimize potential noise impacts on migratory birds nesting adjacent to project demolition activities, all demolition activities resulting in loud noise will be conducted outside of the nesting season, which is generally September 15 to February 1, to the extent feasible.

#### Approach Structure Exclusion Measures

The following exclusion measures will be implemented before demolition of the approach structures and will be approved by the project proponent and CDFW prior to implementation.

The vent holes and expansion joints on the approach structures will be altered to exclude birds and bats from using them prior to initiating demolition activities. After it has been confirmed that purple martins or other birds are no longer nesting in the vent holes, one-way doors will be installed on the vent holes to allow any wildlife (e.g., birds and bats) that may be occupying the hollow box-girders on the existing approach structure to exit and not re-enter. After the one-way doors have been in place for 48 hours, they will be removed and the vent holes will be sealed off to prevent any wildlife from re-entering prior to demolition.

One-way door devices also will be installed along the expansion joints to allow bats to exit but not re-enter. These one-way door devices will be designed such that they do not contain netting or wire mesh that bats could become entangled in. The one-way doors will remain in place for 48 hours, after which they will be inspected for remaining bats. Once each expansion joint is confirmed to be unoccupied, they will be sealed close with an expanding foam sealant to prevent bats from reoccupying the approach structures.

Implementation of the following measures will partially compensate for the loss of purple martin habitat and the long-term effects on the Sacramento area population.

### **Create Purple Martin Replacement Habitat**

Purple martin nesting habitat that will be lost due to demolition of the I Street Bridge approach structure will be mitigated in part with replacement habitat. The amount of replacement habitat will be based on the maximum number of pairs observed nesting in the existing approach structure that is proposed for removal, which was 37 pairs in 2002 (Airola et al. 2014:14). Because of the uncertainty of replacement habitat being used and due to the magnitude of the impact (effects on approximately 25 percent of the Sacramento population), replacement habitat will be provided at a ratio of 2:1 (replacement habitat to habitat removed). Therefore, the following replacement habitat will be of sufficient size to accommodate at least 74 nesting pairs of purple martins.

#### Replacement Habitat on New Bridge Structure

The new bridge will include a hollow box-girder design with at least 74 vent holes on the underside to allow for purple martins to use the new structure for nesting. Vent holes intended for use by martins will be at least 20 feet above the ordinary high water mark of the Sacramento River. Each vent hole will be associated with an individual chamber (i.e., a four sided chamber) that is intended for use by a breeding pair and will be at least 10 feet square. Nest guards consisting of ½ inch wire mesh will be installed along the interior edge of the vent hole to prevent nestlings from falling out. The wire mesh will extend at least 1 inch above the floor of the chamber.

Landscaping will be designed to not disrupt the flight access within 120 feet of replacement nesting habitat (i.e., will not physically or visually obstruct the space around the nesting habitat). Small to medium non-fruit-bearing trees shall be incorporate into the landscaping plans. Where possible, pine trees (*Pinus* spp.) also will be incorporated into landscaping plans to provide a permanent source of nesting material for purple martins. If feasible, some mowed or cut

vegetation along the West Sacramento levee in the BSA will be left in place between March 15 and May 15 to allow purple martins to use this material for nesting.

### **Implement a Monitoring and Management Plan for Purple Martins**

Because of the current status of the population in the region and the impact of the project on this population, the project proponent will develop and implement a purple martin monitoring and management plan. This plan at a minimum will include the following.

- The monitoring and management plan will be implemented by a wildlife biologist with knowledge of the life history, behavior, and habitat requirements of purple martin and with demonstrated prior experience in monitoring purple martin colonies.
- Monitor use of replacement habitat by purple martins over a 10-year period for a minimum of 5 monitoring years (e.g., years 2, 3, 5, 7, and 10) following the completion of the new bridge and the demolition of the existing approach structure that provides nesting habitat for purple martins. The monitoring period may be extended if it is found that (1) purple martins are not using the replacement habitat; or (2) the replacement habitat is not functioning as intended and repairs are made, or additional replacement habitat is created. At a minimum, the following information will be recorded.
  - Number of nesting pairs
  - Documentation of which vent holes (or other replacement structures) are used
  - Documentation of use of perching structures
  - Effectiveness of landscaped areas and semi-natural areas (vegetated levee) in providing nesting materials
  - Observations of predation or presence of known predators
  - Changes in habitat in and around the colony
- To provide context for how the I Street Bridge colony is doing relative to the remaining population, at least 3 reference colonies in the Sacramento population also will be monitored over the same 10-year period for a minimum of 5 monitoring years following the completion of the project. The reference population monitoring will be conducted concurrently with the replacement monitoring. Information collected during the reference colony monitoring will include at a minimum the following.
  - The number of nesting pairs in at least three historical colonies
  - Other relevant observations on the status of the colonies (e.g., sources of predation, changes in habitat).
- The monitoring and management plan will include adaptive management measures to correct problems with replacement habitat, make other habitat improvements, and/or implement management recommendations within or adjacent to the BSA, or elsewhere within the Sacramento population, in an attempt to boost nesting success. These measures may include but would not be limited to the following.

- A commitment to replacing poor-functioning or damaged free-standing purple martin nesting and/or perching habitat such that there is no net loss in the amount of created habitat.
- A process for making and implementing recommendations on the management of vegetation around Sacramento area colonies.

### **Conduct Preconstruction Surveys for Roosting Bats and Implement Protective Measures**

To avoid and minimize potential impacts on pallid bat, western red bat, and non-special-status bat species from the removal of trees and buildings, the project proponent will implement the following actions.

#### Preconstruction Surveys

Within 2 weeks prior to tree trimming or removal and any building demolition (e.g., homes, sheds, other outbuildings), a qualified biologist will examine trees to be removed or trimmed and buildings planned for demolition for suitable bat roosting habitat. High-quality habitat features (e.g., large tree cavities, basal hollows, loose or peeling bark, larger snags, abandoned buildings, attics) will be identified, and the area around these features searched for bats and bat sign (e.g., guano, culled insect parts, staining). Riparian woodland and stands of mature broadleaf trees will be considered potential habitat for solitary foliage-roosting bat species.

If suitable roosting habitat and/or bat sign is detected, biologists will conduct an evening visual emergence survey of the source habitat feature, from a half hour before sunset to 1–2 hours after sunset for a minimum of 2 nights. Full-spectrum acoustic detectors will be used during emergence surveys to assist in species identification. If site security allows, detectors should be set to record bat calls for the duration of each night. All emergence and monitoring surveys will be conducted during favorable weather conditions (calm nights with temperatures conducive to bat activity and no precipitation predicted). The biologist will analyze the bat call data using appropriate software and prepare a report that will be submitted to the project proponent and CDFW.

#### Timing of Tree Removal and Building Demolition

Trees and buildings planned for removal and demolition will have exclusion devices installed between September 15 and October 31 to avoid affecting maternal and hibernating bat roosts. The exact timing of removal and demolition will be determined based on preconstruction surveys of trees and buildings.

#### Protective Measures

Protective measures may be necessary if it is determined that bats are using buildings or trees in the BSA as roost sites, or if sensitive bats species are detected during acoustic monitoring. The following measures will be implemented when roosts are found within trees or buildings planned for removal according to the timing discussed above. Specific measures will be approved by the project proponent and CDFW prior to excluding bats from occupied roosts.

- Exclusion from buildings or bridge structures will not take place until temporary or permanent replacement roosting habitat is available.
- Exclusion from roosts will take place late in the day or in the evening to reduce the likelihood of evicted bats falling prey to diurnal predators, and will take place during weather and temperature conditions conducive to bat activity.
- Biologists experienced with bats and bat evictions will carry out or oversee the exclusion tasks and will monitor tree trimming and removal, and buildings if they are determined to be occupied.
- Trees that provide suitable roost habitat will be removed in pieces, rather than felling the entire tree and should be done late in the day or in the evening to reduce the likelihood of evicted bats falling prey to diurnal predators, and will take place during warm weather conditions conducive to bat activity.
- Structural changes may be made to a known roost proposed for removal, to create conditions in the roost that are undesirable to roosting bats and encourage the bats to leave on their own (e.g., open additional portals so that temperature, wind, light and precipitation regime in the roost change). Structural changes to the roost will be authorized by CDFW and will be performed during the appropriate exclusion timing (listed above) to avoid harming bats.
- Non-injurious harassment at the roost site, such as ultrasound deterrents or other sensory irritants, may be used to encourage bats to leave on their own.
- One-way door devices will be used where appropriate to allow bats to leave the roost but not to return.
- Prior to building demolition and/or tree removal/trimming and after other eviction efforts have been attempted, any confirmed roost site will be gently shaken or repeatedly struck with a heavy implement such as a sledge hammer or an axe. Several minutes should pass before beginning demolition work, felling trees, or trimming limbs to allow bats time to arouse and leave the roost. A biological monitor will search downed vegetation for dead and injured bats. The presence of dead or injured bats will be reported to CDFW. Injured bats will be transported to the nearest CDFW-permitted wildlife rehabilitation facility.

### **Replace Bat Roosting Habitat Lost from Demolition of Approach Structures**

Bat roosting habitat will be incorporated into the new bridge and, if necessary, additional free-standing roosting habitat (e.g., bat houses) will be created and installed within or adjacent to the BSA. At a minimum ratio of 1:1, 1,132 linear feet of roosting habitat will be created to compensate for the loss of bat roosting habitat associated with the approach structures. Bat replacement habitat will consist of crevice habitat built into the new bridge. Bat replacement habitat will be designed generally following the guidelines in *California Bat Mitigation Techniques, Solutions, and Effectiveness* (Johnston et al. 2004), which provides a review of mitigation options for bats in relation to Caltrans projects. Final plans for bat habitat replacement will be approved by the project proponent and CDFW.

### **Monitor Bat Replacement Habitat**

The project proponent will be responsible for monitoring replacement bat habitat over a 5-year period for a minimum of 3 years (e.g., years 2, 3, and 5) to determine whether bats are using the habitat, determine whether the habitat is functioning as intended, and identify any corrective actions that need to be made to the habitat to improve its use by bats. Bat use will be documented through a combination of visual observation (bats and bat sign), which could be conducted during the day where roosting bats are visible or at night during an emergence survey. Acoustic recordings will be used in combination with emergence surveys to attempt to identify the species of bat(s) using the replacement habitat. The locations and amount of occupied habitat will be recorded. Recommendations for corrective actions will be presented to the project proponent and CDFW for approval. Annual monitoring reports will be sent to the project proponent and CDFW.

### **Conduct All In-Water Construction Activities between May 1 and November 30 and during Daylight Hours Only**

The project proponent will conduct all in-water construction work and pile driving (in-water and shore-based within 250 feet of the Sacramento River), installation of cofferdams, removal of temporary sheet piles, and placement of rock revetment between May 1 and November 30 to avoid or minimize causing disturbance and injury to, or mortality of, special-status fish species in the affected reaches of the Sacramento River. In addition, in-water work will be conducted during daylight hours only to provide fish in the affected reaches of the Sacramento River with an extended quiet period during nighttime hours for feeding and unobstructed passage.

Limiting in-water construction to the May 1–November 30 period would achieve several goals.

- In-water construction activities with the potential to generate harmful levels of underwater noise (e.g., driving piles with an impact hammer) would avoid the primary migration periods of adults and juveniles of special-status fish species.
- The length of the in-water construction period would be maximized, thereby limiting the number of construction seasons that in-water construction would be needed and the number of year classes of fish species that potentially would be exposed to in-water construction effects.

### **Implement Measures to Minimize Exceedance of Interim Threshold Sound Levels during Pile Driving**

The project proponent will require the contractor to implement the following measures, developed in coordination with project design engineers, to minimize the exposure of listed fish species to potentially harmful underwater sounds.

- If feasible, the contractor will vibrate all piles to the maximum depth possible before using an impact hammer.
- No more than 20 piles will be driven per day, and pile driving with an impact hammer will occur on no more than 75 individual days total during construction.

- During impact driving, the contractor will limit the number of strikes per day to the minimum necessary to complete the work and will limit the total number of hammer strikes to 16,000 strikes per day (i.e., 800 hammer strikes per pile, per day) for piles for the bridge piers and temporary trestles, and 20,000 strikes per day (i.e., 1,000 hammer strikes per pile, per day) for the piles for the bridge fender system.
- The smallest pile driver and minimum force necessary will be used to complete the work.
- During impact driving, the project proponent will require the contractor to use a bubble curtain or similar device, if feasible, to minimize the extent to which the interim peak and cumulative SEL thresholds are exceeded.
- No pile driving activity will occur at night, thereby providing fish with an extended quiet period during nighttime hours on days pile driving is being conducted for feeding and unobstructed passage.

### **Develop and Implement a Hydroacoustic Monitoring Plan**

The project proponent and/or its construction contractor will develop and implement a hydroacoustic monitoring plan. The monitoring plan will be submitted to the resource agencies (CDFW, NMFS, and USFWS) for approval at least 60 days before the start of project activities. The plan will include the following requirements.

- The project proponent and/or its construction contractor will monitor underwater noise levels during all impact pile driving activities on land and in water to ensure that that peak and cumulative SELs do not exceed estimated values (Table 2.19-8).
- The monitoring plan will describe the methods and equipment that will be used to document the extent of underwater sounds produced by pile driving, including the number, location, distances, and depths of the hydrophones and associated monitoring equipment.
- The monitoring plan will include a reporting schedule for daily summaries of the hydroacoustic monitoring results and for more comprehensive reports to be provided to the resource agencies on a monthly basis during the pile driving season.
- The daily reports will include the number of piles installed per day; the number of strikes per pile; the interval between strikes; the peak SPL, SEL, and RMS per strike; and the accumulated SEL per day at each monitoring station.
- The project proponent or its contractors will ensure that a qualified fish biologist is on site during impact pile driving to document any occurrences of stressed, injured, or dead fish. If stressed, injured, or dead fish are observed during pile driving, the project proponent and/or its construction contractor will reduce the number of strikes per day to ensure that fish are no longer showing signs of stress, injury, or mortality.

### **Monitor Turbidity in the Sacramento River**

The project proponent will require the construction contractor to monitor turbidity levels in the Sacramento River during in-water construction activities (e.g., pile driving, extraction of temporary sheet piles used for cofferdams, placement of RSP). Turbidity will be measured using

standard techniques upstream and downstream of the construction area to determine whether changes in ambient turbidity levels exceed 20 percent, the threshold derived from the Sacramento and San Joaquin Rivers Basins Plan (Central Valley Regional Water Quality Control Board 2011). If it is determined that turbidity levels exceed the 20-percent threshold, then the project proponent and/or its contractors will adjust work to ensure that turbidity levels do not exceed the 20-percent threshold.

### **Implement Cofferdam Restrictions**

The following restrictions will be implemented during installation of the cofferdams and cofferdam dewatering.

- The extent of cofferdam footprints will be limited to the minimum necessary to support construction activities.
- Sheet piles used for cofferdams will be installed and removed using a vibratory pile driver.
- Cofferdams will be installed and removed only during the proposed in-water work window (between May 1 and November 30).
- Cofferdams will not be left in place over winter where they could be overtopped by winter/spring flows and when juveniles of listed species are most likely to be present in the construction area.
- All pumps used during dewatering of cofferdams will be screened according to CDFW and NMFS guidelines for screens.
- Cofferdam dewatering and fish rescue/relocation from within cofferdams will commence immediately following cofferdam closure.

### **Prepare and Implement a Fish Rescue and Relocation Plan**

The project proponent and/or its construction contractor will develop and implement a fish rescue and relocation plan to recover any fish trapped in cofferdams. The fish rescue and relocation plan will be submitted to the resource agencies (CDFW, NMFS, and USFWS) for approval at least 60 days before initiating activities to install cofferdams. At a minimum, the plan will include the following.

- A requirement that fish rescue and relocation activities will commence immediately after cofferdam closure and that dewatering has sufficiently lowered water levels inside cofferdams to make it feasible to rescue fish.
- A description of the methods and equipment proposed to collect, transfer, and release all fish trapped within cofferdams. Capture methods may include seining, dip netting, and/or electrofishing as approved by CDFW, NMFS, and USFWS. The precise methods and equipment to be used will be developed cooperatively by CDFW, NMFS, USFWS, and the project proponent and/or contractor.
- A requirement that only CDFW-, NMFS-, and USFWS-approved fish biologists will conduct the fish rescue and relocation.



- A requirement that fish biologists will contact CDFW, NMFS, and USFWS immediately if any listed species are found dead or injured.
- A requirement that a fish rescue and relocation report be prepared and submitted to CDFW, NMFS, and USFWS within 5 business days following completion of the fish relocation. Data will be provided in tabular form and at a minimum will include the species and number rescued and relocated, approximate size of each fish (or alternatively, approximate size range if large number of individuals are encountered), date and time of their capture, and general condition of all live fish (e.g., good–active with no injuries; fair–reduced activity with some superficial injuries; poor–difficulty swimming/orienting with major injuries). For dead fish, additional data will include fork length and description of injuries and/or possible cause of mortality if it can be determined.

### **Prevent the Spread or Introduction of Aquatic Invasive Species**

The project proponent or its contractors will implement the following actions to prevent the potential spread or introduction of AIS associated with the operation of barges and other in-water construction activities. Species of concern related to the operation of barges and other equipment in the lower Sacramento River include invasive mussels (e.g., quagga mussels [*Dreissena bugensis*] and zebra mussels [*Dreissena polymorpha*]) and aquatic plants (e.g., Brazilian waterweed [*Egeria densa*] and hydrilla [*Hydrilla verticillata*]) (California Department of Fish and Game 2008).

- The project proponent or its contractors will coordinate with the CDFW’s Invasive Species Program to ensure that the appropriate BMPs are implemented to prevent the spread or introduction of AIS.
- Educate construction supervisors and managers about the importance of controlling and preventing the spread of AIS.
- Train vessel and equipment operators and maintenance personnel in the recognition and proper prevention, treatment, and disposal of AIS.
- If feasible, prior to departure of vessels from their place of origin and before in-water construction equipment is allowed to operate within the waters of the Sacramento River, thoroughly inspect and remove and dispose of all dirt, mud, plant matter, and animals from all surfaces that are submerged or may become submerged, or places where water can be held and transferred to the surrounding water.

### **Minimize or Avoid Temporary Construction Lighting and Permanent Bridge Lighting from Directly Radiating on Water Surfaces of the Sacramento River**

The project proponent will minimize or avoid the effects of nighttime lighting on special-status fish species by implementing the following actions.

#### Temporary Construction Lighting

- Avoiding construction activities at night, to the maximum extent practicable.

- Using the minimal amount of lighting necessary to safely and effectively illuminate the work areas.
- Shielding and focusing lights on work areas and away from the water surface of the Sacramento River, to the maximum extent practicable.

#### Permanent Bridge Lighting

- Minimizing nighttime lighting of the bridge structure for aesthetic purposes.
- Using the minimal amount of lighting necessary to safely and effectively illuminate vehicular, bicycle, and pedestrian areas on the bridge.
- Shielding and focusing lights on vehicular, bicycle, and pedestrian areas and away from the water surface of the Sacramento River, to the maximum extent practicable.

## **D.20 Threatened & Endangered Species**

### **D.20.1 Avoidance and Minimization Measures**

No measures are necessary.

### **D.20.2 CEQA Mitigation Measures**

#### **Install Orange Construction Fencing between the Construction Area and Adjacent Sensitive Biological Resources**

Please refer to the discussion of this measure in Section D.16.2.

#### **Conduct Environmental Awareness Training for Construction Employees**

Please refer to the discussion of this measure in Section D.16.2.

#### **Conduct Periodic Biological Monitoring**

Please refer to the discussion of this measure in Section D.16.2.

#### **Compensate for Temporary Effects on and Permanent Loss of Cottonwood Riparian Forest (including SRA Cover)**

Please refer to the discussion of this measure in Section D.16.2.

#### **Protect Water Quality and Prevent Erosion and Sedimentation in Drainages and Wetlands**

Please refer to the discussion of this measure in Section D.17.2.

### **Compensate for Loss of Perennial Stream**

Please refer to the discussion of this measure in Section D.17.2.

### **Conduct All In-Water Construction Activities between May 1 and November 30 and during Daylight Hours Only**

Please refer to the discussion of this measure in Section D.19.2.

### **Implement Measures to Minimize Exceedance of Interim Threshold Sound Levels during Pile Driving**

Please refer to the discussion of this measure in Section D.19.2.

### **Develop and Implement a Hydroacoustic Monitoring Plan**

Please refer to the discussion of this measure in Section D.19.2.

### **Monitor Turbidity in the Sacramento River**

Please refer to the discussion of this measure in Section 2.19.4.

### **Implement Cofferdam Restrictions**

Please refer to the discussion of this measure in Section D.19.2.

### **Prepare and Implement a Fish Rescue and Relocation Plan**

Please refer to the discussion of this measure in Section D.19.2.

### **Prevent the Spread or Introduction of Aquatic Invasive Species**

Please refer to the discussion of this measure in Section D.19.2.

### **Minimize or Avoid Temporary Construction Lighting and Permanent Bridge Lighting from Directly Radiating on Water Surfaces of the Sacramento River**

Please refer to the discussion of this measure in Section D.19.2.

### **Avoid and Minimize Impacts on Valley Elderberry Longhorn Beetle**

The following measures will be implemented prior to and during construction to ensure that the proposed project does not adversely affect elderberry shrubs adjacent to the project footprint.

- Contractors will be briefed on the need to avoid damaging the elderberry shrubs and the possible penalties for not complying with these requirements. Crews also will be educated on the status of the VELB and the need to protect its habitat.

- All elderberry shrubs that are outside of the permanent project footprint or that can be avoided will be identified on construction drawings, with notes indicating that they are sensitive resources to be avoided.
- Orange construction barrier fencing will be placed at a minimum of 20 feet from each shrub's dripline [fencing around shrub 6 (construction will be within 20 feet) will be placed as far out from the dripline as possible]. No construction activities will be permitted within the buffer zone other than those activities necessary to erect the fencing. *As specified in the Conservation Guidelines for the Valley Elderberry Longhorn Beetle (Guidelines) (U.S. Fish and Wildlife Service 1999), signs will be posted every 50 feet (at a minimum) along the perimeter of the buffer area fencing. The signs will contain the following information: This area is habitat of the valley elderberry longhorn beetle, a threatened species, and must not be disturbed. This species is protected by the Endangered Species Act of 1973, as amended. Violators are subject to prosecution, fines, and imprisonment.* The signs should be clearly readable from a distance of 20 feet and must be maintained for the duration of construction.
- Buffer area fences around the shrubs will be inspected weekly by a biological monitor during ground-disturbing activities and monthly after ground-disturbing activities until project construction is complete or until the fences are removed, as approved by the biological monitor. The biological monitor will be responsible for ensuring that the contractor maintains the buffer area fences around elderberry shrubs throughout construction. Biological inspection reports will be provided to USFWS and the project proponent.

### **Transplant Elderberry Shrubs That Cannot Be Avoided**

Elderberry shrubs that cannot be avoided will be transplanted to a USFWS-approved conservation area in accordance with the Guidelines (U.S. Fish and Wildlife Service 1999). Transplanting will occur during the plant's dormant phase (approximately November through the first 2 weeks of February, after they have lost their leaves). A qualified specialist familiar with elderberry shrub transplantation procedures will supervise the transplanting. The location of the conservation area transplantation site will be approved by USFWS before removal of the shrubs.

Implementation of the following measures will compensate for direct impacts on VELB habitat.

### **Compensate for Impacts on Valley Elderberry Longhorn Beetle Habitat**

Before construction begins, the project proponent will compensate for direct impacts (including transplanting) on all elderberry stems measuring 1 inch or more at ground level (i.e., habitat for VELB) that are located within 20 feet of proposed construction activities. Compensation will include planting replacement elderberry seedlings or cuttings and associated native plantings in a USFWS-approved conservation area, at a ratio between 1:1 and 8:1 (ratio = new plantings to affected stems), depending on the diameter of the stem at ground level, the presence or absence of exit holes, and whether the shrub is located in riparian habitat (U.S. Fish and Wildlife Service 1999).

Mitigation credits for VELB will be purchased at a USFWS-approved mitigation bank. The exact amount and location of compensatory mitigation will be based on consultation with USFWS.

Table 3-18 summarizes the compensation required for direct effects on up to five elderberry shrubs (shrubs 1, 2, 3, 5, and 7) that provide VELB habitat. Based on stem counts listed in Table 3-18 for these five shrubs and in accordance with the Guidelines, 34 elderberry seedlings and 34 associated native plants will be planted in a USFWS-approved conservation area. This compensation may be reduced if some of the shrubs occurring within temporary impact areas (shrubs 1, 2, 3, and 7) can be avoided once more detailed plans are available.

**Table 3-18. Required Compensation for Directly Affected Elderberry Shrubs**

Habitat	Stem Diameter	Number of Stems	Exit Holes?	Seedling Ratio	Native Plant Ratio	Total Seedling	Total Native Plants
Riparian	Stems >1" to <3"	0	No	2:1	1:1	0	0
	Stems >1" to <3"	0	Yes	4:1	2:1	0	0
	Stems >3" to <5"	0	No	3:1	1:1	0	0
	Stems >3" to <5"	0	Yes	6:1	2:1	0	0
	Stems >5"	1	No	4:1	1:1	4	4
	Stems >5"	0	Yes	8:1	2:1	0	0
Nonriparian	Stems >1" to <3"	22	No	1:1	1:1	22	22
	Stems >1" to <3"	0	Yes	2:1	2:1	0	0
	Stems >3" to <5"	1	No	2:1	1:1	2	2
	Stems >3" to <5"	0	Yes	4:1	2:1	0	0
	Stems >5"	2	No	3:1	1:1	6	6
	Stems >5"	0	Yes	6:1	2:1	0	0
<b>Total</b>		<b>26</b>				<b>34</b>	<b>34</b>

### Conduct Focused Surveys for Nesting Swainson’s Hawk prior to Construction

The project proponent will retain a wildlife biologist experienced in surveying for Swainson’s hawk to conduct surveys for the species in the spring/summer prior to construction. The surveys will be conducted within the limits of disturbance and in a buffer area up to 0.25 mile from the limits of disturbance. The size of the buffer area surveyed will be based on the type of habitat present and the line-of-sight from the construction area to surrounding suitable breeding habitat. Surveys will follow the methods in *Recommended Timing and Methodology for Swainson’s Hawk Nesting Surveys in California’s Central Valley* (Swainson’s Hawk Technical Advisory Committee 2000). A minimum of six surveys will be conducted according to these methods. If a variance of the survey distance or number of surveys is necessary, the project proponent will coordinate with CDFW regarding appropriate survey methods based on proposed construction activities. Surveys generally will be conducted from February to July. Survey methods and results will be reported to the project proponent and CDFW.

### Conduct Tree Removal during Non-Sensitive Periods for Wildlife

The project proponent will remove or trim trees during the non-breeding season for tree-nesting migratory birds and raptors, and prior to periods when bats would be hibernating (generally

between September 15 and October 31). If tree removal cannot be confined to this period, the project proponent will retain a qualified wildlife biologist with knowledge of the wildlife species that could occur in the project area to conduct the appropriate preconstruction surveys and establish no-disturbance buffers for sensitive wildlife species as described under measures for Swainson's hawk, nesting birds, and roosting bats.

### **Monitor Active Swainson's Hawk Nests during Pile Driving and Other Construction Activities**

Active Swainson's hawk and white-tailed kite nests within 600 feet of the BSA will be monitored during pile driving and other construction activities. Monitoring will be conducted by a wildlife biologist with experience in monitoring Swainson's hawk and white-tailed kite nests. The monitor will document the location of active nests, coordinate with the project proponent and CDFW, and record all observations in a daily monitoring log. The monitor will have the authority to temporarily stop work if activities are disrupting nesting behavior to the point of resulting in potential take (i.e., eggs and young chicks still in nests and adults appear agitated and could potentially abandon the nest). The monitor will work closely with the contractor, the project proponent, and CDFW to develop plans for minimizing disturbance, such as modifying or delaying certain construction activities.

A minimum non-disturbance buffer of 600 feet (radius) will be established around all active Swainson's hawk and white-tailed kite nests. No entry of any kind related to construction will be allowed within this buffer while the nest is active, unless approved by CDFW through issuance of an Incidental Take Permit or through consultation during project construction. The buffer size may be modified based on site-specific conditions, including line-of-sight, topography, type of disturbance, existing ambient noise and disturbance levels, and other relevant factors. Entry into the buffer for construction activities will be granted when the biological monitor determines that the young have fledged and are capable of independent survival or that the nest has failed and the nest site is no longer active. All buffer adjustments will be approved by CDFW.

### **Purchase Channel Enhancement Credits for Impacts on Critical Habitat**

Permanent impacts on critical habitat (bank and substrate below the OHWM and water column habitat), totaling 3.11 acres (up to 80,449 square feet [1.85 acre] from the new bridge piers and RSP and up to 55,000 square feet [1.26 acre] from bridge shading of aquatic habitat) will be mitigated at a 3:1 ratio. The project proponent proposes to mitigate the permanent loss of critical habitat through purchase of 9.33 acres of mitigation credits at a NMFS-approved anadromous fish conservation bank.

## **D.21 Invasive Species**

### **D.21.1 Avoidance and Minimization Measures**

No measures are necessary.

## **D.21.2 CEQA Mitigation Measures**

### **Avoid the Introduction and Spread of Invasive Plants**

The project proponent or their contractor will be responsible for avoiding the introduction of new invasive plants and the spread of invasive plants previously documented in the study area. Accordingly, the following measures will be implemented during construction.

- Educate construction supervisors and managers on weed identification and the importance of controlling and preventing the spread of invasive weeds.
- Dispose of invasive species material removed during project construction offsite at an appropriate disposal facility to avoid the spread of invasive plants into natural areas.
- Minimize surface disturbance to the greatest extent feasible to complete the work.
- Use weed-free imported erosion-control materials (or rice straw in upland areas).
- Use locally grown native plant stock and native or naturalized (noninvasive) grass seed during revegetation.
- If feasible, remove trees of heaven located in and adjacent to the temporary impact area on the east side of 2nd Street in the City of West Sacramento.

Appendix E

**Incomplete or Unavailable Information for  
Project-Specific MSAT Health Impacts Analysis**

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# Appendix E Incomplete or Unavailable Information for Project-Specific MSAT Health Impacts Analysis

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The following is from the FHWA memorandum *Interim Guidance Update on Mobile Source Air Toxic Analysis in NEPA - Appendix C* (Federal Highway Administration 2012).

## **CEQ Provisions Covering Incomplete or Unavailable Information (40 CFR 1502.22)**

### Sec. 1502.22 INCOMPLETE OR UNAVAILABLE INFORMATION

When an agency is evaluating reasonably foreseeable significant adverse effects on the human environment in an environmental impact statement and there is incomplete or unavailable information, the agency shall always make clear that such information is lacking.

- (a) If the incomplete information relevant to reasonably foreseeable significant adverse impacts is essential to a reasoned choice among alternatives and the overall costs of obtaining it are not exorbitant, the agency shall include the information in the environmental impact statement.
- (b) If the information relevant to reasonably foreseeable significant adverse impacts cannot be obtained because the overall costs of obtaining it are exorbitant or the means to obtain it are not known, the agency shall include within the environmental impact statement:
  1. a statement that such information is incomplete or unavailable;
  2. a statement of the relevance of the incomplete or unavailable information to evaluating reasonably foreseeable significant adverse impacts on the human environment;
  3. a summary of existing credible scientific evidence which is relevant to evaluating the reasonably foreseeable significant adverse impacts on the human environment; and
  4. the agency's evaluation of such impacts based upon theoretical approaches or research methods generally accepted in the scientific community. For the purposes of this section, "reasonably foreseeable" includes impacts that have catastrophic consequences, even if their probability of occurrence is low, provided that the analysis of the impacts is supported by credible scientific evidence, is not based on pure conjecture, and is within the rule of reason.
- (c) The amended regulation will be applicable to all environmental impact statements for which a Notice to Intent (40 CFR 1508.22) is published in the Federal Register on or after May 27, 1986. For environmental impact statements in progress, agencies may choose to comply with the requirements of either the original or amended regulation.

## ***Incomplete or Unavailable Information for Project-Specific MSAT Health Impacts Analysis***

In FHWA's view, information is incomplete or unavailable to credibly predict the project-specific health impacts due to changes in MSAT emissions associated with a proposed set of highway alternatives. The outcome of such an assessment, adverse or not, would be influenced more by the uncertainty introduced into the process through assumption and speculation rather

than any genuine insight into the actual health impacts directly attributable to MSAT exposure associated with a proposed action.

The U.S. Environmental Protection Agency (EPA) is responsible for protecting the public health and welfare from any known or anticipated effect of an air pollutant. They are the lead authority for administering the Clean Air Act and its amendments and have specific statutory obligations with respect to hazardous air pollutants and MSAT. The EPA is in the continual process of assessing human health effects, exposures, and risks posed by air pollutants. They maintain the Integrated Risk Information System (IRIS), which is “a compilation of electronic reports on specific substances found in the environment and their potential to cause human health effects” (EPA, <http://www.epa.gov/iris/>). Each report contains assessments of non-cancerous and cancerous effects for individual compounds and quantitative estimates of risk levels from lifetime oral and inhalation exposures with uncertainty spanning perhaps an order of magnitude.

Other organizations are also active in the research and analyses of the human health effects of MSAT, including the Health Effects Institute (HEI). Two HEI studies are summarized in Appendix D of FHWA’s Interim Guidance Update on Mobile source Air Toxic Analysis in NEPA Documents. Among the adverse health effects linked to MSAT compounds at high exposures are; cancer in humans in occupational settings; cancer in animals; and irritation to the respiratory tract, including the exacerbation of asthma. Less obvious is the adverse human health effects of MSAT compounds at current environmental concentrations (HEI, <http://pubs.healtheffects.org/view.php?id=282>) or in the future as vehicle emissions substantially decrease (HEI, <http://pubs.healtheffects.org/view.php?id=306>).

The methodologies for forecasting health impacts include emissions modeling; dispersion modeling; exposure modeling; and then final determination of health impacts - each step in the process building on the model predictions obtained in the previous step. All are encumbered by technical shortcomings or uncertain science that prevents a more complete differentiation of the MSAT health impacts among a set of project alternatives. These difficulties are magnified for lifetime (i.e., 70 year) assessments, particularly because unsupportable assumptions would have to be made regarding changes in travel patterns and vehicle technology (which affects emissions rates) over that time frame, since such information is unavailable.

It is particularly difficult to reliably forecast 70-year lifetime MSAT concentrations and exposure near roadways; to determine the portion of time that people are actually exposed at a specific location; and to establish the extent attributable to a proposed action, especially given that some of the information needed is unavailable.

There are considerable uncertainties associated with the existing estimates of toxicity of the various MSAT, because of factors such as low-dose extrapolation and translation of occupational exposure data to the general population, a concern expressed by HEI (<http://pubs.healtheffects.org/view.php?id=282>). As a result, there is no national consensus on air dose-response values assumed to protect the public health and welfare for MSAT compounds, and in particular for diesel PM. The EPA (<http://www.epa.gov/risk/basicinformation.htm#g>) and the HEI (<http://pubs.healtheffects.org/getfile.php?u=395>) have not established a basis for quantitative risk assessment of diesel PM in ambient settings.

There is also the lack of a national consensus on an acceptable level of risk. The current context is the process used by the EPA as provided by the Clean Air Act to determine whether more stringent controls are required in order to provide an ample margin of safety to protect public health or to prevent an adverse environmental effect for industrial sources subject to the maximum achievable control technology standards, such as benzene emissions from refineries. The decision framework is a two-step process. The first step requires EPA to determine an “acceptable” level of risk due to emissions from a source, which is generally no greater than approximately 100 in a million. Additional factors are considered in the second step, the goal of which is to maximize the number of people with risks less than 1 in a million due to emissions from a source. The results of this statutory two-step process do not guarantee that cancer risks from exposure to air toxics are less than 1 in a million; in some cases, the residual risk determination could result in maximum individual cancer risks that are as high as approximately 100 in a million. In a June 2008 decision, the U.S. Court of Appeals for the District of Columbia Circuit upheld EPA’s approach to addressing risk in its two step decision framework. Information is incomplete or unavailable to establish that even the largest of highway projects would result in levels of risk greater than deemed acceptable.

Because of the limitations in the methodologies for forecasting health impacts described, any predicted difference in health impacts between alternatives is likely to be much smaller than the uncertainties associated with predicting the impacts. Consequently, the results of such assessments would not be useful to decision makers, who would need to weigh this information against project benefits, such as reducing traffic congestion, accident rates, and fatalities plus improved access for emergency response, that are better suited for quantitative analysis.

Due to the limitations cited, a discussion such as the example provided in this Appendix (reflecting any local and project-specific circumstances), should be included regarding incomplete or unavailable information in accordance with Council on Environmental Quality (CEQ) regulations [40 CFR 1502.22(b)]. The FHWA Headquarters and Resource Center staff Victoria Martinez (787) 766-5600 X231, Bruce Bender (202) 366-2851, and Michael Claggett (505) 820-2047, are available to provide guidance and technical assistance and support.

**Source:**

Federal Highway Administration. 2012. *Interim Guidance Update on Mobile Source Air Toxic Analysis in NEPA*. Appendix C. December 6. Available at: <[http://www.fhwa.dot.gov/environment/air\\_quality/air\\_toxics/policy\\_and\\_guidance/aqintguidmem.cfm](http://www.fhwa.dot.gov/environment/air_quality/air_toxics/policy_and_guidance/aqintguidmem.cfm)>. Accessed: May 24, 2016.

Appendix F  
**Sub-Area Travel Forecasting Model  
Development and Validation**

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**TECHNICAL MEMORANDUM**

**Date:** May 28, 2014

**To:** Zach Siviglia & Rob Himes – Mark Thomas & Company

**From:** Kwasi Donkor & Ronald T. Milam – Fehr & Peers

**Subject:** **I Street Bridge Replacement Over The Sacramento River Project - Sub-Area Travel Forecasting Model Development and Validation**

*RS14-3220***INTRODUCTION**

Fehr & Peers has developed a sub-area travel forecasting model for the I Street Bridge Replacement Project using a modified version of the regional SACMET model. The original model was based on network and socioeconomic inputs from the SACOG Metropolitan Transportation Plan/Sustainable Communities Strategy (MTP/SCS). Over time, the model has undergone a variety of refinements and modifications to improve its level of detail and sensitivity for the following projects.

- City of Sacramento General Plan
- American River Crossing Study
- Entertainment and Sports Complex EIR
- Downtown/Riverfront Streetcar Plan
- McKinley Village

For the I Street Bridge Replacement Project, more refinements were necessary, especially in West Sacramento, where the network and traffic analysis zone (TAZ) system had limited detail. Once the refinements were completed, the sub-area model was validated within the overall I Street Bridge Replacement project study area.

Model validation describes a model's performance relative to how well its output matches observed conditions in the base year and how well it responds to input variable changes. Static validation tests are used to statistically measure the model's ability to replicate observed conditions while dynamic

validation tests are used to measure whether the model responds in the correction direction and magnitude when input variables are changed.

## **SUBAREA MODEL REFINEMENTS**

Key modifications that are a part of the I Street Bridge Replacement Project sub-area model are listed below:

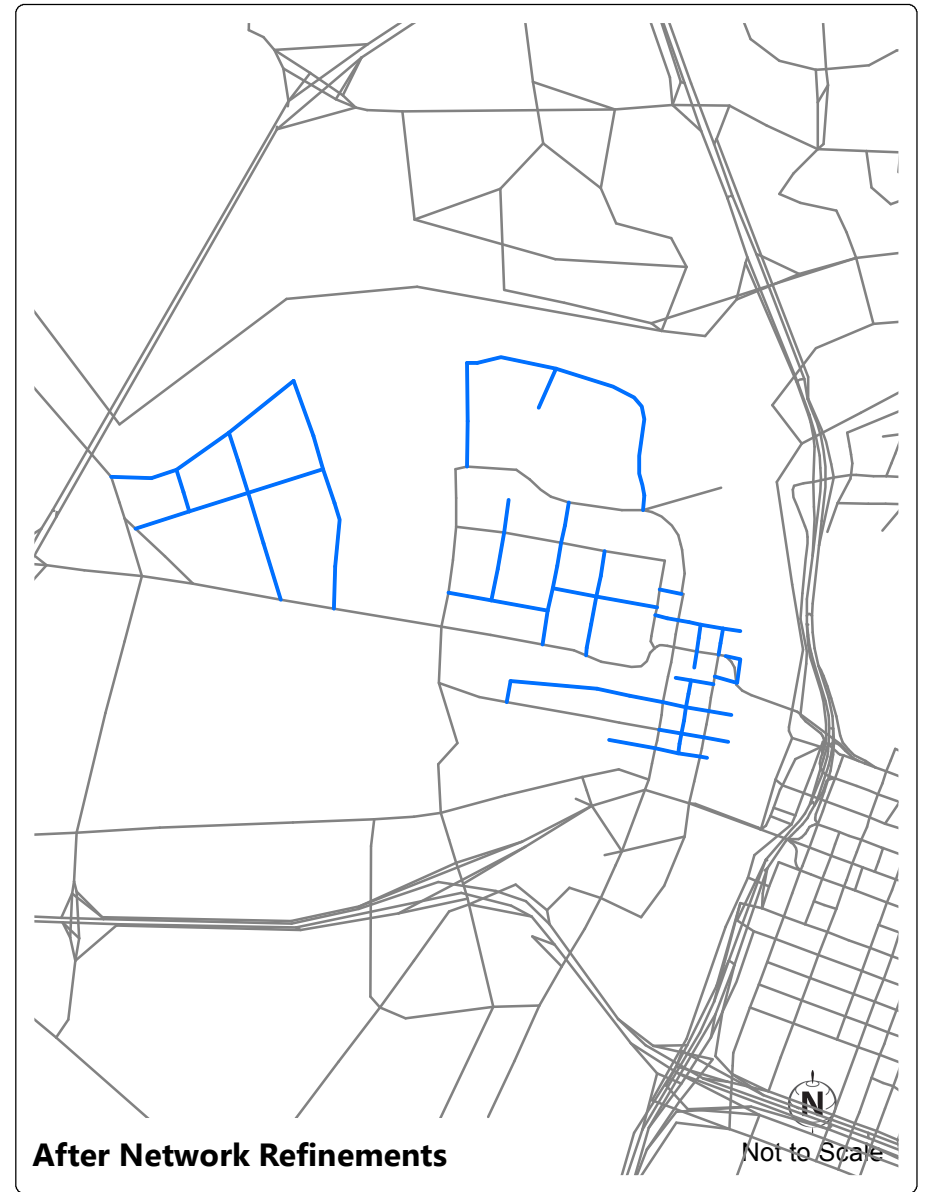
- Updated the base year roadway network to include greater detail within areas of the City of Sacramento and City of West Sacramento, and corrected inconsistencies between model inputs and field observations related to roadway network speeds and capacity. Figure 1 shows the detailed model network refinements.
- Updated the future year roadway network to reflect base year changes and include more detail for planned roadways.
- Added new traffic analysis zones (TAZs) in the study area to increase the level of detail and improve the loading of traffic from TAZs onto the transportation network. Figure 2 shows the added TAZ refinements.

## **VALIDATION**

The *2010 California Regional Transportation Plan Guidelines*, published by the California Transportation Commission, contain the following guidance, criteria, and thresholds for model validation.

### **General**

- Agencies that use metropolitan planning organization (MPO) models for purposes other than regional planning should ensure that the model provides the appropriate scale and sensitivity for applications at a sub-regional level such as corridor, sub-area, or local planning studies. Below the regional level, model refinements are likely necessary to ensure the model meets the validation targets established in these guidelines and is appropriately sensitive to smaller scale changes associated with sub-regional studies.







### **Static Validation**

- *At least 75 percent of the roadway links for which counts are available should be within the maximum desirable deviation, which ranges from approximately 15 to 60 percent depending on total volume (the larger the volume, the less deviation is permitted).*
- *A correlation coefficient of at least 0.88* - The correlation coefficient estimates the overall level of accuracy between observed traffic counts and the estimated traffic volumes from the model. This coefficient ranges from 0 to 1.0, where 1.0 indicates that the model perfectly fits the data.
- *The percent root mean square error (RMSE) below 40%* - The RMSE is the square root of the model volume minus the actual count squared, divided by the number of counts. It is a measure similar to standard deviation in that it assesses the accuracy of the model.

### **Dynamic Validation**

- Dynamic validation can include the following model sensitivity tests, as appropriate given the type of regional model and alternatives under evaluation (*for purposes of this study, the first two tests were performed*).
  - Add lanes to a link
  - Delete a link
  - Add a link
  - Change link speeds
  - Change link capacities

In addition to the static test criteria above, the subarea model volume-to-count ratio was measured against a desired maximum threshold of no more than a 10 percent deviation.

### General Performance

As described above and shown in Figures 1 and 2, the sub-area model received refinements to its network and TAZ system. These changes were made in direct response to the need for the model to include sufficient detail to forecast traffic volume changes in response to a local bridge modification.

Static Validation

The static validation of the subarea model was tested for 87 individual roadway segments and 12 freeway segments in the project study area under daily conditions. Under normal circumstances, the base year model volumes would be compared to base year traffic counts. The model's base year is 2008 and a complete set of traffic counts is not available for 2008. Further, the 2008/09 recession caused a substantial reduction in employment within the model area that has not yet fully recovered. A comparison of 2012 traffic counts conducted for more than 250 roadway segments throughout the City of Sacramento revealed that overall traffic counts were about 8 percent less than the counts for these same locations in 2007. As such, this model validation relied on traffic counts from 2012-2014. Because current employment levels have not yet reached 2008 levels in many areas, the model's base year traffic volume forecasts are expected to slightly overestimate the 2012-2014 traffic counts. Table 1 presents the static validation results produced using the modified subarea model.

<b>TABLE 1 – FINAL RESULTS OF DAILY MODEL VALIDATION</b>		
<b>Validation Item</b>	<b>Criterion of Acceptance</b>	<b>Model Results</b>
Model Wide Volume-to-Count Ratio	Within $\pm$ 10%	+7%
% of Links Within Deviation Allowance	At Least 75%	70%
Correlation Coefficient	At Least 88%	97%
RMSE	40% or less	25%
Green shading denotes the model results pass the applicable test.		
Source: Fehr & Peers, 2013.		

In general, the sub-area model generated traffic volume estimates that closely matched roadway and freeway volumes with overall volumes being slightly higher than counts as expected. The sub-area model performed well passing 3 of the 4 static tests and improving on results compared to the original off-the-shelf model. The largest differences occurred on low volume roadways and on select segments in downtown Sacramento where the grid street pattern makes it difficult for a model to perfectly match localized travel patterns with multiple path choices.

Dynamic Validation

For this sub-area model, the dynamic validation tests focused on roadway network changes given the proposed project to add a new bridge crossing over the Sacramento River. Previous dynamic tests for other projects have confirmed that the SACMET model generally responds in the correct direction and magnitude when making land use and network changes. So, the specific dynamic validation tests for this sub-area model focused on what happens when the I Street Bridge is eliminated or the number of lanes for the I Street Bridge is increased. Table 2 summarizes the dynamic validation results for the roadway network changes.

<b>TABLE 2 – DYNAMIC VALIDATION: CHANGE IN ROADWAY NETWORK (DAILY DEMAND)</b>				
<b>Roadway Change</b>	<b>Before Change</b>		<b>After Change</b>	
	<b>Changed Link Volume</b>	<b>Screenline Volume (1)</b>	<b>Changed Link Volume</b>	<b>Screenline Volume (1)</b>
Delete the I Street Bridge links	16,173	221,505	0	216,653
Add one lane in each direction to the I Street Bridge	16,173	221,505	17,460	221,922
Note: (1) Screenline includes the I Street Bridge, Tower Bridge, and Pioneer Bridge (US 50) Source: Fehr & Peers, 2014.				

The results in Table 2 reveal that the model output responds in the correct direction and magnitude given the input changes. When an important link such as a bridge is eliminated, trips must shift to other bridges but often experience much higher delays due to capacity constraints. The results show the trips shifted to Tower Bridge and US 50 (proportional to their relative capacities) and that total trips across the screenline declined slightly due to the higher overall travel delays. The SACMET model contains a feedback mechanism between trip assignment and trip distribution that can influence trip destinations and mode choice such that a major capacity constraint can result in less overall vehicle trips. Likewise, when lanes are added to the I Street Bridge, the model accounts for the opposite pattern where not only do traffic volumes increase on the I Street Bridge, but the capacity expansion reduces travel times enough that additional trips are induced.

Fehr & Peers also prepared preliminary traffic volume forecasts used to evaluate potential alignments for the new I Street Bridge prior to the model validation. River crossings at both Railyards Boulevard and Camille Lane were modeled using the 2035 version of the SACMET model. The results of the analysis (shown in Table 3) were consistent with the dynamic validation results and serve as another reasonableness check of the model.

<b>TABLE 3 – PRELIMINARY ANALYSIS RESULTS: BRIDGE ALIGNMENT ALTERNATIVES (DAILY DEMAND)</b>				
<b>Roadway Change</b>	<b>Before Change</b>		<b>After Change</b>	
	<b>Changed Link Volume</b>	<b>Screenline Volume (1)</b>	<b>Changed Link Volume</b>	<b>Screenline Volume (1)</b>
New 2-lane Bridge Crossing at Railyards Boulevard	0	314,521	35,851	319,635
Add one lane in each direction (for a total of 4 lanes) to the Railyards Boulevard Bridge	35,851	319,635	48,637	328,201
New 2-lane Bridge Crossing at Camille Lane	0	314,521	32,489	318,169
Add one lane in each direction (for a total of 4 lanes) to the Camille Lane Bridge	32,489	318,169	44,611	325,376
Note: (1) Screenline includes the new I Street Bridge alignments, Tower Bridge, Pioneer Bridge (US 50), and the Broadway Bridge Source: Fehr & Peers, 2014.				

## Appendix G

# Agency Letters

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### **Index**

Notice of Preparation

Letters Received in Response to Notice of Preparation

Species Lists

U.S. Fish and Wildlife Service Biological Opinion

Native American Consultation

State Historic Preservation Office Consultation

## Notice of Preparation

DATE: September 22, 2014

TO: Interested Persons

FROM: Dana Mahaffey, Associate Planner  
Community Development Department

RE: **NOTICE OF PREPARATION OF AN ENVIRONMENTAL IMPACT REPORT AND SCOPING MEETING FOR THE I STREET BRIDGE REPLACEMENT PROJECT: A NEW BRIDGE OVER THE SACRAMENTO RIVER (IDENTIFIED BY THE U.S. COAST GUARD AS THE "C STREET BRIDGE")**

**COMMENT PERIOD**

**September 22, 2014 to October 21, 2014**

**INTRODUCTION**

The City of Sacramento ("City") is the Lead Agency for preparation of an Environmental Impact Report (EIR) for the proposed I Street Bridge Replacement over the Sacramento River (Project). The EIR will evaluate potential significant environmental effects of the project. Written comments regarding the issues that should be covered in the EIR, including potential alternatives to the Project and the scope of the analysis, are invited. The EIR for the Project is being prepared in compliance with the California Environmental Quality Act (CEQA). The Project is subject to state as well as federal environmental review requirements, and project documentation will be prepared in compliance with both CEQA and the National Environmental Policy Act (NEPA). The City of West Sacramento, co-sponsor of the project, is a Responsible Agency under CEQA. The California Department of Transportation (Caltrans) is the NEPA lead agency and anticipates preparation of an Environmental Assessment. In addition, the Federal Highway Administration's responsibilities for environmental review, consultation, and any other action required in accordance with applicable Federal laws for this Project will be carried out by Caltrans as assigned under Moving Ahead for Progress in the 21st Century (MAP-21) (23 United States Code [USC] 327), effective on October 1, 2012.

Under CEQA, upon deciding to prepare an EIR, the City of Sacramento as lead agency must issue a Notice of Preparation (NOP) to inform trustee, the public, and responsible agencies of that decision. The purpose of the NOP is to provide information describing the Project and its potential environmental effects to those who may wish to comment regarding the scope and content of the information to be included in the EIR. Agencies should comment on such information as it relates to their statutory responsibilities in connection with the Project.

The project description, location, and environmental issue areas that may be affected by development of the proposed project are set forth below. The EIR will evaluate the project-specific and cumulative

impacts, identify mitigation measures that may be feasible to lessen or avoid such impacts, and identify alternatives to the proposed project.

### **SUBMITTING COMMENTS**

Comments and suggestions as to the appropriate scope of analysis in the EIR are invited from all interested parties. Written comments or questions concerning the EIR for the proposed project should be directed to the environmental project manager at the following address by October 21, 2014. Please include the contact person's full name and address in order for staff to respond appropriately:

Dana Mahaffey, Associate Planner  
City of Sacramento Community Development Department  
300 Richards Blvd., Third Floor, Sacramento, CA 95811  
Telephone: (916) 808-2762  
E-mail: DMahaffey@cityofsacramento.org

### **SCOPING MEETING**

**A public scoping meeting will be held on Thursday, October 9th, 2014 from 3:30 p.m. to 6:30 p.m. at the following location:**

**Stanford Gallery  
111 I Street  
in Old Sacramento**

**Responsible agencies and members of the public are invited to attend and provide input on the scope of the EIR. The scoping meeting will be conducted in an open house format. Written comments regarding relevant issues may be submitted at the meeting.**

### **PROJECT LOCATION/SETTING**

The Project is located in both the City of Sacramento and the City of West Sacramento and crosses the Sacramento River. The location is shown on the attached figure. The project area is approximately bounded by the I Street Bridge, the intersection of C Street with 3rd Street in West Sacramento, the intersection of Bercut Drive with Railyards Boulevard (under construction) in the Railyards planned development, Jibboom Street, and the I Street/I-5 onramp near 3rd Street in Sacramento.

### **PROJECT DESCRIPTION**

The proposed I Street Bridge Replacement Project would be constructed north of the existing I Street Bridge as shown in the attached location map. The Project would include the construction of a new bridge across the Sacramento River between the Sacramento Railyards and the West Sacramento Washington planned developments. The new bridge would provide a new vehicle, bicycle, and pedestrian crossing connecting C Street in West Sacramento to Railyards Boulevard in Sacramento. The proposed bridge would include a moveable center span to allow passage for watercraft. Additional roadwork would include new signalized intersections at Jibboom Street and Bercut Drive connecting at



Railyards Boulevard and the extension of C Street from the intersection of 3rd Street to the proposed bridge. The River Walk Park in West Sacramento and the Sacramento River Parkway trail in Sacramento, which connects to the American River Bike Trail at Discovery Park, would be extended to the new roadway and pass underneath the abutments of the proposed bridge. The levee maintenance road in West Sacramento will intersect at grade with the new crossing.

The existing I Street Bridge would continue to be used by the railroad. Vehicle and pedestrian traffic would be removed. The existing approach structures for Jibboom Street, I Street and J Street in the City of Sacramento and C Street in the City of West Sacramento would be demolished.

The proposed bridge crossing could also accommodate future transit options, including a streetcar alignment within the bridge. No such use is proposed as part of this project; any future streetcar expansion would be considered under separate CEQA/NEPA review.

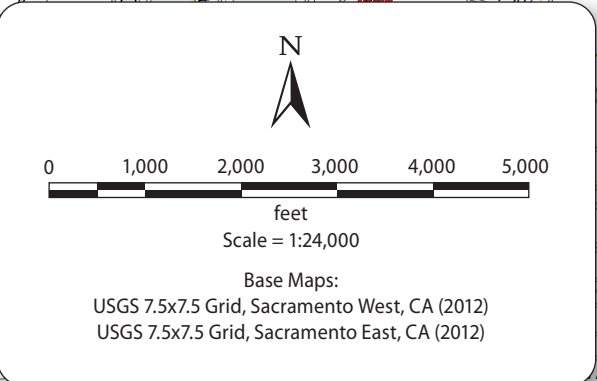
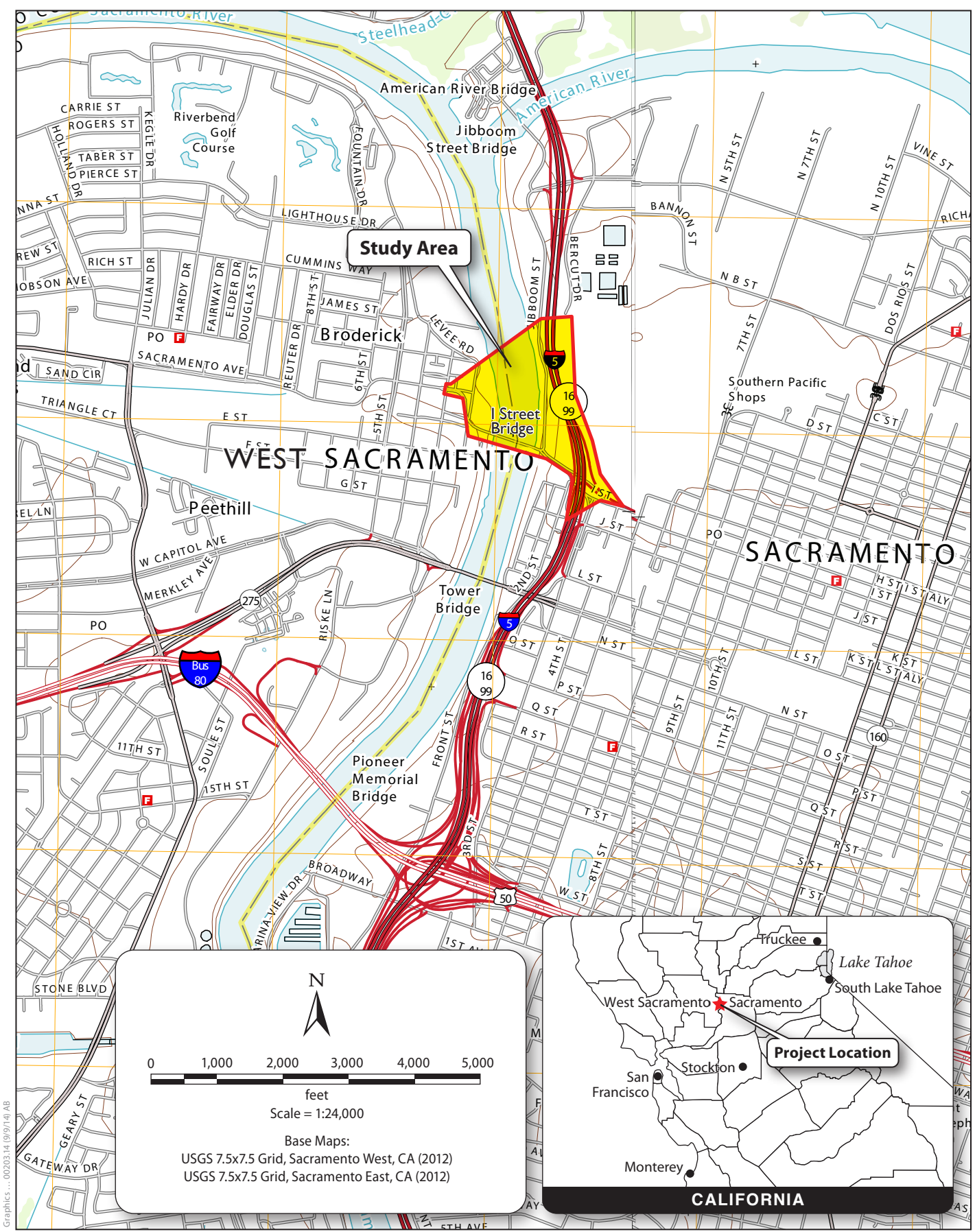
Additional information and materials relating to the proposed project are available on the City's website at <http://portal.cityofsacramento.org/Public-Works/Engineering-Services/Projects/Current-Projects/I-Street-Bridge-Replacement>.

### **ENVIRONMENTAL EFFECTS AND SCOPE OF THE EIR**

The EIR will analyze potentially significant impacts that could result from construction and operation of the Project. Pursuant to section 15063(a) of CEQA Guidelines, an Initial Study has not been prepared for the Project. The EIR will evaluate the full range of environmental issues contemplated for consideration under CEQA and the CEQA Guidelines. The environmental factors that the City has determined would potentially be affected by the Project include:

- Transportation/Traffic
- Cultural Resources
- Hazards & Hazardous Materials
- Biological Resources
- Greenhouse Gas Emissions
- Hydrology/Water Quality
- Land Use/Planning
- Aesthetics
- Noise
- Recreation

The EIR will identify and evaluate alternatives to the proposed project.



Graphics ... 002033.14 (9/9/14) AB



**Location Map**

## Letters Received in Response to Notice of Preparation



Edmund G. Brown Jr.  
Governor

STATE OF CALIFORNIA  
Governor's Office of Planning and Research  
State Clearinghouse and Planning Unit



Ken Alex  
Director

**Notice of Preparation**

September 22, 2014

To: Reviewing Agencies

Re: I Street Bridge Replacement Project: A New Bridge Over the Sacramento River  
SCH# 2014092069

Attached for your review and comment is the Notice of Preparation (NOP) for the I Street Bridge Replacement Project: A New Bridge Over the Sacramento River draft Environmental Impact Report (EIR).

Responsible agencies must transmit their comments on the scope and content of the NOP, focusing on specific information related to their own statutory responsibility, within 30 days of receipt of the NOP from the Lead Agency. This is a courtesy notice provided by the State Clearinghouse with a reminder for you to comment in a timely manner. We encourage other agencies to also respond to this notice and express their concerns early in the environmental review process.

Please direct your comments to:

**Dana Mahaffey**  
City of Sacramento  
300 Richards Blvd., 3rd Floor  
Sacramento, CA 95811

with a copy to the State Clearinghouse in the Office of Planning and Research. Please refer to the SCH number noted above in all correspondence concerning this project.

If you have any questions about the environmental document review process, please call the State Clearinghouse at (916) 445-0613.

Sincerely,

Scott Morgan  
Director, State Clearinghouse

Attachments  
cc: Lead Agency

**Document Details Report  
State Clearinghouse Data Base**

**SCH#** 2014092069  
**Project Title** I Street Bridge Replacement Project: A New Bridge Over the Sacramento River  
**Lead Agency** Sacramento, City of

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**Type** NOP Notice of Preparation  
**Description** The project would include the construction of a new bridge across the Sacramento River between the Sacramento Railyards and the West Sacramento Washington planned developments. The new bridge would provide a new vehicle, bicycle, and pedestrian crossing connecting C Street in West Sacramento to Railyards Blvd. in Sacramento and would include a moveable center span to allow passage for watercraft. The existing I Street Bridge would continue to be used by the railroad. The existing Sacramento would be demolished.

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**Lead Agency Contact**

**Name** Dana Mahaffey  
**Agency** City of Sacramento  
**Phone** (916) 264-5011 **Fax**  
**email**  
**Address** 300 Richards Blvd., 3rd Floor  
**City** Sacramento **State** CA **Zip** 95811

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**Project Location**

**County** Sacramento, Yolo  
**City** Sacramento, West Sacramento  
**Region**  
**Cross Streets** C Street, West Sacramento  
**Lat / Long** 38° 35' 11" N / 121° 30' 21" W  
**Parcel No.** Various  
**Township** 9N **Range** 4E **Section** **Base**

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**Proximity to:**

**Highways** I-5, I-80  
**Airports**  
**Railways** UPRR  
**Waterways** Sacramento & American Rivers  
**Schools** Elkhorn ES, Wayne Geri...  
**Land Use** West Sacramento: Recreation/Parks, Waterfront  
Sacramento: American River Parkway, Heavy Industrial

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**Project Issues** Aesthetic/Visual; Air Quality; Archaeologic-Historic; Biological Resources; Flood Plain/Flooding; Geologic/Seismic; Noise; Public Services; Recreation/Parks; Soil Erosion/Compaction/Grading; Toxic/Hazardous; Traffic/Circulation; Vegetation; Water Quality; Wetland/Riparian; Landuse; Cumulative Effects

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**Reviewing Agencies** Resources Agency; Department of Boating and Waterways; Central Valley Flood Protection Board; Office of Historic Preservation; Department of Parks and Recreation; Department of Water Resources; Department of Fish and Wildlife, Region 2; Native American Heritage Commission; Public Utilities Commission; State Lands Commission; California Highway Patrol; Caltrans, District 3 S; Air Resources Board; Transportation Projects; Regional Water Quality Control Bd., Region 5 (Sacramento)

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**Date Received** 09/22/2014 **Start of Review** 09/22/2014 **End of Review** 10/21/2014

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**NOP Distribution List**

County: Sacramento & Yolo

SCH# 201405069

Resources Agency

- Resources Agency  
Nadell Gayou
- Dept. of Boating & Waterways  
Nicole Wong
- California Coastal Commission  
Elizabeth A. Fuchs
- Colorado River Board  
Lisa Johansen
- Dept. of Conservation  
Elizabeth Carpenter
- California Energy Commission  
Eric Knight
- Cal Fire  
Dan Foster
- Central Valley Flood Protection Board  
James Herota
- Office of Historic Preservation  
Ron Parsons
- Dept of Parks & Recreation  
Environmental Stewardship Section
- California Department of Resources, Recycling & Recovery  
Sue O'Leary
- S.F. Bay Conservation & Dev't. Comm.  
Steve McAdam
- Dept. of Water Resources  
Resources Agency  
Nadell Gayou

- Fish & Wildlife Region 1E  
Laurie Harnsberger
- Fish & Wildlife Region 2  
Jeff Drongesen
- Fish & Wildlife Region 3  
Charles Armor
- Fish & Wildlife Region 4  
Julie Vance
- Fish & Wildlife Region 5  
Leslie Newton-Reed  
Habitat Conservation Program
- Fish & Wildlife Region 6  
Tiffany Ellis  
Habitat Conservation Program
- Fish & Wildlife Region 6 I/M  
Heidi Sickler  
Inyo/Mono, Habitat Conservation Program
- Dept. of Fish & Wildlife M  
George Isaac  
Marine Region

Other Departments

- Food & Agriculture  
Sandra Schubert  
Dept. of Food and Agriculture
- Depart. of General Services  
Public School Construction
- Dept. of General Services  
Anna Garbeff  
Environmental Services Section
- Delta Stewardship Council  
Kevan Samsam

Independent

Commissions, Boards

- Delta Protection Commission  
Michael Machado
- OES (Office of Emergency Services)  
Dennis Castrillo

Fish and Game

- Depart. of Fish & Wildlife  
Scott Flint  
Environmental Services Division
- Fish & Wildlife Region 1  
Donald Koch

- Native American Heritage Comm.  
Debbie Treadway
- Public Utilities Commission  
Leo Wong
- Santa Monica Bay Restoration  
Guangyu Wang
- State Lands Commission  
Jennifer Deleong
- Tahoe Regional Planning Agency (TRPA)  
Cherry Jacques

Business, Trans & Housing

- Caltrans - Division of Aeronautics  
Philip Crimmins
- Caltrans - Planning  
Terri Pencovic
- California Highway Patrol  
Suzann Ikeuchi  
Office of Special Projects
- Housing & Community Development  
CEQA Coordinator  
Housing Policy Division

Dept. of Transportation

- Caltrans, District 1  
Rex Jackman
- Caltrans, District 2  
Marcelino Gonzalez
- Caltrans, District 3 <sup>S</sup>  
Eric Federicks - South  
Susan Zanchi - North
- Caltrans, District 4  
Erik Alm
- Caltrans, District 5  
David Murray
- Caltrans, District 6  
Michael Navarro
- Caltrans, District 7  
Dianna Watson

- Caltrans, District 8  
Dan Kopulsky
- Caltrans, District 9  
Gayle Rosander
- Caltrans, District 10  
Tom Dumas
- Caltrans, District 11  
Jacob Armstrong
- Caltrans, District 12  
Maureen El Harake

Cal EPA

Air Resources Board

- All Other Projects  
Cathi Slaminski
- Transportation Projects  
Nesamani Kalandiyur
- Industrial Projects  
Mike Tollstrup
- State Water Resources Control Board  
Regional Programs Unit  
Division of Financial Assistance
- State Water Resources Control Board  
Jeffery Werth  
Division of Drinking Water
- State Water Resources Control Board  
Student Intern, 401 Water Quality Certification Unit  
Division of Water Quality
- State Water Resources Control Board  
Phil Crader  
Division of Water Rights
- Dept. of Toxic Substances Control  
CEQA Tracking Center
- Department of Pesticide Regulation  
CEQA Coordinator

Regional Water Quality Control Board (RWQCB)

- RWQCB 1  
Cathleen Hudson  
North Coast Region (1)
- RWQCB 2  
Environmental Document Coordinator  
San Francisco Bay Region (2)
- RWQCB 3  
Central Coast Region (3)
- RWQCB 4  
Teresa Rodgers  
Los Angeles Region (4)
- RWQCB 5S  
Central Valley Region (5)
- RWQCB 5F  
Central Valley Region (5)  
Fresno Branch Office
- RWQCB 5R  
Central Valley Region (5)  
Redding Branch Office
- RWQCB 6  
Lahontan Region (6)
- RWQCB 6V  
Lahontan Region (6)  
Victorville Branch Office
- RWQCB 7  
Colorado River Basin Region (7)
- RWQCB 8  
Santa Ana Region (8)
- RWQCB 9  
San Diego Region (9)

- Other \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_  
Conservancy

**From:** [john@goldengatesalmon.org](mailto:john@goldengatesalmon.org) [<mailto:john@goldengatesalmon.org>]

**Sent:** Monday, October 06, 2014 11:14 AM

**To:** Ciara Zanze

**Subject:** [FWD: I Street Bridge Replacement Project - Environmental Scoping Meeting Thursday October 9]

Hi Ciara

The email below was forwarded to me. I don't know if this email will reach the intended targets but any discussion of rebuilding any bridge over the Sacramento River should take into account the damage that night lighting of the river below can have on ESA-listed salmon as well as other fish. Here's a link to a piece I wrote on the issue <http://www.redding.com/opinion/john-mcmanus-lights-on-the-river-kill-salmon>

Attached is a document with a more detailed discussion of the problems associated with lights illuminating the Sacramento River at night. I would hope these concerns will be proactively addressed as the planning for the replacement structure proceeds. Thanks.

John McManus  
Executive Director  
Golden Gate Salmon Association  
650-218-8650

## DRAFT

**D.6. Project:** Eliminate or reduce lighting at in-river structures.

**Relevant Stressor Reduction Target:** To reduce predation on juvenile salmon.

**Action:** This project proposes to reduce night-time predation in the vicinity of man-made structures in the rivers and Delta (e.g., fish screens, bridges, docks, marinas) by eliminating or altering lighting methods and equipment.

**Expected Outcome:** Reduced predation, increased fish survival, increased fish production.

**Background:** Artificial night-time lighting at structures near water is believed to have adverse impacts on juvenile salmon by altering fish behavior and making the fish more prone to predation. For example, in 1984, the U.S. Fish and Wildlife Service and the California Department of Fish and Game (DFG) requested that the U.S. Bureau of Reclamation turn off large sodium vapor lights on top of the Red Bluff Diversion Dam on the Sacramento River to reduce the opportunities for Sacramento pikeminnow predation on juvenile salmon passing the dam (Vogel and Smith 1984), a measure that was ultimately believed to be beneficial for salmon (Vogel *et al.* 1988). More recently DFG identified a potentially severe problem with lighting on the Sundial pedestrian bridge (Figures D.6.1 and D.6.2) over the Sacramento River in Redding:

*Assessment of the impacts from light sources along the Sacramento River which lead to increased predation on juvenile salmonids is also needed. The most upstream issue is the Sundial Bridge in Redding which uses numerous flood lights which illuminate the Sacramento River all night long every night of the year. Approximately 80% of the winter-run Chinook salmon population in the state spawn upstream of the bridge and the out-migrating juveniles must pass through the lighted portion of the river below the bridge and face predators. Studies in Washington State have found lighted portions of streams have significantly higher predation rates on juvenile fish. Downstream of the Sundial Bridge from Redding to the bay, there are several other light sources ranging from highway bridges to lighted water intake structures. These should all be evaluated and recommendation should be developed to fix identified problems (DFG 2011).*

The primary purpose of the Sundial Bridge is aesthetics. The massive array of lights shining directly down on the river all night posed significant risks to fry and juvenile salmon. At night, the structure was likely causing mortality of young fish, including threatened and endangered species. Fortunately, in mid 2013 the city of Redding, working with the California Department of Fish and Wildlife, greatly reduced the lights to the point where they are believed to no longer pose a significant threat to salmon.

The Sacramento River between Redding and the Delta has dozens of structures over or immediately adjacent to the river illuminated at night which may disrupt the downstream migration of juvenile salmon and make the fish more susceptible to predation. The cumulative impact on rearing or migrating salmon from the upper rivers to the Delta could be enormous.



Predators are known to take advantage of lighting on bridges in the Pacific Northwest to prey on migrating salmonids (Nightingale and Simenstad 2002). The USFWS found that lighting on a bridge over the Cedar River in Washington state was having a severe adverse impact to migrating sockeye fry which was largely eliminated by adding shielding over the lights directing light away from the river (Washington DOT 2001). This problem may be particularly severe in the Sacramento River and its tributaries because of relatively clear-water conditions. Those structures having a federal nexus and creating adverse impacts on salmon caused by nighttime lighting may constitute “take” of federally listed species under the Endangered Species Act.



Figure D.6.1. Before photos of the Sundial pedestrian bridge over the Sacramento River in Redding at night. Photo credit: Eric Cassano.





After shot of the Sundial bridge showing reduced lighting

Longcore and Rich (2010) identified several options for addressing light pollution and its impacts on the environment:

- 1) Determination if the need for lighting is actually needed,
- 2) Direct the light toward where it is needed and eliminate light escaping in other directions,
- 3) Reduce excess intensity of lighting to more-appropriate levels,
- 4) Reduce the duration of night-time lighting and,
- 5) Eliminate full spectrum light and use other wavelengths less disruptive to the ecosystem.

**Opportunities and Challenges:** This project proposes to eliminate or reduce night-time lighting at structures over or adjacent to the Sacramento River and its tributaries to reduce predation on juvenile salmon. Many structures possess night-time lighting that could likely be simply turned off due to a lack of real need. Some structures possessing night-time lighting for security purposes could be altered to provide motion sensor activation. Many structures could probably be altered by directing the lighting away from shining directly down into the river, shielding the fixtures, using less-disruptive wavelengths or lower-intensity lighting.

This project will require an initial study identifying structures lit at night and the relative risks to salmonids. The outcome of that study would lead to implementation of a program to eliminate or reduce impacts of night-time lighting on salmon.

**Cost or Difficulty:** The estimated cost for an initial study to identify structures posing risks to salmon from night-time lighting is \$150,000. Owners of facilities lit up at night near water are

initially unlikely to be willing to turn off their lights at night, physically alter the lighting, or change the methods of lighting; associated costs and security will be of concern. Opposition from owners of night-time lit structures will require education on the need for change in lighting methods or equipment. In some instances, lighting changes may result in cost savings due to lower power consumption. The cost for implementation of remedial actions to eliminate or reduce night-time illumination is unknown until after the initial survey is completed.

**Certainty:** High probability of reducing night-time predation near man-made structures in the rivers and Delta.

### **References:**

California Department of Fish and Game. 2011. Draft Conservation Strategy for Restoration of the Sacramento – San Joaquin Delta Ecological Management Zone and the Sacramento and San Joaquin Valley Regions. July 2011. 336 p.

Longcore, T. and C. Rich. 2010. Light pollution and ecosystems. Available online at: [http://www.actionbioscience.org/environment/longcore\\_rich.html](http://www.actionbioscience.org/environment/longcore_rich.html)

Nightingale, B. and C. Simenstad. 2002. Artificial night-lighting effects on salmon and other fishes in the Northwest. Ecological consequences of artificial night lighting: conference abstracts. February 23 – 24, 2002. Los Angeles, CA.

Vogel, D.A., K.R. Marine, and J.G. Smith. 1988. Fish passage action program for Red Bluff Diversion Dam. Final Report on Fishery Investigations. U.S. Fish and Wildlife Service Report No. FR1/FAO-88-19. Fisheries Assistance Office, U.S. Fish and Wildlife Service. October 1988. 77 p.

Vogel, D.A. and J.G. Smith. 1984. Fish passage action program for Red Bluff Diversion Dam. Annual progress report. USFWS Report No. FR1/FAO-85-4. Fisheries Assistance Office, U.S. Fish and Wildlife Service. December 1984. 72 p. plus appendices.

Washington State Department of Transportation. 2001. Cedar River salmon saved by shielding light fixtures. Signals maintenance shapes salmon solution. Northwest Region, Bulletin 01-12. March 23, 2001.

**From:** [jesales@surewest.net](mailto:jesales@surewest.net) [<mailto:jesales@surewest.net>]  
**Sent:** Wednesday, October 08, 2014 11:38 AM  
**To:** Tom Buford; Dana Mahaffey  
**Subject:** Fwd: IDA Statement on Nobel Prize for Physics

As noted below -

IDA recommends a correlated color temperature (CCT) of 3000 Kelvin or less for white LED lighting systems. ... see statement attached.

This would be a good standard to include in lighting portions of the zoning code or even better the Outdoor Lighting section of our zoning code (like Citrus Heights).

See IDAs - [Blue Rich White Light Paper](#) ---

- <http://www.darksky.org/assets/documents/Reports/IDA-Blue-Rich-Light-White-Paper.pdf>

[Seeing Blue](#) ----

<http://www.darksky.org/assets/documents/SeeingBlue.pdf>

[Blue Light Threatens Animals and Humans](#) ---

- [http://www.darksky.org/assets/documents/PR/2009/PR\\_Blue\\_White\\_Light.pdf](http://www.darksky.org/assets/documents/PR/2009/PR_Blue_White_Light.pdf)

A compromise that would be the upper limit could be a correlated color temperature (CCT) of 3000 Kelvin.

An incandescent lamp is normally rated at a CCT of 2700 Kelvin and nearly all LED lamps in Home Depot/Lowe's etc. are 2700K.

As noted below "energy-efficient nature of LEDs encourages the use of excessive amounts of light", this is an issue that must be addressed.

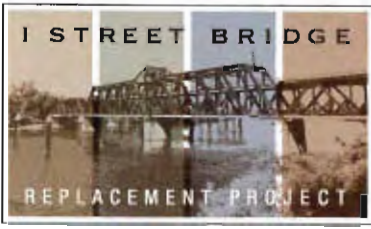
Close to home dimming and other lighting controls have been pioneered by the California Lighting Technology Center at UC Davis. <http://cltc.ucdavis.edu>

Directors Michael Siminovitch and Konstantinos (Kosta) Papamichael have been at the forefront of dimming and concern about blue light.

Please have a look around the CLTC web site and see some of the projects they have been doing at Davis and other campuses.

Regards

Jack Sales



# OPEN HOUSE COMMENT CARD

Please share your thoughts, comments, or questions about the project or potential environmental effects

First input of hard copy regarding  
light on the river and impact on salmon  
"light on the River kills salmon"  
I present 6 different cases of  
light and predation of salmon

Name Jack Sales  
email jesales@surewest.net  
phone 916-726-7405

You may submit your comments to staff tonight or directly to Ciara Zanze at [czanze@aimconsultingco.com](mailto:czanze@aimconsultingco.com) or fax (916) 442-1186.

Submission #       
Subject: Puntledge River

Puntledge River 5th. St. Bridge, Courtenay B.C., Poster - used as display and introduction

Comments, Notes, Internet locations (URLs)

Experimental Attempts to Reduce Predation by Harbor Seals on Out-Migrating Juvenile Salmonids  
H.Yurk, A.W.Trits American Fisheries Society 129: 1360-1366, 2000

Evaluation of an Electric Barrier as a Deterrent on the Puntledge River (Draft) ( Selected pages  
referencing "lighting" )

Prepared by Pacific Salmon Commission, Vancouver B.C. Canada December 2008

**Scan of printed content provided by Jack Sales follows.**

# Puntledge River

## 5th. St. Bridge, Courtenay, B.C.

The Puntledge River was historically one of the largest producers of chinook salmon in British Columbia. However, by 1995, only 208 chinook salmon returned.

At one time harbor seals congregated under artificial lights to eat juvenile salmonids as they migrated downstream, turning the lights off reduced predation.



Harbor seals *Phoca vitulina* in the Puntledge River regularly position themselves side by side, ventral side up, in the upstream shadow of two bridges near the light-shadow boundary. The seals swim against the river current and hold their position in the water. Minimal movements of their hind flippers cause no apparent disturbance to the surface waters. This feeding strategy allows the seals to form an almost continuous barrier so they can intercept smolts that drift downstream near the surface. The seals are assisted in their feeding efforts by the bridge and sports lights that illuminate the water surface. It was estimated that harbor seals consumed an average of 140,000 chum salmon fry and 13,000 coho salmon smolts per night in 1994.

The Puntledge River was historically one of the largest producers of chinook salmon in British Columbia. However, by 1995, only 208 chinook salmon returned to spawn (Trites at al. 1996).

**Reference** - *Experimental Attempts to Reduce Predation by Harbor Seals on Out-Migrating Juvenile Salmonids*, H. YURK & A. W. TRITES , 2000

----- Puntledge River Comments -----

Experimental Attempts to Reduce Predation by Harbor Seals on Out-Migrating Juvenile Salmonids, H. Yurk, A. W. Trites, 2000

NOTE Discussion of lighting and the failure to recognize lighting as the root cause.

URL = <http://www.zoology.ubc.ca/~consort/pdfs/YurkTrites2000-sealpredation.pdf>

URL = <https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=69621>

URL = <http://www.tandfonline.com/doi/abs/10.1577/1548-8659%282000%29129%3C1360%3AEATRPB%3E2.0.CO%3B2#preview>

Evaluation of an Electric Barrier as a Seal Deterrent on the Puntledge River (Draft) December 2008

Pages 1, 12, 13, 18

URL = [http://www.nwd-wc.usace.army.mil/tmt/documents/FPOM/2010/2010\\_FPOM\\_MEET/2010\\_MAR/Seal Fence Report\\_Dec8\\_1.pdf](http://www.nwd-wc.usace.army.mil/tmt/documents/FPOM/2010/2010_FPOM_MEET/2010_MAR/Seal Fence Report_Dec8_1.pdf)

Follow up comments required to show full context.

More?

## Experimental Attempts to Reduce Predation by Harbor Seals on Out-Migrating Juvenile Salmonids

H. YURK\*

Marine Mammal Research Unit, Fisheries Centre, University of British Columbia,  
6248 Biological Sciences Road, Vancouver, British Columbia, Canada V6T 1Z4, and  
Vancouver Aquarium Marine Science Centre,  
Post Office Box 3232, Vancouver, British Columbia, Canada V6B 3X8

A. W. TRITES

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**Abstract.**—During spring, harbor seals *Phoca vitulina* feed at night under two bridges spanning the Puntledge River in Courtenay, British Columbia, Canada. Positioned parallel to one another, ventral side up, the seals form a feeding line across the river to intercept thousands of out-migrating salmonid smolts. During a 4-week observation period in the spring of 1996, we attempted to disrupt the seals' feeding patterns by (a) deploying a mechanical feeding barrier (cork line), (b) altering the lighting conditions (lights on a bridge were turned off), and (c) installing an acoustic harassment device. We found acoustic harassment to be the most effective feeding deterrent. Of the other two deterrents, turning off the bridge lights was more effective than deploying a cork line, which had little effect. Acoustic harassment devices appear to be the most effective, non-lethal means for protecting juvenile salmonids from harbor seal predation in portions of the Puntledge River.

Natural predators that prey upon both out-migrating and returning anadromous fish can detrimentally affect the survival of depressed fish populations (Bigg et al. 1990; Fraker 1994; Olesiuk et al. 1995). In the northeast Pacific, seals and sea lions are commonly observed feeding on returning adult Pacific salmon *Oncorhynchus* spp. in rivers and estuaries during summer and fall (Spalding 1964; Olesiuk et al. 1990). Seals also intercept out-migrating smolts in spring and early summer (Olesiuk et al. 1995). Among the better-studied seal-salmon interactions are those in the Puntledge River on Vancouver Island, British Columbia (Bigg et al. 1990; Olesiuk et al. 1995; Trites et al. 1996; Figure 1).

Harbor seals *Phoca vitulina* in the Puntledge River regularly position themselves side by side, ventral side up, in the upstream shadow of two bridges near the light-shadow boundary. The seals

swim against the river current and hold their position in the water. Minimal movements of their hind flippers cause no apparent disturbance to the surface waters. This feeding strategy allows the seals to form an almost continuous barrier so they can intercept smolts that drift downstream near the surface. Apparently, the seals are assisted in their feeding efforts by the bridge lights that illuminate the water surface.

One way to enhance the survival of salmonids is to disrupt the feeding patterns of their predators. Techniques vary, but include making the smolts foul-losing, creating a mechanical barrier that prevents seals from entering estuaries or river systems, and installing optic or acoustic harassment devices (AHD) to hinder the seals from feeding in particular areas (Gearin et al. 1986; Mate and Harvey 1987; Pfeifer 1989).

The AHDs are generally considered to be effective in deterring seals and sea lions from preying on fish in certain areas. The widespread use of these devices by aquaculture operators, who use them to deter seals and sea lions from entering net-pens, attests to this claim. The AHDs have also deterred a large number of California sea lions *Zalophus californianus* from preying on returning winter steelhead *Oncorhynchus mykiss* in the Chittenden Locks, Seattle, Washington (Fox et al. 1996). However, at aquaculture sites and at the Chittenden Locks, some pinnipeds appear to become acclimated to AHD sounds and may have to be physically removed (Fox et al. 1996).

The goal of our study was to disrupt the feeding patterns of harbor seals feeding on smolts in the Puntledge River. During an observation period in April and May 1996, we evaluated three methods: installation of a mechanical feeding barrier, alteration of artificial light on the river, and deployment of an AHD.

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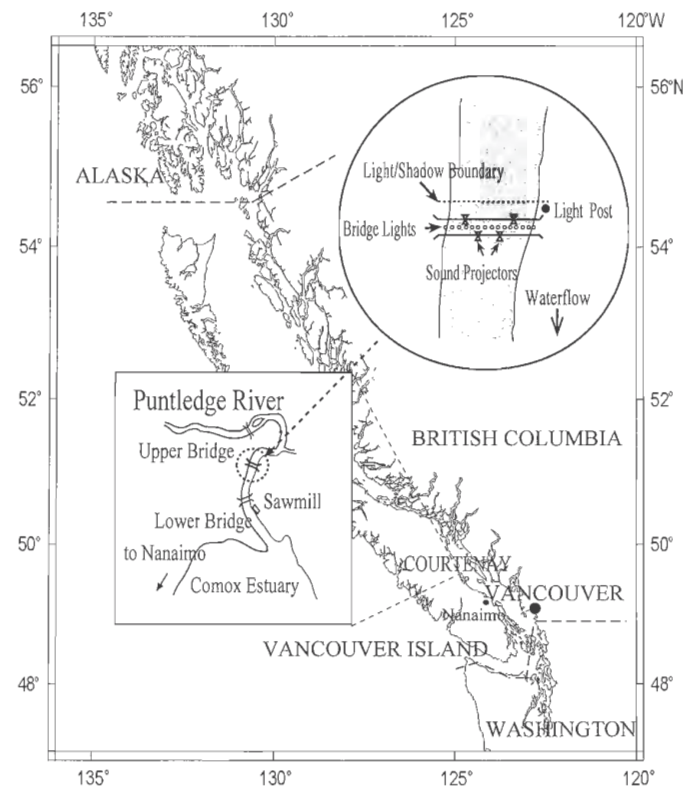


FIGURE 1.—Geographic area and detail map showing placement of sound projectors at the upper bridge on the Puntledge River, Courtenay, British Columbia.

### Study Site and Background

The Puntledge River flows out of the north end of Comox Lake and continues through the city of Courtenay until it reaches Comox Harbor and the Strait of Georgia (Figure 1). Chinook salmon *O. tshawytscha*, pink salmon *O. gorbuscha*, coho salmon *O. kisutch*, and steelhead are raised at the

Puntledge River Hatchery and return to spawn in the Puntledge River system. The Puntledge River was historically one of the largest producers of chinook salmon in British Columbia. However, by 1995, only 208 chinook salmon returned to spawn (Trites et al. 1996).

Salmon smolts migrate out of the Puntledge Riv-

er from March to May (C. Beggs, Puntledge River Hatchery, personal communication). Each year, the migration period begins with pink salmon smolts in March and April, followed by smolts of chum salmon *O. keta* during April and the first half of May. These are followed by coho salmon smolts at the beginning of May and chinook salmon smolts during the second half of May. The outmigrating smolts are of both wild and hatchery origin. The hatchery annually releases 3,000,000–6,000,000 chum salmon, 150,000–400,000 coho salmon, and around 1,000,000 pink salmon. However, in the year of our study (1996), pink salmon smolts were released directly into the estuary, thereby reducing the number of smolts in the river.

Approximately 200 harbor seals (increasing to 700 during the fall) haul out on log booms in the estuary of the Puntledge River year round (Bigg et al. 1990; Jurk et al. 1997; Figure 1). A considerably smaller number of harbor seals enter the river to feed on salmon smolts during the spring (Olesiuk et al. 1995). Visual scans of the river show that the seals feed in two primary areas: under the upper bridge (5th Street) and under the lower bridge (17th Street; Figure 1).

Seals entered the river at around dusk; the majority arrived later in the evening when a clearly defined light-shadow boundary formed under the two bridges (Olesiuk et al. 1995). Illumination of the water at the upper bridge was produced by 14 lights hanging over the center line of the bridge above the roadway (Figure 1). Depending on the height of the river, which was tidally influenced, the lights produced a relatively distinct, straight light-shadow line on the water surface 8–12 m both upstream and downstream of the upper bridge (Figure 1). The lower bridge did not have a row of center lights and, therefore, did not have a similar light-shadow boundary.

#### Methods

We tested three methods of seal deterrence to determine whether any prevented the seals from feeding at the upper bridge, their primary feeding site. The first treatment at the upper bridge involved the temporary installation of a mechanical feeding barrier. We strung a 60-m rope that had cork floats spaced 1 m apart across the river beneath the bridge. Though we tried to place the rope along the shadow line, changes in tidal movements and river currents often caused it to move a few meters downstream (Figure 1). Therefore, we had to adjust the cork line several times during the experiment. For the second treatment, we extin-

guished all of the upper bridge lights for four nights (Figure 1). For the third treatment, we used two different AHDs: (1) the "Seal-Scarer," produced by Airmar Technology (New Hampshire), which was used in seven of the eight experiments, and (2) the "MK3 Seal Scrammer," produced by Ferranti Thompson, Ltd. (Dorset, UK), which was only used once as we did not receive it in time to conduct a thorough test of its effectiveness.

The Airmar Seal-Scarer device consisted of a control unit and four sound projectors that were each attached by 30 m of cable. The AHD was configured to produce broadband signals that pitched at 27 kHz and had a maximum source intensity at 10 kHz (194 decibels [dB], referenced to 1 Pa/V at 1 m from the sound source). The four sound projectors or transducers were suspended 40 cm below the water surface by ropes attached to floats. Attached to the bottom of each projector was a lead weight to ensure that the projectors remained upright and steady in the river current. The Airmar device was set to reach full intensity 1 min after being turned on. It then continuously alternated a 2-s sound burst through each of the transducers. The MK3 "Seal Scrammer" consisted of a control unit with one hydrophone-like transducer. It produced sounds ranging from 10 to 40 kHz and had a peak intensity at 27 kHz (195 dB).

The experiments were conducted by two observers in one 4-d period (two cork line treatments and two control nontreatments) and two 10-d periods (lights out, acoustic harassment, and control) during the nights of 22–26 April, 30 April–10 May, and 15–25 May 1996. We chose this study design after considering peak migration periods of smolts and the time that observers were available. Observations started each night at 2100 hours and ended at 0300 hours, for a total of 161 h of observation over 23 d. Treatment (experiment) and nontreatment (control) nights were randomly selected throughout the observation period. The number of treatments during each observation period could not be kept constant because of a few nights of extreme rainy weather; bridge lights could not be turned off because of public safety concerns. In all, two experiments involved the mechanical feeding barrier (cork line), four experiments involved decreased illumination, and eight experiments involved an AHD. The total number of nontreatment (control) nights was nine.

The observers counted harbor seals every 30 min from the upper bridge decks with a red-filtered, 10<sup>6</sup>-candlepower spotlight to illuminate the river. Observers also counted seals at the lower

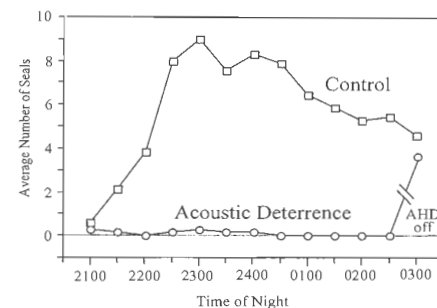


FIGURE 2.—Average number of seals present at the upper bridge on the Puntledge River, Courtenay, British Columbia, during count sessions on seven control nights and seven experimental nights when the Airmar acoustic harassment device was deployed. Note that the Airmar device was turned off at 0235 hours each experimental night.

bridge to determine whether the deterrents forced the animals to relocate. The maximum number of observations per night was 13 (Figure 2) at the upper bridge and 12 at the lower bridge. The seals were repeatedly counted by the two observers for a 5-min period; the highest number was retained as the best estimate of the number of animals present (counts by the two observers rarely differed). This procedure reduced the probability of underestimating the number of seals present.

We used a two-sample *t*-test to compare the mean number of seals present when the AHD device was deployed with the mean number present when no deterrent was used. The average number of seals present was calculated for each night of observation and treated as a single observation. Means of the nightly average number of seals were then calculated and compared for seven control nights and seven experimental nights.

#### Results and Discussion

On the control nights, when no deterrents were used, an average of 8 seals (range, 1–26) fed at the upper bridge. In contrast, we observed only 1 seal on average at the lower bridge (range, 0–8). During their nightly feeding routine, most seals appeared at the upper bridge 1.0–1.5 h after nightfall (between 2030 and 22:30 hours; Figure 2), and the majority appeared to stay until 0300 hours. The mean number of seals at the upper bridge rose from one at 2100 hours to nine at 2300 hours, dropping to an average of five by 0300 hours (Figure 2).

Seals started to appear downriver from the lower bridge earlier in the evening than at the upper bridge, but did not stay there long.

The presence of seals near the bridges did not always mean they were feeding. For example, a lack of head movement and absence of fish in the water column indicated that no feeding took place on the night of 23 April and that only sporadic feeding occurred on the night of 22 April. Feeding behavior also changed over the course of the study. From 24 April to 9 May, the seals stationed themselves at the water surface near the upstream shadow line and, with their ventral sides up, "gulped" the salmon fry (mainly chum salmon) that drifted downstream. After 15 May, the animals stayed further back in the bridge's shadow and more actively pursued their prey (mainly coho salmon smolts).

Olesiuk et al. (1995) estimated that harbor seals consumed an average of 140,000 chum salmon fry and 13,000 coho salmon smolts per night in 1994. We did not remeasure the feeding rates because we were concerned that illuminating the animals with a red spotlight for long stretches of time might affect their behavior and confound our experiment. In contrast to Olesiuk et al. (1995), we observed a behavioral response to the red light: the seals often moved away and seemed sensitive near the light-shadow line of the spotlight. Our procedure of continuous counts during a 5-min period paid special attention to the possibility of animals avoiding the spotlight.

Tidal heights and freshwater flow influenced



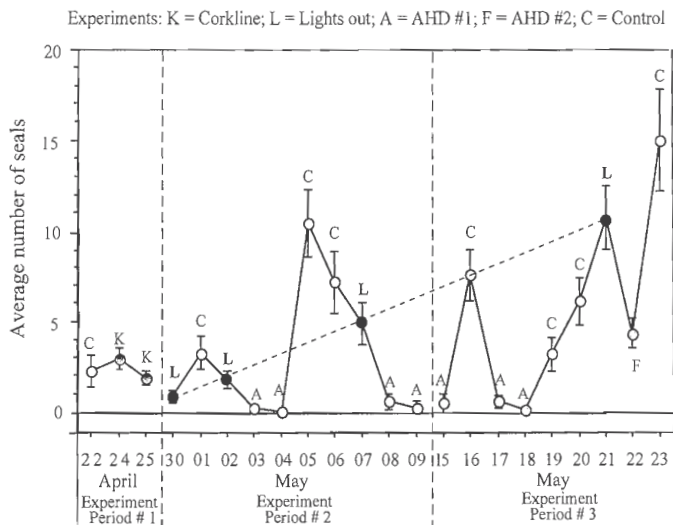


FIGURE 3.—Average number of seals present at the upper bridge on the Puntledge River, Courtenay, British Columbia, on each observation night. Seals were counted every 30 min, for a total number of 13 counts/night (bars =  $\pm$ SE). Letter symbols indicate the type of treatment applied.

feeding activities at the upper bridge. During extreme low tides, the water depth was below 1.5 m. Our observations found that the seals did not attempt to feed until the tide raised the river to almost 2 m. Tidal heights were estimated by comparing hydrographic charts of the river with tidal heights published in regional tide tables. However, our estimates neither took into account the amount of runoff from the lake nor the effects of variable rainfall. During the first 2 weeks of observations in 1996, rainfall exceeded the annual average and caused the Puntledge River to flow faster and at a higher level than normal. This seemed to affect feeding; we did not observe seals feeding on nights of extreme rainfall.

Spot checks along the river away from the bridges revealed a number of seals feeding in areas illuminated by other light sources. For example, we observed as many as seven seals feeding in a stretch of river that was lit by halogen lights from

a ballpark at Lewis Park (upstream of upper bridge). In addition, halogen lights used by a sawmill (below the lower bridge) illuminated another area frequented by feeding seals.

#### Treatment 1: Cork Line

At the upper bridge, we deployed the cork line on two nights for an average of 3 h each night (Figure 3). Within 1 h of setting the cork line on the first night, the number of seals feeding at the lower bridge increased from one to four. As the night progressed, the number of seals at the lower bridge steadily dropped and more seals began appearing next to the cork line at the upper bridge. On the following night, we deployed and retrieved the cork line twice. The animals were not at either bridge during the first deployment and did not seem to be disturbed by the second deployment. A drop in the number of seals toward the end of the second deployment suggested a mild response

TABLE 1.—Number of harbor seals counted at the upper bridge on 7 control nights and 7 nights when the acoustic harassment device (AHD) was deployed. The means (standard deviations) for the control and AHD nights were 7.57 (2.96) and 0.36 (0.20), respectively.

Night	Control	AHD
1	3.31	0.23
2	10.46	0.08
3	7.23	0.62
4	7.62	0.31
5	3.23	0.54
6	6.15	0.62
7	15.00	0.15

to the deterrent. However, the seals that remained appeared to engage in some form of play with the cork line. We concluded that though the cork line had a short-term initial effect on the seals, the animals were quick to habituate to it. We did not attempt any further trials with the cork line after these two nights of testing.

#### Treatment 2: Lights Out

Fewer seals were observed feeding the first night we turned off the lights at the upper bridge compared with adjacent control nights when the lights were left on (Figure 3). However, on subsequent experimental nights, we noted a progressive increase in the number of seals feeding in the residual light (closed circles in Figure 3;  $F_{1,3} = 17.5$ ,  $P = 0.05$ ). By the end of four experimental nights, numbers appeared to reach and even exceed those observed during comparable control nights (Figure 3). Although we do not know whether the reduced light affected their feeding efficiency, the results of this experiment suggest that the seals learned to compensate for the reduced lighting by making effective use of the residual city lighting. Therefore, we concluded that, though the "lights-out" treatment was initially effective as a deterrent, the seals eventually habituated to the lighting change.

#### Treatment 3: Acoustical Deterrence

Significantly fewer seals fed at the upper bridge on the seven nights we deployed the Airmar device compared with seven control nights when no deterrent was used ( $t_{12} = 4.60$ ,  $P = 0.001$ ; Figures 2, 3, Table 1). A mean of 0.4 animals was present during the acoustical tests (range, 0–1) compared with a mean of 8 animals on control nights (range, 0–26). On most experimental nights, no seals fed within a 50-m radius of the bridge.

The first two nights we deployed the Airmar device at the upper bridge, significantly more seals

appeared at the lower bridge than were previously counted on control nights and during the lights-out experiment. On subsequent experimental nights, the numbers dropped steadily at the lower bridge until no seals were observed feeding there. We presume this drop in numbers at the lower bridge reflected poor feeding conditions at this location.

#### Conclusions

Our results show that AHDs were the most effective of the three methods tested to deter seals from feeding on salmon smolts in the Puntledge River. Extinguishing the bridge lights was the second most effective deterrent, followed by the cork line, which had little, if any, effect. The upper bridge appeared to be the preferred feeding site for the harbor seals, as lighting and river topography at this bridge are probably ideal for optimal foraging success. Given that it is doubtful that all incandescent light sources around this bridge can be extinguished, acoustic deterrence could be used to control predation during the months of April and May.

The AHDs are effective within a limited range, but cannot prevent seals from entering the river or from moving or feeding in other areas of the river. The seals only have to swim with their heads out of the water to avoid the underwater noise. By installing AHDs at the Chittenden Locks in Seattle, Washington, the number of sea lions feeding on returning steelhead decreased over the course of 2 years (Fox et al. 1996). Similarly, AHDs could be effective for deterring seals in the Puntledge River and other salmon-producing streams until better measures to protect salmonids are implemented. However, acoustic deterrence can probably only be used as a temporary predation-control mechanism because pinnipeds have a strong ability to learn and adapt to sounds (Fraker 1994). For example, changes in the abundance and availability of prey may lead to motivational changes in pinniped behavior (from avoiding AHDs to ignoring them). Therefore, the effectiveness of the AHDs in the Puntledge River should be tested again during spring out-migrations and, possibly, during fall returns. Hopefully, the Department of Fisheries and Oceans, which is responsible for protecting salmon and seals in Canada, will undertake the necessary steps to continue testing the effectiveness of AHDs.

#### Acknowledgments

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rain watching and counting seals. Also, we are grateful to Graeme Ellis and George Horonowitsch of the Pacific Biological Station, Department of Fisheries and Oceans (DFO), for their relentless efforts to provide the necessary equipment and logistics to plan and execute this study. We would also like to thank Steven Christensen from Airmar Technology, Ltd., and John Ace-Hopkins from Ferranti-Thompson, Ltd., for lending us their AHDs; and Harry Genoe, Chris Beggs, and the staff of the Puntledge River Hatchery for providing boats, technical assistance, and manpower during the study, as well as the City of Courtenay for helping us turn on and off the bridge lights. Furthermore, we would like to thank the Institute of Ocean Sciences, DFO, for providing hydrographic charts of the river. We also thank John Ford for his advice on the design of the study and for allowing us to use his laboratory at the Vancouver Aquarium Marine Science Centre to analyze data. A.W.T. was supported in part by the North Pacific Marine Science Foundation through the North Pacific Universities Marine Mammal Research Consortium. Finally, we would like to thank Jim Boutillier and the Department of Fisheries and Oceans for providing the funds to conduct this study, and Lance Barrett-Lennard, David Rosen, Bruce Wright, and two anonymous reviewers for their comments on earlier drafts of this manuscript.

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**Evaluation of an Electric Barrier as a Seal Deterrent  
on the Puntledge River**

*Prepared For*

Pacific Salmon Commission  
Southern Boundary Restoration & Enhancement Fund Committee  
600 - 1155 Robson Street  
Vancouver, B.C., Canada  
V6E 1B5

December 2008

**DRAFT**

Lisa Harlan, Dave Smith, others? Smith-Root Inc.  
Gary Taccogna, Darcy Miller, Brian Munro, Peter Ofesiuk, Fisheries and Oceans Canada

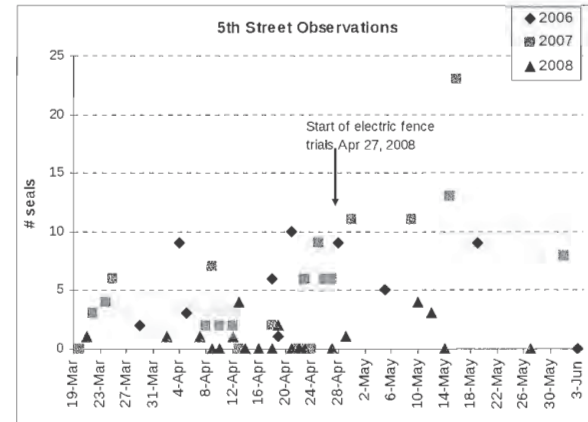
## 4. RESULTS

### 4.1 Baseline Observations

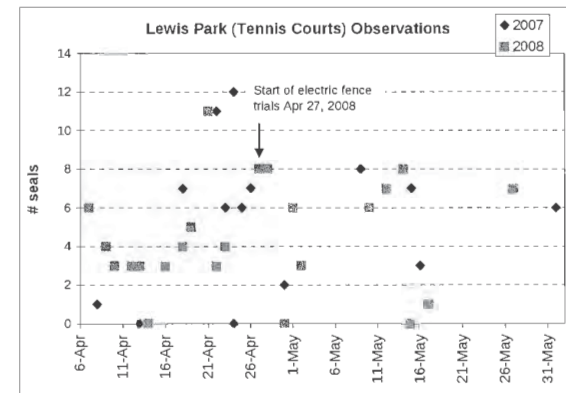
Following observations and assessments conducted in the 1990s on seal predation on outmigrating fry and smolts (Olesiuk et al. 1995), it was strongly recommended that shielding of the lights at the 5th and 17th Street bridges should be evaluated as a mitigative measure to deter seals from foraging beneath them. Predation on outmigrants was determined to be a relatively localized behaviour. With assistance from the City of Courtenay, modifications to the lights on the 5<sup>th</sup> Street bridge were finally completed in the fall of 2007. This included turning off every second light on the bridge truss above the road, and erecting a shield around the remaining lights to prevent light from spilling beyond the bridge deck and into the river, significantly reducing the light shadow used by foraging seals.

Observations of seal foraging behaviour were collected by Puntledge Hatchery personnel during the months of April and May 2008 (before the arrays began operating and during their operation) at 5 main areas of the Puntledge / Courtenay River: Condorsy Road bridge, Lewis Park tennis courts, 5<sup>th</sup> Street bridge, Central Builders, and the 17<sup>th</sup> Street bridge using night vision equipment (see Figure 1). Observations were conducted between dusk and dawn and during favourable tides (when seals typically enter the river for foraging at the 5<sup>th</sup> Street bridge). The 2008 observations are compared to 2007 observations collected during the same months and illustrated in Figure 4.

It appears that the light shields were effective in reducing the number of seals feeding under the 5<sup>th</sup> Street bridge. For the period prior to the start of the electric fence trial on April 27, the maximum number of seals observed on any given monitoring event was 4 in 2008 compared to 9 in 2007 and 10 in 2006. The average number of seals observed during this period was 5.2 in 2006, 3.7 in 2007 and 0.7 in 2008. It was noted that the light shields appeared to have eliminated the distinct shadow line where seals have congregated to feed on outmigrating juveniles in past years. Seals may have been displaced to other well lit areas of the river to feed such as the tennis courts (upstream) or the area adjacent Central Builders (downstream). A comparison of 2007 and 2008 observations at the Lewis Park Tennis Courts provides limited information due to the disproportion in sampling effort between the 2 years (Figure 5). No observations were collected at the Central Builders site downstream of the 5<sup>th</sup> Street bridge in 2007 for comparison. These comparisons do not take into account other variables that may have influenced seal activity such as tide level and river discharge.



**Figure 4.** Observations of seals in the Courtenay River at the 5<sup>th</sup> Street bridge between April and June before lights were shielded (2006-2007) and after (2008). Commencement of the 2008 electric deterrent trials is noted. Trials in 2007 were conducted on April 12-13 and April 23-25



**Figure 5.** Observations of seals in the Courtenay River at the Lewis Park Tennis Courts (upstream of the 5<sup>th</sup> Street bridge), between April and June before lights were shielded (2007) and after (2008). Commencement of the 2008 electric deterrent trials is noted. Trials in 2007 were conducted on April 12-13 and April 23-25.

Pulse width settings greater than 3 msec appeared to cause physiological stress in the seals that were exposed to this electric field, leading the project team to recommend an upper threshold of 3 msec for future trials.

The effectiveness of the barrier was dependent on the strength of the field provided by the pulse width parameter, but may also have been dependent on the environmental conditions during which the array was operated. As the river depth over the array increased due to tidal inundation and increased discharge, the electric field weakened at the surface, potentially creating openings in the electric barrier that seals would quickly learn and habituate to. (data pending from SR).

While the barrier may be considered effective at deterring the upstream movement of a large proportion of seals that approached it, it was noted that even at the highest electrical field strengths tested some seals continued to challenge the array exposing themselves to significant physiological stress and potentially harmful levels. The commencement of trials at the lowest pulse width setting (1 msec) and ramping up gradually to higher levels (4-5 msec) has been criticized by Dr Jennifer Hurley, who has considerable experience with captive sea lions, as essentially training seals to tolerate the electrical stimulus, and charge through the array at levels that may be harmful. However, the gradual ramping up of field strength was necessary to determine the upper threshold for invoking an acceptable behavioural response in seals.

Based on the DIDSON images and shoreline observations there was no apparent effect of the electrical field on juvenile salmon migration behaviour at the levels tested. Conversely, upstream migrating adults appeared to have been obstructed at levels that were considered effective at deterring seals. The delay and/or obstruction of 11 of 14 adult salmon targets in DIDSON imagery recorded on May 18 lead to the conclusion that operation of the electric deterrent at a setting that affects the upstream passage of seals (3msec) adversely affects the migratory behaviour of adult salmon. Therefore, with respect to the second objective, the current technology may only be useful at reducing seal predation on juvenile salmon smolts and fry in localized foraging areas and preventing naive seals from accessing feeding areas further upstream during a brief operating window (late April to mid May). Even during this period, there remains the potential that operation of an electric barrier in the Courtenay River to reduce predation on outmigrating juvenile salmonids will overlap with migrating adults (late steelhead migrants and early summer chinook migrants).

→ The displacement of seals from the 5<sup>th</sup> Street bridge area to other foraging areas downstream continues to be an issue where lighting provides the distinctive shadow that seals utilize to their advantage such as the Central Builders parking lot downstream of the 5<sup>th</sup> Street bridge and the 17<sup>th</sup> Street bridge. Periodic observations at these two locations identified between 8 and 24 seals. Light shielding at the 5<sup>th</sup> Street bridge installed in 2007 appears to have significantly reduced the number seals foraging at this location. Efforts to design similar solutions in other well lit sections of the river should be explored with the City of Courtenay, Ministry of Transportation and other riverside property owners as this treatment seems to have a positive effect at reducing the number of seals from these areas.

Submission #1  
Subject: Ecological Light Pollution General

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## REVIEWS REVIEWS REVIEWS

# Ecological light pollution

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Ecologists have long studied the critical role of natural light in regulating species interactions, but, with limited exceptions, have not investigated the consequences of artificial night lighting. In the past century, the extent and intensity of artificial night lighting has increased such that it has substantial effects on the biology and ecology of species in the wild. We distinguish "astronomical light pollution", which obscures the view of the night sky, from "ecological light pollution", which alters natural light regimes in terrestrial and aquatic ecosystems. Some of the catastrophic consequences of light for certain taxonomic groups are well known, such as the deaths of migratory birds around tall lighted structures, and those of hatchling sea turtles disoriented by lights on their natal beaches. The more subtle influences of artificial night lighting on the behavior and community ecology of species are less well recognized, and constitute a new focus for research in ecology and a pressing conservation challenge.

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As diurnal creatures, humans have long sought methods to illuminate the night. In pre-industrial times, artificial light was generated by burning various materials, including wood, oil, and even dried fish. While these methods of lighting certainly influenced animal behavior and ecology locally, such effects were limited. The relatively recent invention and rapid proliferation of electric lights, however, have transformed the nighttime environment over substantial portions of the Earth's surface.

Ecologists have not entirely ignored the potential disruption of ecological systems by artificial night lighting. Several authors have written reviews of the potential effects on ecosystems or taxonomic groups, published in the "gray" literature (Health Council of the Netherlands 2000; Hill 1990), conference proceedings (Outen 2002; Schmiedel 2001), and journal articles (Frank 1988; Verheijen 1985; Salmon 2003). This review attempts to integrate the literature on the topic, and draws on a conference organized by the authors in 2002 titled *Ecological Consequences of Artificial Night Lighting*. We identify the roles that artificial night lighting plays in changing eco-

logical interactions across taxa, as opposed to reviewing these effects by taxonomic group. We first discuss the scale and extent of ecological light pollution and its relationship to astronomical light pollution, as well as the measurement of light for ecological research. We then address the recorded and potential influences of artificial night lighting within the nested hierarchy of behavioral and population ecology, community ecology, and ecosystem ecology. While this hierarchy is somewhat artificial and certainly mutable, it illustrates the breadth of potential consequences of ecological light pollution. The important effects of light on the physiology of organisms (see Health Council of the Netherlands 2000) are not discussed here.

### ■ Astronomical and ecological light pollution: scale and extent

The term "light pollution" has been in use for a number of years, but in most circumstances refers to the degradation of human views of the night sky. We want to clarify that this is "astronomical light pollution", where stars and other celestial bodies are washed out by light that is either directed or reflected upward. This is a broad-scale phenomenon, with hundreds of thousands of light sources cumulatively contributing to increased nighttime illumination of the sky; the light reflected back from the sky is called "sky glow" (Figure 1). We describe artificial light that alters the natural patterns of light and dark in ecosystems as "ecological light pollution". Verheijen (1985) proposed the term "photopollution" to mean "artificial light having adverse effects on wildlife". Because photopollution literally means "light pollution" and because light pollution is so widely understood today to describe the degradation of the view of the night sky and the human experience of the night, we believe that a more descriptive term is now necessary. Ecological light pollution includes direct glare, chronically increased illumina-

#### In a nutshell:

- Ecological light pollution includes chronic or periodically increased illumination, unexpected changes in illumination, and direct glare
- Animals can experience increased orientation or disorientation from additional illumination and are attracted to or repulsed by glare, which affects foraging, reproduction, communication, and other critical behaviors
- Artificial light disrupts interspecific interactions evolved in natural patterns of light and dark, with serious implications for community ecology

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Figure 1. Diagram of ecological and astronomical light pollution.

tion, and temporary, unexpected fluctuations in lighting. Sources of ecological light pollution include sky glow, lighted buildings and towers, streetlights, fishing boats, security lights, lights on vehicles, flares on offshore oil platforms, and even lights on undersea research vessels, all of which can disrupt ecosystems to varying degrees. The phenomenon therefore involves potential effects across a range of spatial and temporal scales.

The extent of ecological light pollution is global (Elvidge *et al.* 1997; Figure 2). The first atlas of artificial night sky brightness illustrates that astronomical light pollution extends to every inhabited continent (Cinzano *et al.* 2001). Cinzano *et al.* (2001) calculate that only 40% of Americans live where it becomes sufficiently dark at night for the human eye to make a complete transition from cone to rod vision and that 18.7% of the terrestrial surface of the Earth is exposed to night sky brightness that is polluted by astronomical standards. Ecosystems may be affected by these levels of illumination and lights that do not contribute to sky glow may still have ecological consequences, ensuring that ecological light pollution afflicts an even greater proportion of the Earth. Lighted fishing fleets, offshore oil platforms, and cruise ships bring the disruption of artificial night lighting to the world's oceans.

The tropics may be especially sensitive to alterations in natural diel (ie over a 24-hour period) patterns of light and dark because of the year-round constancy of daily cycles (Gliwicz 1999). A shortened or brighter night is more likely to affect tropical species adapted to diel patterns with minimal seasonal variation than extratropical species adapted to substantial seasonal variation. Of course, temperate and polar zone species active only during a portion of the year would be excluded from this gen-

eralization. Species in temperate zones will also be susceptible to disruptions if they depend on seasonal day length cues to trigger critical behaviors.

#### ■ Measurements and units

Measurement of ecological light pollution often involves determination of illumination at a given place. Illumination is the amount of light incident per unit area – not the only measurement relevant to ecological light pollution, but the most common. Light varies in intensity (the number of photons per unit area) and spectral content (expressed by wavelength). Ideally, ecologists should measure illumination in photons per square meter per second with associated measurements of the wavelengths of light present. More often, illumination is measured in lux (or footcandles, the non-SI unit), which expresses the brightness of light as perceived by the human eye. The lux measurement places more emphasis on wavelengths of light that the human eye detects best and less on those that humans perceive poorly. Because other organisms perceive light differently – including wavelengths not visible to humans – future research on ecological light pollution should identify these responses and measure light accordingly. For example, Gal *et al.* (1999) calculated the response curve of mysid shrimp to light and reported illumination in lux adjusted for the spectral sensitivity of the species.

Ecologists are faced with a practical difficulty when communicating information about light conditions. Lux is the standard used by nearly all lighting designers, lighting engineers, and environmental regulators; communication with them requires reporting in this unit. Yet the use of lux ignores biologically relevant information. High-pressure sodium lights, for instance, will attract moths because of the presence of ultraviolet wavelengths, while low-pressure sodium lights of the same intensity, but not producing ultraviolet light, will not (Rydell 1992). Nevertheless, we use lux here, both because of the need to communicate with applied professionals, and because of its current and past widespread usage. As this research field develops, however, measurements of radiation and spectrum relevant to the organisms in question should be used, even though lux will probably continue to be the preferred unit for communication with professionals in other disciplines.

Ecologists also measure aspects of the light environment other than absolute illumination levels. A sudden change in illumination is disruptive for some species (Buchanan 1993), so percent change in illumination, rate, or similar measures may be relevant. Ecologists may also measure luminance (ie brightness) of light sources that are visible to organisms.

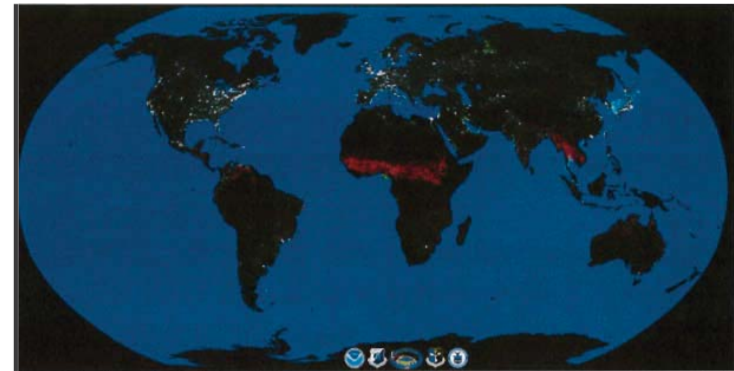


Figure 2. Distribution of artificial lights visible from space. Produced using cloud-free portions of low-light imaging data acquired by the US Air Force Defense Meteorological Satellite Program Operational Linescan System. Four types of lights are identified: (1) human settlements – cities, towns, and villages (white), (2) fires – defined as ephemeral lights on land (red), (3) gas flares (green), and (4) heavily lit fishing boats (blue). See Elvidge *et al.* (2001) for details. Image, data processing, and descriptive text by the National Oceanic and Atmospheric Administration's National Geophysical Data Center.

#### ■ Behavioral and population ecology

Ecological light pollution has demonstrable effects on the behavioral and population ecology of organisms in natural settings. As a whole, these effects derive from changes in orientation, disorientation, or misorientation, and attraction or repulsion from the altered light environment, which in turn may affect foraging, reproduction, migration, and communication.

#### Orientation/disorientation and attraction/repulsion

Orientation and disorientation are responses to ambient illumination (ie the amount of light incident on objects in an environment). In contrast, attraction and repulsion occur in response to the light sources themselves and are therefore responses to luminance or the brightness of the source of light (Health Council of the Netherlands 2000).

Increased illumination may extend diurnal or crepuscular behaviors into the nighttime environment by improving an animal's ability to orient itself. Many usually diurnal birds (Hill 1990) and reptiles (Schwartz and Henderson 1991), for example, forage under artificial lights. This has been termed the "night light niche" for reptiles and seems beneficial for those species that can exploit it, but not for their prey (Schwartz and Henderson 1991).

In addition to foraging, orientation under artificial illumination may induce other behaviors, such as territorial singing in birds (Bergen and Abs 1997). For the northern mockingbird (*Mimus polyglottos*), males sing at night before mating, but once mated only sing at night in artificially

lighted areas (Derrickson 1988) or during the full moon. The effect of these light-induced behaviors on fitness is unknown.

Constant artificial night lighting may also disorient organisms accustomed to navigating in a dark environment. The best-known example of this is the disorientation of hatchling sea turtles emerging from nests on sandy beaches. Under normal circumstances, hatchlings move away from low, dark silhouettes (historically, those of dune vegetation), allowing them to crawl quickly to the ocean. With beachfront lighting, the silhouettes that would have cued movement are no longer perceived, resulting in disorientation (Salmon *et al.* 1995). Lighting also affects the egg-laying behavior of female sea turtles. (For reviews of effects on sea turtles, see Salmon 2003 and Witherington 1997).

Changes in light level may disrupt orientation in nocturnal animals. The range of anatomical adaptations to allow night vision is broad (Park 1940), and rapid increases in light can blind animals. For frogs, a quick increase in illumination causes a reduction in visual capability from which the recovery time may be minutes to hours (Buchanan 1993). After becoming adjusted to a light, frogs may be attracted to it as well (Joeger and Hallman 1973; Figure 3).

Birds can be disoriented and entrapped by lights at night (Ogden 1996). Once a bird is within a lighted zone at night, it may become "trapped" and will not leave the lighted area. Large numbers of nocturnally migrating birds are therefore affected when meteorological conditions bring them close to lights, for instance, during inclement weather or late at night when they tend to fly lower.



Figure 3. Attraction of frogs to a candle set out on a small raft. Illustration by Charles Copeland of an experiment in northern Maine or Canada described by William J Long (1901). Twelve or fifteen bullfrogs (*Rana caesbeiana*) climbed on to the small raft before it flipped over.

Within the sphere of lights, birds may collide with each other or a structure, become exhausted, or be taken by predators. Birds that are waylaid by buildings in urban areas at night often die in collisions with windows as they try to escape during the day. Artificial lighting has attracted birds to smokestacks, lighthouses (Squires and Hanson 1918), broadcast towers (Ogden 1996), boats (Dick and Donaldson 1978), greenhouses, oil platforms (Wiese et al. 2001), and other structures at night, resulting in direct mortality, and thus interfering with migration routes.

Many groups of insects, of which moths are one well-known example (Frank 1988), are attracted to lights. Other taxa showing the same attraction include lacewings, beetles, bugs, caddisflies, crane flies, midges, hoverflies, wasps, and bush crickets (Eisenbeis and Hassel 2000; Kolligs 2000; Figure 4). Attraction depends on the spectrum of light – insect collectors use ultraviolet light because of its attractive qualities – and the characteristics of other lights in the vicinity.



Figure 4. Thousands of mayflies carpet the ground around a security light at Millecoquins Point in Naubinway on the Upper Peninsula of Michigan.

Nonflying arthropods vary in their reaction to lights. Some nocturnal spiders are negatively phototactic (ie repelled by light), whereas others will exploit light if available (Nakamura and Yamashita 1997). Some insects are always positively phototactic as an adaptive behavior and others always photonegative (Summers 1997). In arthropods, these responses may also be influenced by the frequent correlations between light, humidity, and temperature.

Natural resource managers can exploit the responses of animals to lights. Lights are sometimes used to attract fish to ladders, allowing them to bypass dams and power plants (Haynes et al. 1984). Similarly, lights can attract larval fish to coral reefs (Munday et al. 1998). In the terrestrial realm, dispersing mountain lions avoid lighted areas to such a degree that Beier (1995) suggests installing lights to deter them from entering habitats dead-ending in areas where humans live.

### Reproduction

Reproductive behaviors may be altered by artificial night lighting. Female *Physalaemus pustulosus* frogs, for example, are less selective about mate choice when light levels are increased, presumably preferring to mate quickly and avoid the increased predation risk of mating activity (Rand et al. 1997). Night lighting may also inhibit amphibian movement to and from breeding areas by stimulating phototactic behavior. Bryant Buchanan (pers comm) reports that frogs in an experimental enclosure stopped mating activity during night football games, when lights from a nearby stadium increased sky glow. Mating choruses resumed only when the enclosure was covered to shield the frogs from the light.

In birds, some evidence suggests that artificial night lighting affects the choice of nest site. De Molenaar et al.



Figure 5. Crowned hornbill (*Tockus alboterminatus*) hawking insects at a light at the Kibale Forest National Park, Uganda.

(2000) investigated the effects of roadway lighting on black-tailed godwits (*Limosa l. limosa*) in wet grassland habitats. Breeding densities of godwits were recorded over 2 years, comparing lighted and unlighted conditions near a roadway and near light poles installed in a wet grassland away from the road influence. When all other habitat factors were taken into account, the density of nests was slightly but statistically lower up to 300 m away from the lighting at roadway and control sites. The researchers also noted that birds nesting earlier in the year chose sites farther away from the lighting, while those nesting later filled in sites closer to the lights.

### Communication

Visual communication within and between species may be influenced by artificial night lighting. Some species use light to communicate, and are therefore especially susceptible

to disruption. Female glow-worms attract males up to 45 m away with bioluminescent flashes; the presence of artificial lighting reduces the visibility of these communications. Similarly, the complex visual communication system of fireflies could be impaired by stray light (Lloyd 1994).

Artificial night lighting could also alter communication patterns as a secondary effect. Coyotes (*Canis latrans*) group howl and group yip-howls more during the new moon, when it is darkest. Communication is necessary either to reduce trespassing from other packs, or to assemble packs to hunt larger prey during dark conditions (Bender et al. 1996). Sky glow could increase ambient illumination to eliminate this pattern in affected areas.

Because of the central role of vision in orientation and behavior of most animals, it is not surprising that artificial lighting alters behavior. This causes an immediate conservation concern for some species, while for other species the influence may seem to be positive. Such "positive" effects, however, may have negative consequences within the context of community ecology.

### Community ecology

The behaviors exhibited by individual animals in response to ambient illumination (orientation, disorientation) and to luminance (attraction, repulsion) influence community interactions, of which competition and predation are examples.

### Competition

Artificial night lighting could disrupt the interactions of groups of species that show resource partitioning across illumination gradients. For example, in natural commu-

nities, some foraging times are partitioned among species that prefer different levels of lighting. The squirrel treefrog (*Hyla squirella*) is able to orient and forage at lighting levels as low as  $10^3$  lux and under natural conditions typically will stop foraging at illuminations above  $10^3$  lux (Buchanan 1998). The western toad (*Bufo boreas*) forages only at illuminations between  $10^1$  and  $10^3$  lux, while the tailed frog (*Ascaphus truei*) forages only during the darkest part of the night at below  $10^3$  lux (Hailman 1984). While these three species are not necessarily sympatric (ie inhabiting the same area), and differ in other niche dimensions, they illustrate the division of the light gradient by foragers.

Many bat species are attracted to insects that congregate around light sources (Frank 1988). Although it may seem that this is a positive effect, the increased food concentration benefits only those species that exploit light sources and could therefore result in altered community structure. Faster-flying species of bats congregate around lights to feed on insects, but other, slower-flying species avoid lights (Blake et al. 1994; Rydell and Baagøe 1996).

Changes in competitive communities occur as diurnal species move into the "night light niche" (Schwartz and Henderson 1991). This concept, as originally described, applies to reptiles, but easily extends to other taxa, such as spiders (Frank pers comm) and birds (Hill 1990; Figure 5).

### Predation

Although it may seem beneficial for diurnal species to be able to forage longer under artificial lights, any gains from increased activity time can be offset by increased predation risk (Gotthard 2000). The balance between gains from extended foraging time and risk of increased preda-



tion is a central topic for research on small mammals, reptiles, and birds (Kotler 1984; Lima 1998). Small rodents forage less at high illumination levels (Lima 1998), a tendency also exhibited by some lagomorphs (Gilbert and Boutin 1991), marsupials (Laferrier 1997), snakes (Klauber 1939), bats (Rydell 1992), fish (Gibson 1978), aquatic invertebrates (Moore et al. 2000), and other taxa.

Unexpected changes in light conditions may disrupt predator-prey relationships. Gliwicz (1986, 1999) describes high predation by fish on zooplankton during nights when the full moon rose hours after sunset. Zooplankton had migrated to the surface to forage under cover of darkness, only to be illuminated by the rising moon and subjected to intense predation. This "lunar light trap" (Gliwicz 1986) illustrates a natural occurrence, but unexpected illumination from human sources could disrupt predator-prey interactions in a similar manner, often to the benefit of the predator.

Available research shows that artificial night lighting disrupts predator-prey relationships, which is consistent with the documented importance of natural light regimes in mediating such interactions. In one example, harbor seals (*Phoca vitulina*) congregated under artificial lights to eat juvenile salmonids as they migrated downstream, turning the lights off reduced predation levels (Yurk and Triess 2000). Nighttime illumination at urban crow roosts was higher than at control sites, presumably because this helps the crows avoid predation from owls (Gorenzel and Salmon 1995). Desert rodents reduced foraging activity when exposed to the light of a single camp lantern (Kotler 1984). Frank (1988) reviews predation by bats, birds, skunks, toads, and spiders on moths attracted to artificial lights. Mercury vapor lights, in particular, disrupt the interaction between bats and tympanate moths by interfering with moth detection of ultrasonic chirps used by bats in echolocation, leaving moths unable to take their normal evasive action (Svensson and Rydell 1998).

From these examples, it follows that community structure will be altered where light affects interspecific interactions. A "perpetual full moon" from artificial lights will favor light-tolerant species and exclude others. If the darkest natural conditions never occur, those species that maximize foraging during the new moon could eventually be compromised, at risk of failing to meet monthly energy budgets. The resulting community structure would be simplified, and these changes could in turn affect ecosystem characteristics.

#### ■ Ecosystem effects

The cumulative effects of behavioral changes induced by artificial night lighting on competition and predation have the potential to disrupt key ecosystem functions. The spillover effects from ecological light pollution on aquatic invertebrates illustrates this point. Many aquatic invertebrates, such as zooplankton, move up and down within the water column during a 24-hour period, in a

behavior known as "diel vertical migration". Diel vertical migration presumably results from a need to avoid predation during lighted conditions, so many zooplankton forage near water surfaces only during dark conditions (Gliwicz 1986). Light dimmer than that of a half moon ( $<10^1$  lux) is sufficient to influence the vertical distribution of some aquatic invertebrates, and indeed patterns of diel vertical migration change with the lunar cycle (Dodson 1990).

Moore et al. (2000) documented the effect of artificial light on the diel migration of the zooplankton *Daphnia* in the wild. Artificial illumination decreased the magnitude of diel migrations, both in the range of vertical movement and the number of individuals migrating. The researchers hypothesize that this disruption of diel vertical migration may have substantial detrimental effects on ecosystem health. With fewer zooplankton migrating to the surface to graze, algae populations may increase. Such algal blooms would then have a series of adverse effects on water quality (Moore et al. 2000).

The reverberating effects of community changes caused by artificial night lighting could influence other ecosystem functions. Although the outcomes are not yet predictable, and redundancy will buffer changes, indications are that light-influenced ecosystems will suffer from important changes attributable to artificial light alone and in combination with other disturbances. Even remote areas may be exposed to increased illumination from sky glow, but the most noticeable effects will occur in those areas where lights are close to natural habitats. This may be in wilderness where summer getaways are built, along the expanding front of suburbanization, near the wetlands and estuaries that are often the last open spaces in cities, or on the open ocean, where cruise ships, squid boats, and oil derricks light the night.

#### ■ Conclusions

Our understanding of the full range of ecological consequences of artificial night lighting is still limited, and the field holds many opportunities for basic and applied research. Studies of natural populations are necessary to investigate hypotheses generated in the laboratory, evidence of lunar cycles in wild populations, and natural history observations. If current trends continue, the influence of stray light on ecosystems will expand in geographic scope and intensity. Today, 20% of the area of the coterminous US lies within 125 m of a road (Ritters and Wickham 2003). Lights follow roads, and the proportion of ecosystems uninfluenced by altered light regimes is decreasing. We believe that many ecologists have neglected to consider artificial night lighting as a relevant environmental factor, while conservationists have certainly neglected to include the nighttime environment in reserve and corridor design.

Successful investigation of ecological light pollution will require collaboration with physical scientists and

engineers to improve equipment to measure light characteristics at ecologically relevant levels under diverse field conditions. Researchers should give special consideration to the tropics, where the constancy of day-night lighting patterns has probably resulted in narrow niche breadths relative to illumination. Aquatic ecosystems deserve increased attention as well, because despite the central importance of light to freshwater and marine ecology, consideration of artificial lighting has so far been limited. Research on the effects of artificial night lighting will enhance understanding of urban ecosystems – the two National Science Foundation (NSF) urban Long Term Ecological Research sites are ideal locations for such efforts.

Careful research focusing on artificial night lighting will probably reveal it to be a powerful force structuring local communities by disrupting competition and predator-prey interactions. Researchers will face the challenge of disentangling the confounding and cumulative effects of other facets of human disturbance with which artificial night lighting will often be correlated, such as roads, urban development, noise, exotic species, animal harvest, and resource extraction. To do so, measurements of light disturbance should be included routinely as part of environmental monitoring protocols, such as the NSF's National Ecological Observatory Network (NEON). Future research is likely to reveal artificial night lighting to be an important, independent, and cumulative factor in the disruption of natural ecosystems, and a major challenge for their preservation.

Ecologists have studied diel and lunar patterns in the behavior of organisms for the greater part of a century (see Park 1940 and references therein), and the deaths of birds from lights for nearly as long (Squires and Hanson 1918). Humans have now so altered the natural patterns of light and dark that these new conditions must be afforded a more central role in research on species and ecosystems beyond the instances that leave carcasses on the ground.

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## LIGHTS OUT! FOR NATURE

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Humans have radically transformed the physical characteristics of the nighttime hours in ways that would have been unimaginable only a hundred years ago (Figure 1, Longcore and Rich 2004). The cost of industrial development, affluence, and mass consumption has been the loss of natural patterns of darkness over vast expanses of the Earth's surface, both on land and at sea (Cinzano et al. 2001).

Those concerned with the nighttime environment, whether scientists or advocates, regulators or lighting manufacturers, in the private or public sector, together face the challenge of restoring the night sky and natural patterns of light and dark in a global economy. We are motivated by an affinity for the night sky (Mizon 2002), respect for our natural heritage, concern for our own health (Stevens and Rea 2001, Pauley 2004), and a desire to protect the night for the other living beings with which we share the planet.

Astronomers were the first to express concern about the widespread proliferation of artificial night lighting, and they rightfully raised the alarm about the degradation of the night sky (Riegel 1973). Concern about the effects of artificial lighting on wildlife and plants has been a relatively recent phenomenon (Verheijen 1985, Uppgren 1996, Outen 1998). This is not to say that scientists were not interested in the effects of light on other species. Naturalist William Beebe was fascinated with the ability of ultraviolet lights to attract juvenile fish, as documented in a sketch from an expedition in 1935 (Figure 2). But Beebe's observations were not motivated by concern that lights had widespread ecological consequences.

A substantial and growing body of research on the ecological effects of artificial night lighting is now available (see Rich and Longcore 2006). New scientific articles that extend this knowledge are being published at a steady rate (e.g., Oro et al. 2005, Baker and Richardson 2006, Miller 2006). Sufficient information is now available to devise policies to mitigate and avoid the range of profound, adverse consequences on other



Figure 1. The view of Los Angeles from the Mount Wilson Observatory showing the extent of night lighting.



This sketch shows the method of capturing the invisible zone of ultraviolet light the attract fish. Irresistibly impelled to enter its beam, they were held there by traps as long as the light was on, arranged in a very evident reproduction of nature.

Figure 2. William Beebe shows the attractive effect of different light types on fish on an expedition to Bermuda in 1935. Reprinted from the *Bulletin*, published by the former New York Zoological Society, now known as the Wildlife Conservation Society.

species caused by artificial light at night.

Urban planners and open space managers can incorporate this knowledge to better protect nature at night. Here we provide examples of three general types of impacts on wildlife: direct mortality, altered reproductive behaviors, and disrupted interactions between species. These examples give an indication of the breadth of this problem and of the opportunities for solutions.

#### Lights that kill

Anyone with a porch light knows that lights can kill. Many insects are attracted to their deaths at lights; in Germany alone, the estimate of total insect deaths at streetlights in a summer is 100 billion (Eisenbeis 2006).

Migratory birds are attracted to the lights on tall towers when weather conditions are adverse. In North America, an estimated 4–5 million birds are killed per year in collisions with towers, their guy wires, and each other. Most of these are Neotropical migrants, birds that migrate to Central and South America, which are already under severe population stress (Banks 1979, Shire et al. 2000, Longcore et al. 2007). Based on past patterns, we have calculated that two species of federal conservation concern, blackpoll warbler and bay-breasted warbler, suffer losses of over 100,000 individuals each year (Longcore et al. 2007). Over 10,000 individuals of an additional 20 species of conservation concern are killed annually. A change in lighting type would probably eliminate up to 80% of this mortality (Gehring and Kerlinger 2007), and the U.S. Federal Communications Commission is considering such a change based on expert testimony from us, other groups, and the U.S. Fish and Wildlife Service.

Although they are not afforded the same attention as birds, the mortality of insects can be significant. In a study along a forested stream, a single streetlight installed on the bank attracted and killed as many caddisflies as emerged from the stream along an entire 200 meter stretch (Scheibe 1999). This process is described by Professor Gerhard Eisenbeis as the “vacuum cleaner effect,” vividly evoking the image of lights sucking insects out of the surrounding habitat (Eisenbeis 2006).

Beachfront lighting and sky glow threaten the survival of hatchling sea turtles and affect the nest site choice of female turtles (Witherington 1992, Salmon et al. 2000).

Hatchlings are disoriented by lights and fail to make their dash to the ocean and out to sea. This problem was identified first in the 1960s (MacFarlane 1963) and many programs have been put in place to control beachfront lighting (Salmon 2006).

#### Interference with reproduction

Even when lights do not kill wildlife, they can interrupt important behaviors such as those associated with reproduction. For example, stray light can wash out the visual messages between male and female fireflies (Lloyd 2006).

In a recently published article, two Canadian researchers investigated the effects of intermittent light on the reproductive behavior of northern green frogs (Baker and Richardson 2006). They counted the number of calls by males to attract mates under natural ambient darkness and under the light of a flashlight shined on them. This simulates the effects of a security light on a motion detector or the flash of lights from a passing car. The results show a significant 44% decrease in the number of calls and a 675% increase in the number of moves made by individuals (Baker and Richardson 2006).

Under different circumstances, extra light causes species to expend energy calling at night. In another recent article, current and historic singing records for American robins were used to show that males sing well before dawn only in those locations with high light levels (Miller 2006). Subsequent research on European robins concluded that daytime noise is a more important predictor of nighttime singing, although locations where birds sang at night were on average brighter than areas where birds did not sing at night (Fuller et al. 2007). Our analysis of the data reported by Fuller et al. (2007) suggests a threshold effect where increased illumination allows nocturnal singing in noisy locations; no birds sang at night at any of the darkest 20% of locations, even if the location was noisy during the day.

The effects of lighting can extend to the ocean. Seabirds are attracted to and incinerated at flares at oil platforms, migratory birds are killed running into cruise ships, and lighted squid boats each shine 30,000 Watts into the ocean (Montevecchi 2006). But even sky glow at the level of the full moon could easily disrupt the tightly synchronized spawning of corals. Under normal lunar cycles the release of coral larvae, also known as *planula*, always follows the new moon, presumably to reduce predation on these larvae. This synchronization breaks down in experiments where corals are subjected to perpetual full moon illumination (Jokiel et al. 1985).

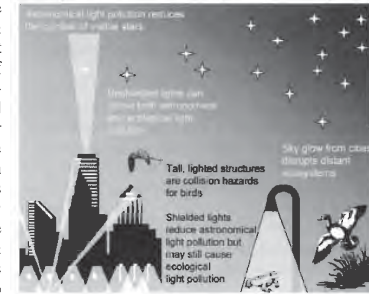


Figure 3. Ecological and astronomical light pollution is caused by lights at night. Figure reprinted from Longcore and Rich (2004).

### Predators, prey, and night lights

Lights at night also disrupt ecological interactions. Predator-prey interactions are particularly vulnerable to influence by lighting. In general, additional light benefits the predator, except when the prey are found in groups where individuals warn each other of predators, such as flocks of birds and schools of fish (Longcore and Rich 2004). But examples of lights increasing nocturnal predation are many.

In a study of European storm-petrel nests in caves on an island off the coast of Spain, the birds in the cave illuminated by city lights were killed far more often by gulls than those in the cave facing away from the city (Oro et al. 2005). In addition, bird survival decreased after completion of a major lighting project in the city, declining significantly in the years that followed (Oro et al. 2005). In a separate study of black-vented shearwaters, another seabird, nesting birds were predated far more in the light of the full moon than the dark of the new moon, again by gulls (Keitt et al. 2004).

Young salmon, known as salmon fry, migrate from the streams where they hatch to the ocean. They migrate en masse at night, cued by illumination levels, and this timing is designed to reduce predation. Researchers in the Pacific Northwest documented harbor seals positioning themselves under lights on a bridge to locate and capture the outmigrating fry (Yurk and Trites 2000). When they turned off the lights, predation levels declined at first but then increased as the seals relocated under other lights from the town. They were found eating salmon fry under the lights of a ball field, a sawmill, and other urban glow (Yurk and Trites 2000).

A recent study from Florida showed alteration in the foraging behavior of beach mice under night lighting (Bird et al. 2004). Some species of these small rodents are federally endangered and they are an important part of the coastal dune ecosystem. The research found that beach mice reduced the proportion of bait stations they visited closer to lights. In addition, this pattern was found for both low-pressure sodium vapor lights, which are generally considered to have fewer environmental impacts because they are less attractive to insects, and for yellow "bug lights," which are also promoted as being turtle-friendly and mandated for this reason (Bird et al. 2004). In this example, we see that lights that reduce impacts for one species are not necessarily benign for others.

### Nature needs the night

Our question, from this ecological perspective, is whether the international community is up to the challenge of restoring the night. The geographic scope is great, extending throughout the world from urban lights, roadway lights, tower lighting, light-induced fisheries, offshore oil production, and many other sources (Longcore and Rich 2004).

The range of species is also great, extending across all major taxonomic groups and habitats. Any species that evolved with natural patterns of light and dark is potentially susceptible to adverse effects of artificial lighting. Direct glare, sky glow, and steady and intermittent lights from urban to rural environments, both on land and at sea, all alter the nighttime environment, causing both ecological and astronomical light pollution (Longcore and Rich 2004).

Unfortunately, there is no one-size-fits-all solution to mitigate the effects of artificial night lighting on nature. Some species are sensitive to yellow light, others to blue.

As we have seen, turtle-friendly lights still disrupt foraging of endangered beach mice (Bird et al. 2004). Attraction of migratory birds to tall towers can be reduced by using flashing lights (Gauthreaux and Belser 2006), while flashing lights in other contexts would be detrimental. Effective solutions will be place- and habitat-specific, such as a road in Florida where lights that attract turtles were replaced by LED lights embedded in the pavement (Figure 4, Salmon 2006).

Our message is simple. Nature needs the night. Substantial progress has been made in understanding the many effects of light on other species and indeed on humans as well. We hope that readers will put this knowledge to work — as researchers, as advocates, as regulators, and as informed citizens.



Figure 4. An example of embedded roadway lighting from Boca Raton, Florida. In the top view, the streetlights are visible from the sea turtle nesting beach, while the embedded lights in the lower view are not visible from the beach (Bertolotti and Salmon 2005). Figure reprinted from "Protecting Sea Turtles from Artificial Night Lighting at Florida's Oceanic Beaches" by Michael Salmon. Found in *Ecological Consequences of Artificial Night Lighting* by Catherine Rich and Travis Longcore, eds. Copyright © 2006 Island Press. Reproduced by permission of Island Press, Washington, D.C.

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## The influence of artificial light on stream and riparian ecosystems: questions, challenges, and perspectives

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**Abstract.** Artificial light at night is gaining attention for its potential to alter ecosystems. Although terrestrial ecologists have observed that artificial light at night may disrupt migrations, feeding, and other important ecological functions, we know comparatively little about the role artificial light might play in disrupting freshwater and riparian ecosystems. We identify and discuss four future research domains that artificial light may influence in freshwater and associated terrestrial ecosystems, with an emphasis on running waters: (1) dispersal, (2) population genetics and evolution, (3) ecosystem functioning, and (4) potential interactions with other stressors. We suggest that future experimental and modeling studies should focus on the effects of different spectral emissions by different light sources on freshwater organisms, the spatial and temporal scale over which artificial light acts, and the magnitude of change in light at night across the landscape relative to the distribution of running and standing waters. Improved knowledge about the effects of artificial light on freshwater ecosystems will inform policy decisions about changes to artificial light spectral emissions and distributions.

**Key words:** aquatic invertebrates; artificial illumination; ecosystems; fish; multiple stressors; riparian; streams; urbanization.

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### INTRODUCTION

Human activities influence and have modified the majority of the Earth's ecosystems (Vitousek et al. 1997). Freshwater ecosystems are especially affected, both because they accumulate and integrate the effects of activities within their

catchments, and because they have always been preferred sites for human activities (Ricciardi and Rasmussen 1998, Dudgeon et al. 2006, Balian et al. 2008).

The effects of chemical pollution (Likens et al. 1996), alteration to natural flows (Poff et al. 1997) and nutrient cycles (Turner and Rabalais 1991),

invasive species (Ricciardi and Rasmussen 1998), increasing urbanization (Morely and Karr 2004), and loss of riparian margins (Sweeney et al. 2004) on freshwater ecosystems have influenced policy decisions for the past 40–50 years (e.g., the USA Environmental Protection Agency's Clean Water Act of 1972). In contrast, the influence of artificial lighting as a human-induced impact affecting freshwater systems has only been recognized in the past 10 years or so (Moore et al. 2000, Longcore and Rich 2004, Moore et al. 2006, Nightingale et al. 2006), and there are still many gaps in empirical knowledge. This is despite the fact that the use of artificial lighting is now widespread and has increased over the past century (Holden 1992). While Cinzano et al. (2001) reported that approximately 67% of Americans and 20% of people world-wide now live in locations where Milky Way is no longer visible due to interference from artificial light sources, the wider effects of artificial light on other organisms and on ecosystems are poorly quantified. While many studies have focused on the control of natural light on biorhythms (Bishop 1969, Grau et al. 1981), few have looked at the potential of artificial light as a disrupter of these rhythms (Moore et al. 2000). This is surprising as approximately 30% of vertebrates and 60% of invertebrates are nocturnal (Hölker et al. 2010a) and could, therefore, be highly influenced by the presence of artificial light.

Longcore and Rich (2004) and Navara and Nelson (2007) presented broad reviews of artificial light and summarized a range of evidence, yet over two thirds of their examples relate to terrestrial organisms. Both Moore et al. (2006) and Nightingale et al. (2006) identified some effects of artificial light on lakes and fish, but in general, freshwater ecosystems are poorly represented in the current literature. An initial search of Web of Science (13 October 2011) of peer-reviewed literature using various terms relating to human alterations and ecosystems revealed a noticeable lack of research on artificial light and freshwater systems, especially when compared to other common pressures to which these systems are subjected (Table 1). This is despite freshwaters having high biodiversity and being disproportionately affected by species loss. Globally, freshwaters are inhabited by more than 125,000 known species, and even though freshwaters

Table 1. Number of references returned on a Web of Science search (13 October 2011) for various human impacts and ecosystem type terms.

Human impact term	Ecosystem term			
	River	Lake	Wetland	Riparian
"Artificial light"	7	8	0	1
"Light pollution"	4	4	0	0
"Environmental flows"	90	14	9	24
"Climate change"	241	213	64	41

Notes: Terms were searched for in the category of "Topic," with lemmatization option off. "Ecology" was added as term to all searches to limit results to ecologically relevant papers.

cover only about 0.8% of the Earth's surface, they are home to about 9.5% of all animal species, and one-third of all vertebrates (Balian et al. 2008). Nevertheless, there have been some seminal contributions to our understanding, for example in the use of artificial lights to: (1) increase fish growth rates in hatcheries (Boeuf and Le Bail 1999), (2) understand how it influences zooplankton movements (Moore et al. 2000), and (3) guide fish around dangerous in-stream structures (Johnson et al. 2005).

Here, we attempt to redress the balance in available literature to date by focusing on freshwater, and in particular streams with their associated riparian margins, defined as areas that are "transitional semiterrestrial areas regularly influenced by fresh water, usually extending from the edges of water bodies to the edges of upland communities" (Naiman et al. 2005:2). We give special attention to adult aquatic insects, as they represent a key in the exchange of nutrients between stream and riparian systems (Richardson et al. 2010).

Our goal is to illustrate how artificial light influences species interactions and processes in stream and riparian ecosystems, and to stimulate research in an area that we consider of major importance for their future conservation and management. Ecologists have only recently started to acknowledge the alteration of the night-scape as a major concern in conservation policy and freshwaters are no exception (Rich and Longcore 2006, Hölker et al. 2010a).

RESEARCH DOMAINS

We begin by presenting four major research domains relating to the ways artificial light can

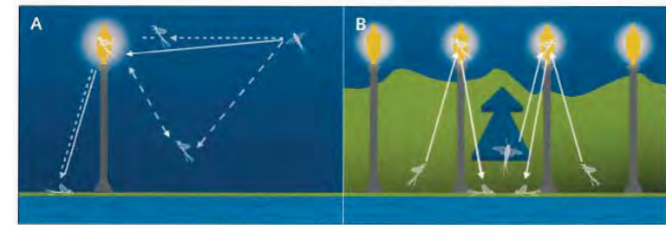


Fig. 1. Eisenbeis (2006:281–304) proposes three different ways for artificial lights to trap flying insects. Two are shown here: fixation (dashed line), captivity (dotted line), and directly lethal (solid line) effects (A) and the crash barrier effect (B). Fixated insects do not suffer mortality directly from artificial light, but are stunned by it and are easy targets for predators or fail to engage in basic behaviors, such as reproduction. Captive insects fly to the light and circle around it endlessly until they die of exhaustion or are consumed by predators. The crash barrier effect is the result of a row of lights (like those lining a street) preventing the dispersal of insects through their attractive properties.

act on stream and riparian ecosystems, through altering: dispersal, population genetics and evolution, ecosystem functioning, and interactions with other common stressors; and then outline a range of key research questions which need addressing.

Dispersal

There is evidence that artificial lights located near streams change the behavior of adult aquatic insects as they disperse through the terrestrial environment. Eisenbeis (2006) proposes three different ways for artificial lights to trap flying insects (Fig. 1). The first is through fixation or captivity effects (Fig. 1A). Here insects located near lights fly directly to them and are killed immediately, or they circle close to the light and are unable to leave eventually dying from exhaustion, predation, or heat. The lights may also induce settling behavior that incapacitates the insects, rendering them easy targets for predators. The second mechanism is the crash barrier effect (Fig. 1B), where insect dispersal and migration are impeded by running into a "barrier" of lights, such as a row of street lights. The final mechanism is termed the vacuum cleaner effect, whereby insects from a large area are attracted to a nearby light source. However, these are only hypotheses and carefully designed

experiments are needed to determine how much of an effect these mechanisms actually play in disrupting aquatic insect dispersal.

Studies comparing different trapping techniques provide evidence for the vacuum cleaner effect. These studies illustrate that light traps differentially capture certain insects (e.g., Trichoptera) more readily than other kinds of traps (e.g., Collier and Smith 1998). While the height of streetlights is designed to maximize safety for car drivers, lights that are used along walking and bike paths, as well as those used for decorative purposes could be adjusted to attract fewer insects, if we can predict which heights have the highest concentrations of insects based on landscape features and insect species. Svensson (1974) found that light traps at 11 and 50 m height captured fewer trichopterans than those at 1 m due to the propensity of several species to fly low to the ground, suggesting that higher lights might trap fewer insects than lower lights, but this has yet to be generalized across taxa and habitats.

Overall, research on insect dispersal, especially adult aquatic insect dispersal, is extremely limited. Part of this lack is that it is very difficult to rigorously study insect dispersal. Stable isotope and elemental markers are potentially valuable tools, as is the increasing use of genetic

analysis (Smock 2007); however, capturing insects in substantial numbers generally requires the use of light or pheromone traps. While these methods are adequate for most studies of aquatic insect dispersal, light traps cannot be used in studies of artificial light as they obviously create a confounding factor. In addition, while population genetic analyses hold promise for longer-term studies and determining if populations adapt to artificial light, they are not really useful as a tool for short-term dispersal studies.

It is also unclear how much the dispersal of adult aquatic insects matters for the population dynamics of these organisms. Masters et al. (2007) found that the recovery of the benthos from acidification is not limited by adult dispersal. Furthermore, Bunn and Hughes (1997) calculated that it is likely that populations of *Tasiogma* spp. (Trichoptera) in a reach are maintained through the reproduction of only 3–12 females per generation. It is not obvious how much of an effect land use changes have on adult aquatic insect dispersal (Petersen et al. 2004); however, studying the effects of artificial light on insect dispersal will likely further this field.

Clearly, we need to come up with new and innovative ways to study aquatic insect dispersal. One possibility is to use Malaise traps to capture individuals marked with fluorescent dyes or stable isotope tracers (Macneale et al. 2005). Conducting more basic studies of aquatic insect dispersal will help those studying the effects of artificial light to develop hypotheses (e.g., the effect of light height, light distances from streams) more effectively.

Aquatic insects are not the only stream organisms that may have their dispersal interrupted by the addition of artificial lights. It is well established that the migration of Pacific salmon species (*Oncorhynchus* spp.) can be slowed or stopped by the presence of artificial lights (Nightingale et al. 2006). Furthermore, exposure to constant light can decrease smoltification and increase the deterioration in body condition associated with smoltification in chinook salmon (*O. tshawytscha*) (Hoffnagle and Fivizzani 1998). This might be due to the synchronization of downstream migration with the new moon; however, it is possible that the lunar timing of downstream migration is stock-dependent (Hoffnagle and Fivizzani 1998). It is

likely that any species that uses lunar cycles to cue migration or dispersal will be disrupted by the addition of artificial lights (see *Key Research Questions*; Fig. 2).

*Population genetics and evolution*

To our knowledge, no one has yet experimentally investigated the possibility that artificial light can act as an evolutionary force in freshwater or riparian species. However, its potential to influence evolution has received attention from Moore et al. (2006) and Nightingale et al. (2006).

Artificial light at night could reduce effective population sizes through the direct loss of individuals, reproductive failure, or changes to sex ratios. The direct mortality of individuals is probably most likely in the case of aquatic insects; either through the attraction of the adults to lights (Scheibe 2003, Eisenbeis 2006), or increased predation through improved predator vision. However, mid-trophic fish species could also suffer higher rates of predation under artificial light (see: *Ecosystem functioning: Food webs*). Reproductive failure could be due to the inability to locate suitable mates, as in the case of several amphibian species (Longcore and Rich 2004). Aquatic insects are again likely to suffer

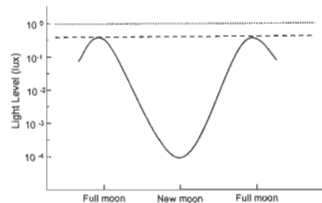


Fig. 2. Sky glow eliminates monthly variation in light levels. The solid line shows the natural light provided by a full moon in a temperate region. The dashed line is the light level measured in the center of Berlin on a clear night and is roughly equivalent to a full moon, while the dotted line is the light level in the center of Berlin on a cloudy night and is roughly four times greater (Kyba et al. 2011). The y-axis is logarithmic.

from changes to sex ratios, as there are often biases in light trap catches, depending on the species (Waringer 1989).

Reduction in effective population sizes will lead to less genetic diversity and possibly genetic drift; leaving a population with insufficient variation to adapt to future stressors, and therefore is a major concern for species conservation (Lande and Barrowclough 1987). If some populations are eliminated, it could result in reduced gene flow across the range of some species, with the potential to lead to the diversification of populations and potentially even speciation.

There is already some evidence that other environmental stressors alter genotype frequencies in a population. Populations of a common aquatic insect (*Chironomus riparius*) that were exposed to a chemical stressor (tributyltin) in a laboratory study had increased rates of larval mortality and reduced genetic variation (Nowak et al. 2009). This result was especially significant because the changes were seen in neutral markers, not in response genes, and therefore represent a true reduction in effective population size. Conversely, mosquitoes living on an arid slope showed increasing diversity (due to higher rates of recombination and mutation) as a result of exposure to greater environmental stress, such as increased temperatures and solar radiation, than those living on a humid slope of the same valley (Nevo 2001). Furthermore, females from the arid slope showed an increased tendency to mate with males that were also from the arid slope, potentially leading to sympatric speciation between the two groups (Nevo 2001). While it might be difficult to forecast which species will have increased or decreased genetic diversity, artificial light could also change the frequency of heritable behaviors that could influence the evolution of organisms.

Mating and reproductive behaviors in freshwater species are likely to be influenced by artificial light (Moore et al. 2006, Nightingale et al. 2006). Sexual selection for traits that are visually stimulating could increase or decrease with exposure to artificial light, depending on the spectral qualities of the light and species' visual sensitivities. For instance, cichlid fishes undergo strong sexual selection that favors brightly colored individuals and has driven speciation

events in populations in clear water that allows plenty of light (Seehausen et al. 1997). The effects of artificial light on sexual selection could be especially interesting and unpredictable, given the common use of high pressure sodium lamps, which have a very limited emission spectra and could prevent females from recognizing male color patterns (Fig. 3). This has taken place in Lake Victoria, where turbidity from eutrophication reduces the spectral range of light entering the water to wavelengths that are similar to the emission spectra of high pressure sodium lamps, and reduces female selectivity based on color (Seehausen et al. 1997). Similarly, guppy habitat specialization has been driven by a combination of diverse ambient light conditions, predation, and sexual selection (Endler 1992). The introduction of artificial light to these streams could lead to the visual homogenization of these environments, which could lead to reduced speciation as well as increasing susceptibility to predation.

Other behaviors that could be influenced by artificial light that are potentially important to evolution are feeding behaviors. Some spiders are more likely to build their webs in close proximity to artificial light to take advantage of the increased densities of insects found at lights (Heiling 1999). If there is a genetic basis for this behavior, then the presence of artificial light could very well contribute to the evolution of this species. Ultimately, any behavior that could be altered by artificial light and is under genetic control could allow artificial light to change the evolution of a species exhibiting such a behavior.

It is also important to consider the effect of artificial light in combination with species interactions in driving rapid evolutionary change, which could lead to altered ecological dynamics, e.g., different guppy phenotypes result in altered ecosystem structure and function (Schoener 2011). To test if artificial light causes rapid evolution of exposed organisms, researchers could hatch diapausing copepod eggs that were laid before artificial light became widespread. The feeding and diel vertical migration (DVM) behavior of pre-lighting and modern copepods could then be compared (Hairston et al. 1995). To determine what percentage of the behavioral change is really due to evolution, and not some other ecological factor, genetic techniques should be used to identify genes that are likely respon-



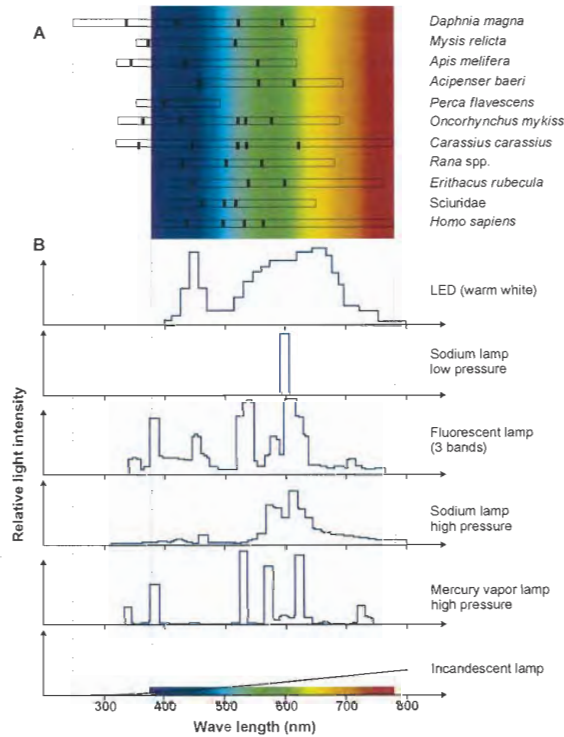


Fig. 3. The light sensitivities of various animals are displayed against a background of wavelengths that humans perceive as visible light (A). The black ovals represent the peak sensitivities for each organism; note that some organisms have sensitivities in the UV range. The dashed vertical lines designate the limits of the UV (10–400 nm) and human-visible light (390–750 nm) (Menzel and Blakers 1976, Smith and Macagno 1980, Lythgoe 1984, Loew and Wahl 1991, Fratzler et al. 1994, Hawryshyn and Hárosi 1994, Vorobyev and Osorio 1998, Gal et al. 1999, Wiltshko and Wiltshko 1999, Sillmann and Dahlin 2004). The wavelengths of light emitted from various artificial light sources (B) are highly variable, with some emitting light over a broad spectrum and others having only a few narrow peaks.

sible for the observed behavior and then tested to ensure that they are responsive to altered light conditions and change organism behavior (Hairston et al. 2005, Fussmann et al. 2007). Furthermore, it will be beneficial to establish if any of these rapid evolutionary changes results in genetic isolation, and eventually, speciation (Hendry et al. 2007).

**Ecosystem functioning**

As previously addressed by Moore et al. (2000), Longcore and Rich (2004), and Moore et al. (2006), we expect that modified lighting regimes will lead to a range of whole freshwater ecosystem changes and also influence the linkages between freshwater and riparian ecosystems. Of particular interest is how artificial light could alter the exchange of organic matter between stream and riparian systems. Artificial light could influence ecosystems in ways that might be unexpected from single species studies, e.g., by changing species interactions, especially predator-prey interactions, and therefore have important conservation implications (Wooten et al. 1996).

**Primary production.**—Primary production is a key ecosystem process controlled by light. To our knowledge, only one study has found evidence that riparian vegetation could be influenced by the presence of artificial light at night (Cathey and Campbell 1975). Their work illustrated that trees and shrubs exposed to streetlamps, particularly incandescent or high pressure sodium luminaires, may have longer growing periods, earlier leaf-out and later leaf fall times than those in darker environments (Cathey and Campbell 1975). This may have a range of bottom-up effects. For example, earlier leaf-out could cause earlier inputs of terrestrial insects (that use riparian vegetation as habitat) to freshwater systems, but only if terrestrial insects are able to use this new habitat resource. Later leaf fall could result in a mismatch of resources and consumers, as detritivorous aquatic invertebrate taxa might have evolved to match the timing of the allochthonous inputs of leaves with critical life stages (Hershey and Lamberti 1998:169–199). However, substantial changes in leaf-out/fall and growth are unlikely unless artificial lights are present with warmer temperatures that allow for a longer growing season (Cathey and Camp-

bell 1975). While this situation is currently unlikely in temperate climates, global temperatures are projected to increase by 0.6–6.4°C in the next 90 years, with greater warming in northern temperate regions (IPCC 2007), which would increase the chances that artificial light might influence riparian vegetation. The effects of increased temperatures and light could be studied in urban areas that not only have increased levels of artificial light, but also artificially high temperatures due to the heat island effect (Oke 1973).

**Food webs.**—Light is an important cue for both predator avoidance and feeding in freshwater systems. Aquatic invertebrates in lotic systems drift at light levels below 10<sup>-3</sup> lux (at 400–535 nm) to avoid predation by fish (Bishop 1969). However, Atlantic salmon have been shown to change foraging strategies below light levels of 10<sup>-1</sup> lux, moving to areas of slow-moving water that, while not as rich in prey, allow more time for identification of prey items and night-time foraging (Metcalf et al. 1997). Light adaptations are also evident in lentic environments, where zooplankton engage in DVM in the water column to feed on phytoplankton during the night when they are less visible to predators (Young and Watt 1996). Moore et al. (2000) were able to detect a decrease in the amplitude of DVM in *Daphnia retrocurva* as a result of artificial light from a nearby city, by monitoring the vertical migration inside darkened versus clear enclosures. Light intensity also had a significant influence on the ability of vendace (*Coregonus albula*) to feed on *Daphnia magna*, with declining efficiency down to a threshold of 0.05 lux (Ohlberger et al. 2008). On the other hand, a decrease in feeding movements to avoid artificial light has been observed in vendace (Schmidt et al. 2009). These studies suggest that artificial light can result in altered food webs in lentic systems, leading to increased algal biomass as zooplankton spend less time in the upper euphotic water column feeding on algae (Moore et al. 2000, Moore et al. 2006). Lotic systems could see higher relative abundances of armored grazers, such as glososomatid caddisflies or snails, as invertebrates with less physical protection, such as mayflies, are eliminated through heavy predation (McNeely et al. 2007). In this case, there would eventually be a reduced number of

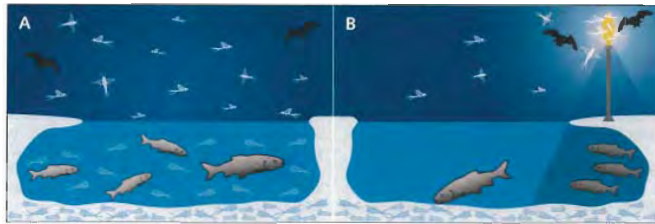


Fig. 4. A schematic of a stream ecosystem under natural nighttime conditions (A), and the same system under the influence of artificial light (B). Note the predicted shifts as light is introduced from A to B in the positions of small fishes seeking cover, suppression of streaminvertebrate drift, adult insects attracted to lights, and bats shifting their foraging efforts near the lights. Refer to *Ecosystem functioning: Food webs* in the text for details.

invertebrates available to fish predators, but if there are adequate numbers of protected invertebrate grazers, they would likely control lotic algal standing biomass.

We expect that artificial light at night not only influences freshwater food webs (Fig. 4), but also the exchange of materials between stream and riparian environments (Richardson et al. 2010; Fig. 5), which can be mediated by predators (Baxter et al. 2004). Accordingly, one key question here is how artificial light changes predator-prey relationships. Some species might be able to exploit artificial light to extend foraging opportunities, at least in the short-term (Moore et al. 2006, Nightingale et al. 2006). One example of this is the spiders who build their webs near light sources (Heiling 1999). However, foraging benefits, if they exist, may be short-lived due to resulting reductions in prey populations (Beier 2006). This will probably depend on the trophic structure of specific food webs, as apex predators will benefit more than mid-trophic species that have to avoid predation themselves.

Patterns of invertebrate drift and fish feeding are both likely to change under the influence of artificial light (Moore et al. 2006, Nightingale et al. 2006). If fish are able to feed much more efficiently on drifting insects, it could result in a decrease of emerging aquatic insects. However, light is known to depress drift rates (Bishop 1969); if fish are more active under artificial lights but prey is less available, fish could suffer from

increased energetic demands. Conversely, the number of terrestrial invertebrates entering the stream and available for fish to prey on could also change. Under natural conditions, terrestrial insects are an important allochthonous resource for fish (Fig. 4A). Kawaguchi and Nakano (2001) found that terrestrial insects contribute about 50% of the total annual prey consumption of salmonids in some Japanese streams, while about 84% of the consumption in a cyprinid (*Alburnus alburnus*) in a German lake comes from terrestrial sources (Mehner et al. 2005). In the presence of artificial light near a waterbody, terrestrial insects could become an even more important food source for fish. On the other hand, juvenile and other vulnerable fish might retreat to overhangs and reduce foraging efforts in order to avoid predation (Nightingale et al. 2006; Fig. 4B).

While adult aquatic insect flight in a dark riparian forest might normally be restricted to areas immediately adjacent to streams (Petersen et al. 1999), insects may cluster around artificial lights located in floodplains (Figs. 1, 5). Many aquatic insects emerge at night (Tobias 1967, Jackson 1988, Pinder et al. 1993), and are therefore vulnerable to attraction to artificial lighting while in their adult phase. We hypothesize that as the distance of an artificial light source from a water body increases, the proportion of freshwater carbon transferred to the terrestrial ecosystem increases relative to a riparian system that does not have lights, as

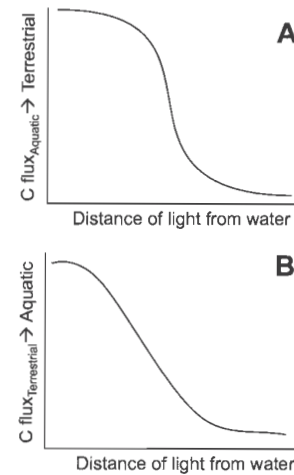


Fig. 5. Theoretical changes in carbon flux from freshwater to terrestrial systems, in the form of insects. Aquatic insects will be attracted to lights very near aquatic bodies in high densities, while lights that are farther away will increase the inland dispersal of aquatic insects, up to some threshold (A). Similarly, there will be higher inputs of terrestrial insects to the aquatic system when lights are close to the aquatic environment but these inputs will decrease quickly as the light location moves inland (B).

aquatic insects are attracted further into the terrestrial system (Fig. 5A). Preliminary support for this hypothesis comes from Kovats et al. (1996) who found adult caddisflies 5 km inland when using light traps. Conversely, we predict the amount of terrestrial carbon contributed to a freshwater system through terrestrial invertebrates will decrease as the distance of an artificial light source to a water body increases. For instance, a light situated on a dock will draw terrestrial insects to the water body, while lights from a road running parallel and several hun-

dred meters away from a water body will draw terrestrial insects away from the water (Fig. 5B). This will create areas that are highly dense in resources for insectivorous organisms, while creating other areas that are depauperate. Outcomes of this process may be an increase in competitive interactions between insectivores (Rydell 2006) and also an increased transfer of freshwater resources to terrestrial consumers.

*Interaction with other stressors*

There is a growing concern about how environmental stressors might interact with each other, and in fact, an entire issue of the journal *Freshwater Biology* (see Ormerod et al. 2010) was dedicated to this topic. However, the specific ways that artificial light might interact with other common urban stressors have not yet been described in the peer-reviewed literature. As artificial light most frequently occurs in urbanized areas, its effects may be confounded with other urban stressors, making it impossible to determine how much a role artificial light has played in declines in biodiversity and ecosystem functioning. Artificial light may already play a major role in changing organism behavior and ecosystem functioning. However, to fully understand its importance, we must elucidate how it interacts with other stressors in freshwater and riparian ecosystems. Does light pollution act synergistically with other stressors to increase the stress experienced by organisms, or does it potentially lessen the effect of some stressors? How artificial light interacts with other stressors will help prioritize what areas are most important to protect. Dudgeon et al. (2006) enumerated the five major threat categories to freshwater ecosystems as overexploitation, water pollution, habitat degradation, species invasion, and flow modification. Of course, another major threat to freshwater ecosystems is climate change. Artificial light has the potential to interact with all of these threats. By conducting carefully designed studies to understand the interaction between artificial lighting and the threats mentioned in Dudgeon et al. (2006), we will be able to develop a model for when artificial light is likely to do the most harm and be carefully controlled, or conversely, when it could be used as a mitigating factor for some other stressor.

In this section, we explain the ways artificial

light could combine with changes to temperature regimes, increased chemical pollution and urban development, altered flow regimes, and increased nutrient concentrations. We also describe how the effects of artificial light might be masked by the presence of other stressors and may not become apparent until the other stressors are removed.

One potential concern is for light to interact with other common urban stressors, such as temperature and pollution, to interfere with migration and dispersal. For example, some fish have been shown to become disoriented when swimming near lights (Tabor et al. 2004, Nightingale et al. 2006), which they are more likely to encounter when traversing urban areas that also contain other stressors. In the absence of light, migratory fish, such as salmonids, travel quickly through large rivers (Økland et al. 2001) that are more likely to have sub-optimal temperatures or increased pollutants, but the disorientation caused by urban lights could increase the time these fish spend in polluted environments and, as a result, increase their risk of mortality (McCormick et al. 1998).

The interaction of artificial light and other urban stressors could also alter patterns of the dispersal of riparian obligates, such as adult aquatic insects. For instance, the presence of culverts has been shown to reduce the upstream flight of adult caddisflies (Blakely et al. 2006). These culverts are usually installed to allow roads to pass over small streams, leading to a high probability of street lighting being associated with culverts. The street lighting would most likely run perpendicular to the stream (Fig. 6), leading the insects farther away from the stream. We hypothesize that this will lead to decreased dispersal and gene flow, and potentially the elimination of up-stream populations; however, it is possible that these lights could draw the insects over to a neighboring small watershed and, as a result, enhance genetic exchange. Similarly, Málnás et al. (2011) found that a bridge reduced the upstream flight of the mayfly *Palingenia longicauda* on a river in Hungary. At least part of the disruption was caused by polarized light reflecting off the surface of the bridge, which enticed gravid females to oviposit there (Horváth et al. 2009, Málnás et al. 2011).

The construction of dams has led to altered

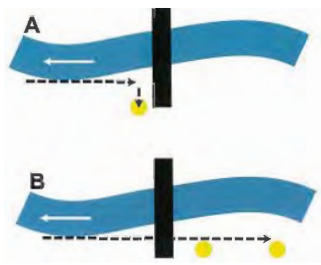


Fig. 6. Artificial lights located near culverts intersecting streams may strengthen their disruption of aquatic insect upstream flight (A) or mediate it (B), depending on their location. The white arrow represents the direction of streamflow, the dashed line is the flight path of the aquatic insects, the yellow circles are lights and the black line is a culvert.

flow regimes, often with a dampening of pre-dam high flows. These high flows can serve as a signal to cue migration or spawning events (McCormick et al. 1998, Bunn and Arthington 2002). Normally, light is also a strong *Zeitgeber* for these behaviors (Grau et al. 1981, Greenstreet 1992), but where artificial lighting and flow alterations occur, there could be a complete loss of external cues for these behaviors. This could lead to asynchronous migration and spawning events, and ultimately result in lower population sizes.

While flow modifications are largely a concern of stream environments, increasing loads of nitrogen and phosphorus pollution is a common problem across all freshwater systems (Carpenter et al. 1998). Areas with increased nutrient loading that are also exposed to artificial light at night could be at an increased risk for algal blooms, largely as a result of night-time light altering the behavior of grazing macroinvertebrates (Moore et al. 2000, Moore et al. 2006). Other common pollutants in freshwater ecosystems could also interact with artificial light, most resulting in further reductions of biodiversity. However, bright artificial light could mitigate effects of pollutants that degrade under light

Table 2. Key research questions in each research domain.

Key research question	Research domain			
	Dispersal	Evolution	Ecosystem functioning	Interactions with other stressors
Spectral qualities	How do different spectra change an organism's attraction to light? How do different spectra change hormone production?	Are there changes in sexual selection as a result of specific spectra entering the environment?	Is primary production changed? Does the spectrum of artificial light fall within visual predators or prey or both?	Is the light spectra reaching aquatic organisms altered by pollution?
Spatial & temporal scales	Patterns of light across the landscape: does it create traps or barriers? What time of day do species move, does the presence of artificial lights change this?	How quickly does adaptation to/selection from artificial light happen? Are entire populations affected or only fractions of some populations?	Are there refuges available? Is daytime behavior altered? Are there energetic costs?	Is light present year-round or seasonally? What effects might this have on spawning? What is the distribution across watersheds? Specifically, how does artificial light overlap with other stressors?
Magnitude of change in brightness	Is sky glow or direct glare a bigger problem?	Is sky glow or direct glare a bigger problem?	Is sky glow or direct glare a bigger problem? Are there thresholds of effective light levels?	Is sky glow or direct glare a bigger problem? Are there thresholds of effective light levels? Is there an increase in light brightness due to reductions in riparian vegetation (as a result of anthropogenic activities)? Are the light levels high enough to photodegrade chemicals?

exposure.

In restoration efforts, common urban stressors might act in concert to hide the negative effects of artificial light. For instance, water quality was the limiting factor in fish survival and reproduction in a central European river system. However, after decades of efforts to improve water quality, hydromorphological degradation then emerged as the main obstacle to further ecological improvement and freshwater diversity (Borchardt et al. 2005, European Commission 2007). Improving degraded habitats became important once pollutants and oxygen stress had been eliminated; similarly, after degraded habitats have been improved artificial lights could prevent a restoration site from achieving full functionality. This is important to consider as freshwater and riparian ecosystems that have undergone successful restoration often become attractive places for recreation (Woolsey et al. 2007). As recreational uses of these areas increase, user groups might call for the installa-

tion of artificial lights, particularly along biking and running paths in temperate zones with long periods of dark during winter months.

#### KEY RESEARCH QUESTIONS

We have identified three main general questions facing researchers in artificial light that deserve more attention. These include understanding how different spectral qualities of various sources of artificial light, spatial and temporal scales over which artificial light acts, and the magnitude of changes in light influence organisms and ecosystems (Table 2).

Diverse organisms have sensitivities in different parts of the light spectrum, and various artificial lighting sources emit very distinctive wavelengths of light (Fig. 3). Therefore, different light sources (e.g., high pressure sodium, metal halide) with distinct color spectra are expected to elicit unique responses from different organisms (Fig. 3; Moore et al. 2006). Recently, the European

Eco-Design Directive has enacted a step-by-step plan to phase out particularly energy-intensive lighting products (e.g., high-pressure mercury lamps, the European Parliament and the Council of the European Union 2009). Thus, many countries and the EU have launched a number of programs to adopt efficient lighting systems with a focus on LEDs as a promising energy-efficient lighting technique. There is some evidence that LEDs will attract fewer insects than previous bulb types (Eisenbeis and Eick 2011), but this needs to be more rigorously tested, as the light levels and luminaire construction in this study varied in addition to bulb type. Further, it is completely unknown how other freshwater organisms might respond to different wavelengths, although some fish (e.g., *Acipenser baeri* and *Oncorhynchus mykiss*) have peak sensitivities that correspond to peak emissions from LEDs (Hawryshyn and Hárosi 1994, Sillman and Dahlin 2004; Fig. 3).

The spatial and temporal scalar influence of artificial light is also an area that requires elucidation. Scheibe (2003) showed that one street light located near a stream can attract caddisflies hatching from several hundred meters of stream, but it is unclear how applicable his results are for different habitat and ecosystem types, or what the impact of multiple light sources might be. At larger spatial scales, it is clear that the sky glow created by the cumulative lights of a large city can influence natural areas 10s and even 100s of kilometers away (Albers and Duriscoe 2001, Kyba et al. 2011). For example, Moore et al. (2000) found that artificial light from 16 km away was strong enough to alter the DVM of *Daphnia*. We need to know if wide-spread use of artificial lights near freshwater and riparian habitats will contribute to the decline or disappearance of sensitive species, lead to localized decreases close to bright light sources, or even be beneficial for other species. Even if sky glow does not cause extinctions, it could very likely alter food web structure either by changing predators' ability to detect prey or prey behavior (Moore et al. 2006). Another question that needs to be answered is if light-sensitive species are able to re-colonize areas when lights are removed. Mapping the occurrence of artificial light across landscapes will allow us to make better predictions about the

likelihood of specific habitats being recolonized.

While the results of Scheibe (2003) and Moore et al. (2000) suggest that artificial light can influence organisms over a relatively large spatial area, we do not know the temporal scale of this influence. Does exposure to artificial light during the night alter the behavior of organisms during the day? Perhaps some organisms have life stages that are particularly vulnerable to exposure to artificial light, but are not sensitive during the rest of their lives. These species might be able to take advantage of dark refuges for sensitive life stages and then live in artificially lit areas at other times. If populations are negatively affected by artificial light, are they able to recover quickly once artificial light is removed from their habitat? This largely depends on whether artificial light alters the genetic structure of populations. Furthermore, spatial analysis is needed to determine the overlap of artificial lights and freshwater bodies. As noted in the introduction, freshwater environments are preferred sites for human activities, which will often lead to an increase of artificial lights. We expect to find the greatest amount of lighting in already damaged urban areas, but we also need to determine if vacation homes and highways introduce a meaningful amount of light to more natural areas.

The magnitude of changes in light also needs to be better understood. While direct glare is the most conspicuous form of light pollution, sky glow is a much more wide-spread phenomenon that is likely to influence animal behavior (Longcore and Rich 2004, Moore et al. 2006, Nightingale et al. 2006). Sky glow can increase ambient light levels hundreds of kilometers away from the cities from which it emanates. This is the case in several ecologically important U.S. National Parks (Everglades, Channel Islands, and Joshua Tree), which have night skies that are substantially brighter than natural due to sky glow from nearby cities (Albers and Duriscoe 2001). One potential problem of increased light from sky glow is that it reduces or eliminates the natural monthly variation in night-time light that arises from the lunar cycle (Longcore and Rich 2004, Kyba et al. 2011; Fig. 2). If the general increase in ambient light caused by sky glow can alter behavior and harm ecosystems, then managing artificial light becomes a much more pressing

conservation concern. However, it will be very difficult to study the effects of sky glow on ecosystems, as there are very few places left in North America and Europe that do not have elevated levels of sky glow to use as control sites (Cinzano et al. 2001). Furthermore, once researchers have located a promising location, how do they mimic an increase in sky glow that would normally be produced by a city of 500,000+ inhabitants that is 50 km away? While researchers may be able to introduce direct glare by introducing a few lights to an ecosystem, those interested in understanding the influence of sky glow may have to introduce artificial darkness to an already lit area, as Moore et al. (2000) did.

## CONCLUSION

How artificial light at night might influence stream and riparian ecosystems is a relatively unexplored topic, with many possibilities for relevant research. Even though the experimental knowledge of the ecological impacts of artificial light at night is still developing, governments are creating legislation to regulate it, mostly to reduce energy costs and decrease greenhouse gas emissions (Hölker et al. 2010b). Reducing energy consumption is a desirable goal, but if it is achieved solely through changing lighting fixtures and not necessarily reducing lighting, and without knowing how different aspects of artificial light (e.g., intensity and spectral qualities) influence ecosystems, this legislation could have unintended and even negative impacts on ecosystems. We also expect that governments will not be able to regulate artificial light everywhere, but by understanding its potential consequences, we can better prepare for or mitigate them.

Carefully designed experiments are needed to determine the exact effects of artificial light on ecosystems and over what spatial and temporal scales they act. From a management perspective, it is highly important to consider and incorporate the mitigation of potential ecological impacts and losses of biodiversity and ecosystem services into new lighting concepts (Rich and Longcore 2006, Hölker et al. 2010a, b). While there are many challenges to overcome in pursuing this research, the potential for new breakthroughs in under-

standing ecosystems and their functioning is high and should motivate researchers to innovate new techniques.

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## Cloud Coverage Acts as an Amplifier for Ecological Light Pollution in Urban Ecosystems

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### Abstract

The diurnal cycle of light and dark is one of the strongest environmental factors for life on Earth. Many species in both terrestrial and aquatic ecosystems use the level of ambient light to regulate their metabolism, growth, and behavior. The sky glow caused by artificial lighting from urban areas disrupts this natural cycle, and has been shown to impact the behavior of organisms, even many kilometers away from the light sources. It could be hypothesized that factors that increase the luminance of the sky amplify the degree of this “ecological light pollution”. We show that cloud coverage dramatically amplifies the sky luminance, by a factor of 10.1 for one location inside of Berlin and by a factor of 2.8 at 32 km from the city center. We also show that inside of the city overcast nights are brighter than clear rural moonlit nights, by a factor of 4.1. These results have important implications for chronobiological and chronocological studies in urban areas, where this amplification effect has previously not been considered.

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### Introduction

The ambient light level is one of the strongest factors driving animal behavior and chronobiology, evidenced by the dramatic split of most species into diurnal or nocturnal activity. It is therefore unsurprising that changes in ambient nighttime lighting result in behavioral and physiological changes for many nocturnal species [1], whether in terrestrial [2–4], marine [5], or freshwater [6–8] habitats.

With the exception of life in the deep oceans and underground, all life on Earth has evolved to live in an environment of cycles of light and dark, with a substantial proportion of the global biodiversity being nocturnal (30% of all vertebrates and >60% of all invertebrates [9]). Most organisms, humans included, have evolved molecular circadian clocks which are set by natural day/night cycles. Until the invention of artificial light, this meant that many behavioral and physiological traits were determined by the motions of the sun, the moon, the stars, and the weather (e.g. [10–12]).

The first lighting technology was fire, which was used expressly to modify animal behavior: fire allowed human activity to continue past sundown and frightened away human predators. Small scale urban lighting began with gas lamps, but the nighttime environment drastically changed with the widespread deployment of electric lighting in the last century. Since then, the rapid global increase of artificial light has fundamentally transformed night-scapes, both in terms of quantity, increasing several percent each year, and in quality (color spectra) [13].

Light pollution, which causes the “light dome” dome of sky glow over urban areas, is an unintended result of this electric lighting, and because of it approximately 10% of the world’s

population, and more than 40% of the US population, no longer view the night sky with dark adapted vision [14]. In addition to emptying the night sky of stars, it has been suggested this unwanted light may be damaging to our health [15–18], although this hypothesis is debated [19].

For any given individual species, the impact of artificial light may be neutral, beneficial (e.g. increased foraging), or detrimental (e.g. collisions with lighted structures [20]). In either of the latter cases this may disrupt predator-prey relationships and ecosystem functions [21,22]. Thus, light pollution can also be considered an important driver behind the erosion of ecosystem services (e.g. pollination of plants by moths or bats, loss of biodiversity, and changes to food webs [9]). Aesthetic values, such as the visibility of the Milky Way, could be also considered a vulnerable cultural ecosystem service [23]. While the fact that artificial light affects animal behavior has been recorded since Aristotle, recognition of the potential danger posed to entire social-ecological systems by urban lighting is relatively recent [13,24].

Sky glow occurs when light escaping upwards from a city is scattered back to the ground, through interactions with atmospheric components. On clear nights with extremely good visibility, urban sky glow is caused by the scattering of light by molecules (Rayleigh scattering), Rayleigh scattering affects blue light much more strongly than red, and is responsible for making the sky blue and the sunset red. The glow of distant cities is red for the same reason [25].

Atmospheric visibility is generally reduced due to the presence of aerosols, small particles or droplets suspended in the air that can come from natural (e.g. dust, sea salt) or artificial (e.g. soot) sources. Aerosols can impact light pollution in several ways. First, higher aerosol concentrations should amplify the sky glow

(particularly on cloud free nights), as aerosols increase the chance that light is scattered back to Earth. Second, if the aerosols are absorbing in the visible band (which is typical in the case of smog), they could reduce the extent to which environmental changes (e.g. snow, or as we shall see, cloud cover) amplify light pollution, as multiply scattered light would have increased chances of absorption. Third, in the case of very short visibility, the probability of light propagating to the city limits will be reduced, and thus the horizontal extent of the sky glow outside of the city should be reduced.

Clouds are effectively thick collections of aerosols (small water droplets) that almost non-absorbing at visible wavelengths. This makes clouds very reflective [26,27], and therefore we expect them to amplify sky glow. In the case of optically thick clouds, if we consider only the upward and downward propagation of light (as in the so-called two-stream approximation), then, to first order, the cloud bottom can be thought of as a two-sided, white (Lambertian) boundary, which diffusely reflects sun, moon, or city light back towards the hemisphere from which it came. While this analogy is clearly an oversimplification (e.g. one can usually see quite well outdoors in the daytime even under thick clouds), it is useful for gaining a "feel" for how clouds interact with light pollution. In the particular case of an observer under optically thick clouds and inside of a large city (where the cloud bottom is much closer to the observer than is the edge of the city), the model of the cloud bottom as a Lambertian surface is probably a reasonably good approximation.

This redirection of light back towards the ground gives rise to the effect shown in Figure 1, that while in pristine environments clouds appear as dark objects on the star filled sky, in cities clouds appear as bright objects on a dark background, nearly devoid of stars. While this phenomena has been qualitatively observed by many people, we believe that this work represents the first systematic and quantitative study of this effect presented in the scientific literature. The reasons a similar study by [28] did not observe this effect are considered in the discussion section. Measurements of the increase of light due to cloud coverage were shown in [29] and in a poster by Posch, Hollau, Kerschbaum, and Bleha presented at the Cancer and Rhythm conference, Graz Austria, 2004, but in both cases only for single nights.



**Figure 1. Photograph showing the amplification effect that clouds have on the sky glow.** Inside of cities clouds appear as bright objects on a dark sky. In natural environments, clouds look more like the tower in the photo: dark silhouettes against a star-lit sky. Photo: C. Gya. doi:10.1371/journal.pone.0017307.g001

While an atmospheric model of clouds as white surfaces and "Rayleigh scattering only" skies is sufficient to qualitatively discuss the results of this paper, we should note that quantitative modeling of light pollution requires much more attention to detail. For an observer on the ground, the radiance of the sky observed in any given direction depends upon a host of variables, including the wavelength of the light in question, the makeup of the atmosphere, the distribution of city lights on the ground, the topography of the city, and the observer's position within it. In the next two paragraphs we point to more detailed references, which together describe each of the components needed to fully characterize the sky glow produced by a city.

The scattering and absorption of light in the atmosphere is of central importance to climate science, and has thus been described in detail elsewhere (see e.g. [27,30]). Modeling the interaction of light pollution with clouds requires understanding of the optical properties of the cloud, in particular the cloud optical thickness (a description of the probability that light interacts with water droplets in the cloud), the single scatter albedo (the propensity of photons to be scattered rather than absorbed), and the asymmetry parameter (the relative proportion of photons that are scattered forward rather than backward) [27]. A detailed discussion of cloud reflectance can be seen in e.g. [26].

In most cases, atmospheric scientists focus discussion on the interaction of sunlight with the atmosphere. Light pollution, however, is very different from sunlight in that the angular distribution of upward traveling light depends strongly on position, and the spectral distribution depends very strongly on local factors (i.e. what types of lamps are in common use). An evaluation of the combined luminance of all of the sources of light a single city is given in [31], a comprehensive review of the spectrum of different lamp types is given in [32], and discussion of the geometry of light pollution, and sky maps showing the sky radiance caused by single or multiple lamps is given in [33].

Historically, light pollution research and advocacy has been undertaken by astronomers, who justifiably have little interest in cloudy nights. In the first serious model of light pollution [34], only the case of clear skies was considered, and with some exceptions (e.g. [33]), models and measurements generally consider only cloud-free conditions [14,35–38].

We expect the presence of clouds to significantly brighten urban skies, and to amplify the degree of ecological light pollution. We aim to show that in studying the impact of sky glow on ecology, health, or interruption of circadian rhythm, it is essential that cloud coverage be taken into account. In performing our analysis, we also expect to show that the level of light pollution in Berlin is ecologically relevant (meeting or exceeding the light levels produced by the moon), and finally that the total light produced by Berlin decreases as the night progresses.

**Materials and Methods**

The main goal of this paper is to measure how cloud coverage affects sky brightness in an urban environment. This measurement is referred to as the "cloud analysis". In order to allow for comparisons to the sky brightness typical of natural environments, we also study how the elevation of the moon above the horizon affects sky brightness. This is called the "moon analysis".

Our night sky brightness data were taken using the "Sky Quality Meter" (SQM) produced by Unihedron (Grimbsy, Canada), shown in Figure 2. The SQM measures luminance (surface brightness) for a patch of the sky, in units of magnitudes per square arc second (mag/arcsec<sup>2</sup>). The photosensitive element of the meter is a silicon photodiode (TAOS TSL237S light-to-frequency

converter), which responds to light with wavelengths in the range of 320 to 1050 nm, with a peak at about 680 nm. The photodiode is covered by a HOYA CM-500 filter, which reduces the wavelength response to 320 to 720 nm, in order to provide better agreement with the wavelength response of human night vision. The response of the SQM contains an internal temperature sensor which is used by the SQM software to provide compensation (i.e. the results reported by the SQM should have no temperature dependence over the range -25 to 70 degrees Celsius).

Unihedron produces several different models of the SQM, which are differentiated by their method of data readout and by their field-of-view (FOV). The SQM is available as a hand-held device with a digital display, or as a continuous measurement device using either a USB or Ethernet connection. We made use of Ethernet enabled SQMs, as Ethernet allows longer cable runs than USB. The field-of-view is determined by the presence (SQM-LE) or absence (SQM-E) of a focusing lens, which reduces the FOV from a wide angle to a small patch of the sky. The half-width at half-maximum has been measured to be 4° and 10° for the SQM-E and SQM-LE respectively [39]. For the measurements reported in this paper, we made use of one SQM-LE and two SQM-E devices.

The SQM reports the sky brightness in units of magnitudes per square arcsecond (mag/arcsec<sup>2</sup>), a logarithmic unit in use by the astronomy community. The scale is defined so that an increase of 5 in mag/arcsec<sup>2</sup> corresponds to a factor of 100 decrease in luminance. It is possible to approximately convert mag/arcsec<sup>2</sup> into nit (cd/m<sup>2</sup>) using the formula:  $cd/m^2 = 9.0 \times 10^{-8} \times 10^{0.4x}$ , where  $x$  is the luminance in mag/arcsec<sup>2</sup>. (This equation was provided to us by Unihedron, and originates from the webpage of Paul Schlyter: [www.ajarniimilen.se/comp/radfaq.htm](http://www.ajarniimilen.se/comp/radfaq.htm)) This conversion, however, contains an implicit assumption about the wavelength distribution of star light, which we can neither assume to be the same as light pollution, nor the same for both clear and

cloudy conditions. A general conversion from mag/arcsec<sup>2</sup> to lux is not possible, as converting luminance measurements to illuminance measurements requires making an assumption about the angular distribution of the sky brightness intensity, which we expect to change in the presence of clouds. The SQMs have a quoted systematic uncertainty of ~10% (0.10 mag/arcsec<sup>2</sup>).

The Ethernet enabled SQMs were installed at three locations: our measurement tower at the Institute for Space Sciences at the Freie Universität (52.4577°N, 13.3107°E), at the Leibniz-Institut für Freshwater Ecology and Inland Fisheries (52.4487°N, 13.6513°E), and on an island of the Spree river outside of the city (52.3681°N, 13.8049°E). The locations are approximately 10, 18, and 32 km from the center of Berlin, and can be classified as urban, suburb, and rural respectively. In order to protect the devices from rain and snow, the SQMs were installed in a protective housing produced by Unihedron. The housing consists of a short length of 3" PVC pipe fitted on the top and bottom with 3" PVC endcaps. The bottom endcap has a hole drilled in it to allow for entry of cables and to allow moisture to escape, and the top endcap has a hole to allow a window for observations. This window is covered with a glass top which is glued to the surface of the endcap. The attenuation of the glass cover has been measured to be 0.11 mag/arcsec<sup>2</sup> [40], and to correct for this effect we subtract this amount from the readings reported by the device. The internal web server of the SQM-LE produces enough heat to quickly melt snow and evaporate water from the glass surface.

The data were read out from the SQMs using a custom developed Perl script, partially based on sample code provided by the manufacturer. The devices were polled approximately once per second, and whenever the readout value changed, the time and sky brightness measurement were recorded to a file. These values were then averaged by our analysis program to create a minute-by-minute dataset. Despite the logarithmic scale, we directly averaged the measurements in mag/arcsec<sup>2</sup>, as we expect measurement differences at very short time scales are more likely to be due to the device electronics rather than a physical change in the sky brightness.

Our cloud coverage figures were taken from synoptic measurements at a manned weather station (Berlin-Dahlem, World Meteorological Index 10381) located adjacent to our measurement location at the Freie Universität. The SYNOP data were retrieved from the OGIMET website, <http://www.ogimet.com>. In synoptic observations cloud coverage is reported in "oktas", which represent the fraction of the sky obscured by cloud in eighth's. Zero oktas corresponds to a cloud-free sky, while eight oktas corresponds to completely overcast conditions. The synop data were reported hourly, so the maximum time difference between any sky brightness measurement and the most recent cloud observation was 30 minutes. Berlin has several synop stations, and we have verified that using cloud data from a different station (e.g. closer to the rural site) has only a minor impact on the results. Because we are most interested in what is happening at the urban location we used the data from the adjacent weather station.

In natural ecosystems, the moon is the highest source of light at night. The relationship between the intensity of moonlight (both direct and scattered) and the moon's position parameters (distance from Earth, phase, elevation above the horizon, and time of year) is computationally very complex (see e.g. the simulation presented in [28]). We eliminated the need to compensate for moonlighting in the cloud analysis by simply considering only moonless nights. To do this, it was necessary to calculate the position of the moon for each data point. This was accomplished using the "Astro:Coord:ECI" and "Astro:Coord:ECI:Moon" open source Perl scripts (v0.033), which were developed by Thomas R. Wyant, and



**Figure 2. Photograph showing the Sky Quality Meter installed in its protective housing (SQM-LU left), along with an expanded view (SQM-LE right).** The housing at left is shown with the two included hose clamps that allow easy attachment to a stake or pole. The USB version (left) requires only one cable, but at the cost of shorter cable runs and the internal heating provided by the Ethernet version (right). doi:10.1371/journal.pone.0017307.g002

are freely distributed by the Comprehensive Perl Archive Network (<http://search.cpan.org/~wyant/Astro-satpass-0.033/>). The algorithm is based upon calculations in [41], and has a quoted moon position uncertainty of 10 seconds of arc in latitude.

The moon positioning algorithm was initialized using the longitude, latitude, and elevation (91 m) of the measurement tower at the Freie Universität. The moon position was calculated at the 30 second mark of each minute, matching the median time of our sky brightness measurements. We define our data to be "moonless" when the moon's true position (i.e. ignoring any effects of refraction in the atmosphere) is 2° or more below the horizon.

The sky brightness data for the cloud analysis were taken during the period from April 22 to September 21, 2010, using wide field-of-view SQM-Es at our urban and rural measurement stations (10 and 32 km from the city center, respectively). Within this time span the data from six nights were rejected due to failures in the data acquisition chain (e.g. from a power interruption). The summer air in Berlin is relatively clean, and visibilities of 30–40 km were typical during this study. Because we expected the total amount of light produced by the city to decrease as the night progressed (from decreased auto, residential, and advertising lighting), we only considered data taken during the same time window each night. This considerably restricts the size of our dataset, but reduces the possibility of introducing systematic bias or larger variation into the observed sky glow.

The optimal duration of the data taking window depends upon the analysis that one wishes to pursue. For the cloud analysis our goal was to include as many different cloud coverage values as possible, getting a "snapshot" of the sky brightness at the same time as the cloud coverage measurement was taken, and for a variety of weather conditions, was more important than sampling unchanging skies over several hours. The large size of weather systems means that overcast or clear conditions often persist for several days, and for this reason we wished to use data from as many nights as possible. Due to the extremely short duration of the night at the time of the summer solstice in Berlin, this restricted us to using only data taken between 12:45 am and 1:15 am local time (UTC+2, Central European Summer Time). Berlin is near the center of its time zone, so the moment of "true" local midnight occurred during this half-hour period for each night in our dataset.

In the case of our moon analysis we were less concerned with including as many individual nights as possible. Instead, we preferred to use a longer time interval each night, which allowed

the moon to move through a substantial range of elevation above the horizon each night. For this reason we only used data taken at least three weeks away from the summer solstice (i.e. April 22–May 30, and July 13–September 21). This allowed us to use a wider time window than that used in the cloud analysis, from 12:00 am to 2:00 am. To avoid the possible influence of clouds, we only included data for which the cloud coverage in the two synop reports nearest to the sky brightness measurement was 0 or 1 oktas.

The computer reading out the data at the Freie Universität has access to an Internet connection, which allowed timing to be maintained to better than second accuracy throughout the data taking period. The computer collecting data at the remote location, however, was located in a non-climate controlled container, and experienced clock drift. This computer's time was periodically corrected manually, at intervals ranging from 5 to 38 days. When these corrections were made, the total drift since the last correction was noted. This allowed us to remove the linear portion of the clock drift in software, and pass the corrected data to our analysis program after the data was collected. Over the entire period of data taking, the average clock drift was +12.9 seconds/day, and we do not expect that the maximum deviation from true time at any period in our dataset was more than 5 minutes.

**Results**

The sky brightness values recorded on three representative nights (clear, partly cloudy, and overcast) at our three measurement locations are shown in Figure 3. In all weather conditions, the rural site was darkest (largest value of mag/arcsec<sup>2</sup>) and the urban site was brightest. The plot at left shows the data for the clear (0–1 oktas) night of June 4–5, 2010, during which the half full moon rose at 1:21 am. The middle plot shows data for May 20–21, which was partly cloudy (3–4 oktas) until 3 am, when the sky cleared (to 1 okta). The right hand plot shows the data for May 13–14, which was overcast (8 oktas) the entire evening. A dotted line is drawn in the right hand panel to show the portion of the data from that night that contributes to the cloud analysis.

At midnight on the clear night in the left hand frame of Figure 3, the sky brightness at the rural site was on average about 1.85 mag/arcsec<sup>2</sup> darker than the urban site (2.4 mcd/m<sup>2</sup> compared to 0.43 mcd/m<sup>2</sup>, ~1/5 the luminance), while on the overcast night it was 3.15 mag/arcsec<sup>2</sup> darker (26 mcd/m<sup>2</sup> compared to 1.4 mcd/m<sup>2</sup>, ~1/20 the luminance). It is immediately apparent from these plots that the sky glow exhibits a strong

urban→rural gradient, and that clouds have a very significant impact on urban sky brightness. Note that the suburban data were taken with a narrow FOV SQM-LE, which we found tends to record darker values for clear and partly cloudy conditions. We included the suburban data in Figure 3 to emphasize the urban→rural transition, but we do not use the data from that location in our cloud or moon analysis.

While we would in principle prefer to have equivalent statistics for each level of cloudiness, in practice we must make use of the conditions that nature provides. Table 1 shows the number of nights in the dataset for which each degree of cloudiness was observed at 1 am. The table also shows the effective number of nights available for the cloud analysis. Fractional values occur because of occasional data loss, and because of nights during which the moon rose or set during the 30 minute analysis period. Clear or overcast conditions occurred much more frequently than partly cloudy (2–6 oktas) skies.

Our results for the cloud analysis using the full dataset are shown in the left panel of Figure 4, and numerically in Table 2. In the figure, the upper set of points represent the data at the rural location, while the lower set were taken inside of the city. For each value of cloudiness (in oktas) the median sky brightness observed is shown with a horizontal line. The variation in the observed data is shown by the thick and thin lines, which cover the ±1 and 2σ bands (containing ~68% and 95% of the observed data, respectively). The large separation between the distributions for clear and cloudy conditions at the urban site refutes the null hypothesis (i.e. that clouds do not amplify urban sky glow) with certainty.

We found that on the clearest nights around the time of the solstice, the sky at the rural location doesn't appear to get quite as dark as it might on an equivalent night in the spring or fall. As is shown in Figure 5, on these nights the ʌ shaped pattern of the sky darkening and then brightening doesn't include the typical broad plateau. However, due to both our narrow time window of 15 minutes around 1:00 am, the large number of clear nights, and the marked difference between the urban and rural measurements, the impact of this effect is a minor increase in the spread of the data for the darkest nights. As a test, we tried selecting data within 15 minutes of 1:08 am (which is a better approximation of local midnight), and found that this had a negligible impact.

The results of the moon analysis are shown in the right hand panel of Figure 4. The data are grouped in bins of 5° of moon elevation above the horizon, and the bars show the ±1 and 2σ bands, as in the plot at left. Negative values of elevation indicate that the moon was below the horizon, and are shown in individual bins as a consistency demonstration.

As discussed in the Materials and Methods section, the analysis uses only a small portion of the data from each night because the

total amount of light produced by the city is expected to change as the night progresses. We tested this hypothesis by selecting a small number of nights with completely overcast skies. In order to guarantee overcast skies, data were only included if the cloudiness was 8 oktas in both of the adjacent hourly synop reports. Figure 6 shows how the sky glow over the Freie Universität changed during nights between April 26 and May 15. The left hand plot shows the data in mag/arcsec<sup>2</sup>, the right hand plot shows the same data on a linear scale, using the approximate conversion to cd/m<sup>2</sup> (nit). Over the course of the night the sky brightness decreased from 15.95 to 16.55 mag/arcsec<sup>2</sup>, a decrease in luminance of approximately 40%.

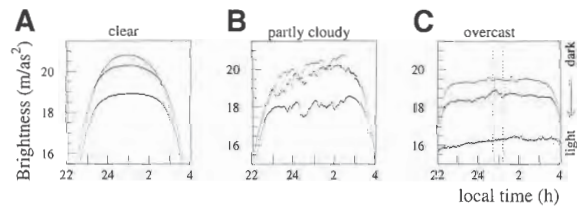
The data on which these results are based is provided in supplemental File S1. The table's contents are: the date, time of observation in "hours after midnight" in the GMT+1 time zone (i.e. +0.5 is 12:00:00 am, and -0.0083 is 11:59:30 pm), the sky brightness value observed at the urban and rural sites (in mag/arcsec<sup>2</sup>), the cloud coverage from the most recent SYNOP report in oktas, the difference in oktas between the two adjacent SYNOP reports, the cloud base (an integer code number as per the SYNOP specifications, see e.g. <http://weather.unisys.com/wsp/Appendices/Formats/SYNOP.html>), the visibility (in meters), and finally the elevation (in degrees), illuminated fraction, and distance (in km) of the moon.

**Discussion**

Using two SQMs, we studied changes in the sky brightness of Berlin in a rural and urban location over a period of 152 calendar days. The degree to which Berlin's skies are polluted by light can be demonstrated by comparing the sky brightness measured here with that measured in a more natural setting. In a recent study of sky brightness at the Zschiegen Landscape Protection Area in Hungary (an International Dark-Sky Park), the darkest measurements obtained on clear moonless nights using an SQM were 21.5–21.6 mag/arcsec<sup>2</sup> [38]. The very darkest observations for clear moonless nights in Berlin were ~21.2 mag/arcsec<sup>2</sup> at our rural location and ~19.3 mag/arcsec<sup>2</sup> at our urban location, a luminance greater by 38% and 690%, respectively. Typical nights at both locations, however, were far brighter even than this.

The left hand plot of Figure 4 demonstrates the significant degree with which clouds amplify the impact of light pollution. The data show a strong dependence on the cloudiness level, with very rapid brightening as the sky becomes fully overcast. The measured sky brightness for fully overcast skies at our urban measuring station was 16.5 mag/arcsec<sup>2</sup>, a luminance approximately 10600% brighter than that observed for dark nights at the dark-sky park in Hungary.

We can see that this sky brightening is ecologically relevant by comparing the brightness at the urban station to the brightness observed on moonlit, cloud free nights at our rural station. The two panels of Figure 4 show that regardless of weather conditions, the night sky of Berlin is almost always as bright as that naturally experienced during a high elevation summer moon. (Although it should be kept in mind that the SQM-E effectively measures the integral amount of light incident on a plane parallel to the ground. The angular distributions of sky glow and direct moonlight, and therefore an organism's visual experience of the environment under the two, are very different.) This means that for light avoiding organisms that moderate their behavior in the presence of moonlight, for example zooplankton in a lake system [42], the light pollution from Berlin is expected to be a considerable stressor. It has been previously shown, in lake food webs, that light mediated diurnal vertical migrations of zooplankton may be



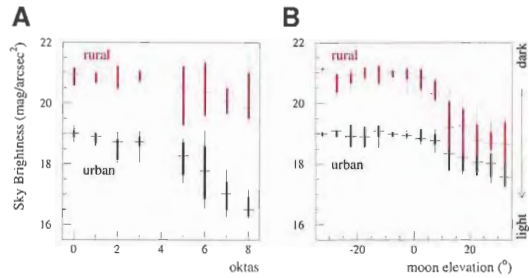
**Figure 3. Examples of the sky brightness (in mag/arcsec<sup>2</sup>) observed for different cloud conditions and at different locations.** The minute by minute data for individual clear (A, June 4–5), partly cloudy (B, May 20–21), and overcast (C, May 13–14) nights at each of our rural (red), suburban (blue), and urban (black) measurement stations is shown. Larger values of mag/arcsec<sup>2</sup> indicate darker skies. The unit is logarithmic, with a 2.5 increase in mag/arcsec<sup>2</sup> corresponding to a sky that is ~10 times as dark. The dotted lines in the plot at right show the time window used in the cloud analysis. doi:10.1371/journal.pone.0017307.g003

**Table 1. Frequency of cloud coverage conditions over the course of data taking.**

Okta	0	1	2	3	4	5	6	7	8
Total Nights	21.5	26.5	7	12.5	7	13	10	23	26
Moonless Nights	11.9	10.6	3	7	0	5	6	9.2	13.6

For each value of cloud coverage (0 is clear, 8 is overcast), the number of nights in the observation period is shown along with the effective number of nights that the moon was at least 2° below the horizon between 12:45 and 1:15 am. Fractional values occur due to occasional data loss due to power outages, and to nights during which the moon rose. doi:10.1371/journal.pone.0017307.t001





**Figure 4. Profile histograms of the sky brightness data.** Panel A shows the sky brightness observed as a function of cloud coverage. The bars show the  $\pm 1$  and  $2\sigma$  spread of the data. Panel B shows the sky brightness as a function of moon elevation for clear (0–1 oktas) nights. Larger values of mag/arcsec<sup>2</sup> indicate darker nights. doi:10.1371/journal.pone.0017307.g004

suppressed, decreasing the grazing pressure on phytoplankton [7,43].

The amplification of sky glow by clouds surely amplifies this stressor, since we observed that the sky glow typical on overcast nights within Berlin was 4.1 times as bright as that observed outside the city on clear nights with a high elevation moon. In pristine ecosystems at a similar latitude to Berlin, a sky glow brighter than 19 mag/arcsec<sup>2</sup> is likely only experienced for several hours on a few nights each summer, namely on cloud free nights when the moon happens to be high in the sky. This “worst case scenario” for some zooplankton species in their natural environment represents almost the most favorable conditions they can ever face in the urban waterways of Berlin. While it can be expected that some species will be genetically capable of adapting their behavior, physiology, growth, and reproduction to live in or take advantage of unnaturally lit environments, other species will not, and at least some light-sensitive species and genotypes will be lost in the long term [9].

The “error bars” shown in Figure 4 are not uncertainties, but rather represent the spread of the observed data. For the data in the cloud analysis there are three sources of variation. First, during a single night, changes in the local cloud coverage (i.e. the positions of clear and cloudy patches of the sky relative to the SQM) lead to changes in the measured sky brightness, in part due to the angular response of the SQM. This was shown in Figure 3. While only data taken within 15 minutes of the synoptical

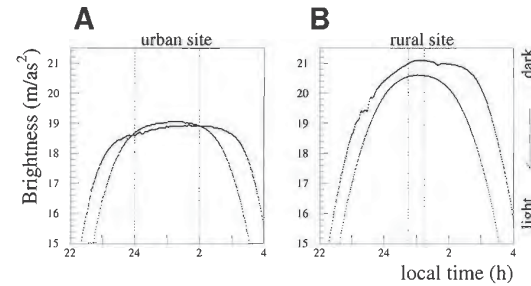
observation we considered, in some cases the cloud coverage changes during this time. Second, “oktas” are a relatively crudely spaced measure, and are determined by human observers, each of whom might have a slightly different idea of where the cutoff lies between, say, 3–4 oktas. Third, from night to night the baseline value for a given number of oktas is expected to be different, due to differences in the environmental conditions: cloud type (i.e. the cloud height, optical thickness, single scatter albedo, and asymmetry parameter), surface albedo, visibility, and atmospheric aerosol content. It is this second source of variation that gives rise to some of the “lopsided” distributions, where the upward and downward lengths of the 1 or 2σ bars differ considerably in length. For example, the large upward tail on the rural 8 oktas measurement in Figure 4 is due to a night with exceptionally low clouds (100–200 meter ceiling). Finally, in the case of the rural data, the cloud condition at the rural site may be slightly different than at the urban site, where the synoptical observation was made.

We believe the largest source of the night to night variation, and the reason for the steep increase in brightness with cloud level at 4–5 oktas, is changes in cloud type and thickness. Scattering from aerosols is strongly forward peaked, so while light may be deflected as it propagates through a thin cloud it is not particularly likely to be scattered back towards the ground. Thick clouds on the other hand, are expected to be very efficient at scattering light back down to ground level, as the photons must undergo many scattering events before leaving the cloud top. The hypothesis that

**Table 2. Amplification factor of clouds.**

Okta	0	1	2	3	4	5	6	7	8
Rural (mag/arcsec <sup>2</sup> )	21.0	20.8	20.7	20.9	/	20.5	20.4	20.1	19.9
Urban (mag/arcsec <sup>2</sup> )	19.0	18.9	18.7	18.7	/	18.3	17.8	17.0	16.5
Rural amplification	1	1.2	1.3	1.1	/	1.5	1.7	2.3	2.8
Urban amplification	1	1.1	1.3	1.3	/	2.0	3.1	6.1	10.1

For each value of cloud coverage (0 is clear, 8 is overcast), the median observed sky brightness over the course of data taking is shown in mag/arcsec<sup>2</sup>. These data were used to calculate a sky brightness amplification factor for each level of cloudiness (relative to clear skies). Under clear conditions urban skies were 6.1 times brighter than at the rural site. doi:10.1371/journal.pone.0017307.t002



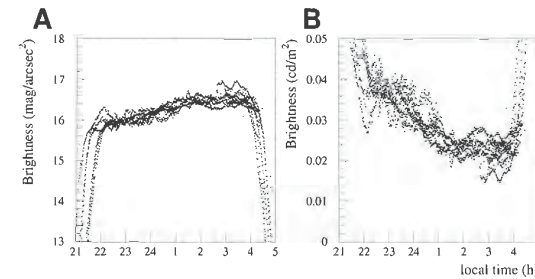
**Figure 5. Nights are dramatically shorter around the time of the summer solstice.** The minute by minute sky brightness data (in mag/arcsec<sup>2</sup>) for the night of June 16–17 (red) is compared to July 20–21 (black) at our urban (A), and rural (B) locations. In the left plot the dotted lines indicate the time window used in the moon analysis, and in the right plot the time window used in the cloud analysis. Due to the shortening days we reject data taken within three weeks of the summer solstice from our moon analysis. The curve for July 20–21 at the rural site appears lopsided because the moon set shortly before 1am. doi:10.1371/journal.pone.0017307.g005

the night to night variation is due to changes in cloud type could be easily tested by repeating this experiment in a location that has access to continuous LIDAR measurement of cloud properties.

We have demonstrated that in Berlin, and presumably in urban areas in general, cloud coverage has a strong amplification effect on light pollution. Due to this amplification, the luminance of the night sky in Berlin is 10.1 times brighter on overcast nights than on clear moonless nights, and 4.1 times brighter than that observed at our rural location on the brightest clear nights with a high elevation moon. Since many organisms are known to modify their behavior in the presence of moonlight, and because of the high frequency of overcast conditions, the cloud amplification effect has strong implications for the ecology of urban areas. The influence of cities extends over large areas: at 32 km from the city center the

impact of clouds was still to brighten (by a factor of 2.8), rather than to darken, the night sky.

In contrast to the results reported here, a similar study undertaken in Hong Kong as part of a Master’s thesis did not find a dependence of the night sky brightness on cloud coverage [28]. Although there were several methodological differences between that study and the present work, we believe that the primary reason for the different conclusions is that the studies were taken under completely different environmental conditions. The horizontal visibility measured by the synop station in Hong Kong was typically between 4 and 12 km. This is far shorter than that reported in Berlin, which was in almost all cases >10 km. A second important difference is that the data presented in [28] are for a site 15–20 km away from Hong Kong itself, a very large



**Figure 6. The sky brightness measured at the urban location is shown against local time for overcast skies in the April 26 - May 15 period.** Data were included if the cloudiness was reported as 8 oktas in both the hourly report before and after the data was taken. Panel A shows the minute-by-minute data in the usual logarithmic scale (mag/arcsec<sup>2</sup>), panel B shows the same data on a linear scale, using the approximate conversion to cd/m<sup>2</sup>. The data shown were taken during the nights of April 26, May 2–3, May 6–7, May 9–10, May 11, and May 13–15, 2010. doi:10.1371/journal.pone.0017307.g006

distance compared to the typical visibility. It may be that an examination of the data taken within Hong Kong itself would reveal a stronger relationship between cloud coverage and sky brightness. We agree with the suggestion in [44], that duplication of this study in other cities could help to elucidate the interaction between visibility, aerosols, clouds, and sky brightness, particularly if the site has access to LIDAR data.

The recent development of convenient sky brightness meters (both the Sky Quality Meter and the International Year of Astronomy Lightmeter) has made the continuous monitoring of ecological light pollution simple. The long term deployment of these devices by light pollution researchers in cities and dark sky parks, and by ecologists and physiologists in their research environments, will allow for both a quantitative understanding of the difference in night lighting across social-ecological systems, and for systematic, high precision, ground based tracking of year-to-year changes in sky brightness.

The well known map of world light pollution [14] includes by necessity only data from clear nights. Our analysis indicates that it is very important that biological conclusions based upon those results (e.g. [16]) consider the potential role that weather plays in enhancing the brightness of urban areas. Additionally, researchers performing *in situ* experiments in or near urban areas in which the presence or absence of the moon is known to affect the result (e.g. insect catches, [4,45]) should be aware that clouds and aerosols may play a larger role than the moon in determining ambient lighting.

It may be the case that the regional frequency of overcast nights is more important than population density in determining the

threat posed to urban ecosystems by light pollution. By extending this analysis to include cities and towns of varying size, different regions, rural areas, and dark sky parks, we could test if this is the case. The development of a global dataset of continuous measurements from sky brightness meters would allow for rigorous evaluation of the results of [14], would provide strong constraints for verifying light pollution models, and would be beneficial to ecologists and light pollution researchers everywhere. We encourage anyone interested in participating in such a measurement to contact us.

### Supporting Information

#### File S1

(TXT)

### Acknowledgments

We would like to thank Unihedron for their technical and software support.

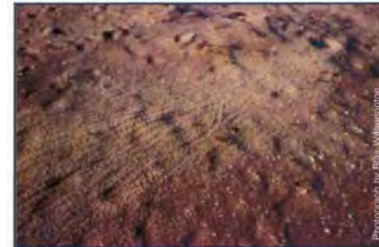
### Author Contributions

Conceived and designed the experiments: CCMK TR FH JF. Performed the experiments: CCMK FH TR. Analyzed the data: CCMK. Contributed reagents/materials/analysis tools: CCMK. Wrote the paper: CCMK FH JF TR.

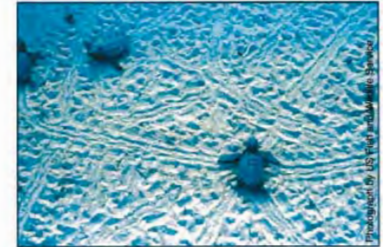
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# IDA Practical Guide



Turtle trails that go straight to the ocean, as they should.



Turtles that are confused by light pollution (shown above with their erratic trails), are unable to find their way to the ocean.

## Topic : *Effects of Artificial Light at Night on Wildlife*

FROM THE BEGINNING OF EXISTENCE, humans have controlled their immediate environment, building shelters to keep out the elements and fires to banish the darkness. As civilizations continue to develop, humans are able to affect dizzying change on habitats in all corners of the globe. Though agreeable to us, many of the comforts of advanced society are devastating to the creatures that share the earth. A growing body of data suggests that artificial night lighting has negative and deadly effects on a wide range of creatures, including amphibians, birds, mammals, insects, and even plants.

Humans have evolved as diurnal animals, biased toward the daytime and dependant on visual cues, so illumination of our nightscapes seems comfortable and necessary. All animals, including humans, depend on a regular interval of daylight and darkness for proper functioning of behavioral, reproductive and immune systems. Many of these animals need the natural night to survive. For thousands of species, the natural dark night of the evolutionary past is an integral component of their continued existence.

Artificial night lighting harms species directly by triggering unnatural periods of attraction or repulsion that lead to disruptions in reproductive cycles, by fixation, by

disorientation, or by interfering with feeding and sustenance. Light pollution has been shown to disorient migratory birds and hatchling turtles, disrupt mating and reproductive behavior in fireflies and frogs, and interfere with communication in species from glowworms to coyotes. Disturbances such as degradation of habitat, creation of artificial and dangerous habitat, and energy waste that may lead to climate change can all be linked to excessive artificial night lighting. Research biologists are warning that the negative synergy of such combinations can result in a cascade effect, with disastrous results for entire ecosystems around the world.

Climate characteristics vary from one year to the next; it is not uncommon to experience cool summers, dry springs, and slow falls. A season's photoperiod is the only consistent factor in the natural environment. Therefore, many species of plants and animals rely on the length of the day to indicate the proper season for mating, molting, and other life cycle activities. This photoperiodic sensitivity is often so acute that many species can detect discrepancies in natural light as short as one minute. Reproduction cycles are most often disrupted when artificial light at night interferes with species' natural detection systems. Tees have been known to bud prematurely; some flowers cease blooming. Artificial light also can cause animals such as squirrels and robins to mate out of season. Changes in plant and animal reproductive activity can create difficulty in finding food and increase chances of starvation.

**Diurnal**—active during daylight  
**Photoperiod**—duration of sunlight as determined by season (photoperiodic—internal clock governed by how long the day is)  
**Phototaxis**—movement in response to light  
**Predation**—predatory behavior in animal relationships



Pine Barrens tree frog

Photograph by Alexei Pucev

**There is evidence that the use of high and low pressure sodium light in ecologically sensitive areas such as wetlands, woods, and coastal areas has less impact on habitat and life cycle behavior than use of other kinds of light.** The relatively monochromatic wavelength emitted by the yellow tinted sodium vapor lights attracts fewer insects and can be more easily filtered to minimize negative effects.

Insects, frogs, toads, and salamanders have demonstrated both physical and behavioral disruptions as a result of artificial night lighting. A majority of frog and toad species are nocturnal and, because they must remain close to a water source, are less able to compensate for changes in the environment by relocating.

Like other amphibians, salamanders are currently suffering population declines around the world. Many species of pond-breeding salamanders show strong site fidelity to their home ponds, and studies to date have shown that artificial illumination can disrupt salamanders' ability to return to home ponds to breed.

Artificial light at night contributes to lack of food (starvation) by interfering with predator/prey relationships. For instance, moths and other night-flying insects are attracted to lights. This involuntary phototaxis leads to their easy capture. Their incessant gravitation toward artificial points of light not only makes them vulnerable as prey and subjects them to increased predation, but disrupts the normal nocturnal patterns of predator species by creating an artificial feed concentration around points of light. For some species of predators, such as bats or birds that are not repelled by light, this disruption means a change in the concentration and location of their feed, which can lead to imbalances in predator/prey ratio. For species repelled by light, such as horseshoe bats, long eared bats, and mouse eared bats, feed becomes scarcer and difficult to procure, as many insects swarm around lights, leaving fewer to be caught as they fly free. The decreasing amount of available food due to

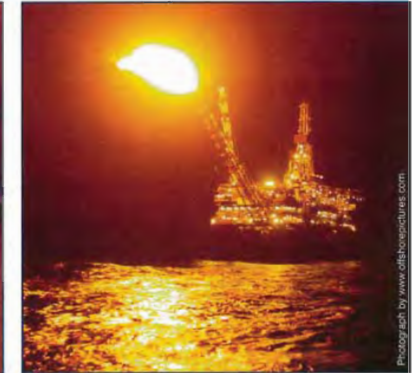


Insects are attracted to the white light of floodlights.

Photograph by Alexei Pucev



Visible for miles, squid boat lights unnaturally attract species of fish and migratory birds.



Relentless lights are common on offshore oil platforms.

Photograph by www.elfsbiostructures.com

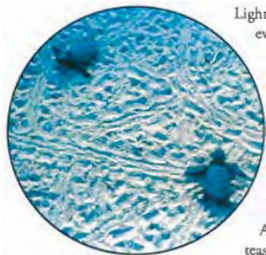
**Upon discovering the magnitude of fatal bird collisions,** some cities are initiating mitigation procedures. The Lights Out Toronto campaign, established in 2006 in Toronto, Canada calls for residents to turn out any unnecessary lights for the protection of migratory birds. In addition, the city has issued bird friendly development guidelines for all new buildings, which include the control of unnecessary artificial light. In September 2008, Boston, MA, USA began a two-month initiative to conserve electricity by shutting off lights at 34 city skyscrapers. A stated purpose of this project was the protection of migrating birds. Chicago, IL and New York, NY USA also participate in a "Lights Out" during migration season.

**As awareness of the danger of artificial light to sea turtles grows,** an increasing number of communities are restricting coastal illumination. Countries all over the world have passed ordinances that control the amount and type of light used in coastal environments. As the list grows, hatchling sea turtles are starting to be able to find the sea without the help of human volunteers to guide them. Learn more about local and regional action by visiting [www.seaturtle.org](http://www.seaturtle.org).

a combination of habitat loss and life cycle disruption is causing many bat populations, such as Europe's horseshoe bat, to become threatened or endangered.

Since the eyes of nocturnal animals are specially evolved for foraging in low-light conditions, small changes in illumination can compromise strategies and profoundly alter their relationship with prey species. Even fish are affected by artificial light. Some species of fish, normally exposed only to natural light sources such as phosphorescence, can be temporarily blinded and left vulnerable by artificial light. Artificial light also inhibits normal anti-predation behavior such as schooling, and can affect migration patterns in species such as salmon and sockeye fry.

Offshore, brightly lit oil and gas platforms and squid vessels that attract prey and affect numerous species of fish with lights pose both primary and secondary hazards to marine birds. The illumination and heat of offshore hydrocarbon platforms and squid fishing vessels also encourage algae growth, attracting fish and invertebrates. Marine birds are then killed around squid vessels by swallowing hooked prey or by feather contamination in oil-fouled water at hydrocarbon platforms. Marine birds that feed on bioluminescent prey may be particularly sensitive to light source attraction, many threatened and endangered species at great risk from artificial ocean lighting. Many species are susceptible to fixation—also known as "capture"—on artificial lights at sea; exhausted birds will circle for hours or days until they fall into the sea. Off eastern Canada in 1998, tens of thousands of seabirds were observed circling the newly operational Hibernia platform, fixated by an unrelenting point of illumination.



Light fixation is a constant bird hazard that continues to kill thousands of birds in urban areas every year. Hundreds of terrestrial bird species fly and migrate under cover of night. While the mechanisms for birds' attraction to artificial night lighting are not well understood, its hazards to birds have been well documented. During the 1960s, it is estimated that over a million birds a year were killed in collisions with lighted television towers in the United States. Since that time, the number and height of communication towers has increased exponentially. Skyscrapers and other urban buildings also threaten birds, posing collision, fixation, and disorientation hazards.

### Light and Sea Turtles

Artificial light at night is devastating sea turtle populations around the world for several reasons. Studies in Florida have shown that loggerhead, leatherback, and green turtle females choose the darkest beaches for their nest sites and will not nest at beaches lit by mercury vapor lights. On beaches subject to indirect light trespass, turtles will avoid the more brightly lit areas in preference to the dark. Nests are, therefore, more concentrated in the dwindling dark spaces, causing more hatchlings to succumb to predators and other site-specific hazards.

However, the most deadly problem facing these internationally protected sea turtles is disorientation from excessive and carelessly placed light. Many types of coastal illumination, including street, residential, and business lighting, confuses newly emerged hatchlings, which instinctively orient to the brightest light source. For thousands of years, this source was the reflection of moon and starlight on the sea. The turtles' natural programming allowed them to reach the water safely. Today, development along coastlines can cause hatchlings to head inland instead toward artificial lights, where they die of exhaustion, dehydration, predation, and road traffic. Each year, Florida alone loses hundreds of thousands of hatchlings.

Inappropriate artificial night lighting disrupts physiological as well as environmental functions. Hormone production in vertebrates, for example, is regulated by the circadian rhythm. Studies in humans and rats show a correlation between exposure to even low levels of illumination during normally dark hours and depressed levels of melatonin (a hormone produced in the retina), resulting in an increased risk of accelerated growth in breast cancer tumors. The effect of artificial night lighting on melatonin and other hormonal systems has yet to be studied in the wild, a study made more difficult by the scarcity of natural dark night conditions in most Western ecosystems.

While the wide range of potential damage caused by artificial light at night is still being discovered, steps to reset the natural balance between light and darkness are already being taken. To help preserve wildlife and minimize damage to ecosystems, start by following the steps listed in the Practical Actions to the right. A list of resources to increase knowledge of these topics and links to information on local and regional action groups can be found at the end of this practical guide.

### Practical Actions:

- Turn off unnecessary lights around your house and yard.** Use timers and sensors to help put light only where and when it is needed.
- Use fully shielded fixtures to direct the light ONLY WHERE NECESSARY FOR COMFORT AND SAFETY.**
- See red:** Use red filters on house and street lights. Red lights emitting a low wavelength generally have less of an impact on wildlife. Sea turtles and other coastal creatures, as well as amphibians and many species of insects, react especially well to red light—by hardly reacting at all.
- ...or yellow:** Yellow lights such as high pressure sodium (HPS) or low pressure sodium (LPS) lamps attract fewer insects and moths (think of your typical yellow front porch bug light). If light is required, advocate for their use in environmentally sensitive areas such as coastal regions or forest preserves.
- Get educated:** field guides and nature walks will help identify vulnerable species in your area.
- Raise awareness:** Most people are blind to the impact artificial light has on wildlife. A presentation to a social club or activist group could increase interest and win supporters.
- Ask that any further development in your community include a report on ecological issues of light pollution in their environmental impact statement.**

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### Related Practical Guides and Web Links:

Blair E. Witherington and R. Erik Martin. "Artificial Lighting and Sea Turtle Hatchling Behavior." *Florida Marine Research Institute Technical Reports*. TR-2 (1996)—[http://research.myfwc.com/features/view\\_article.asp?id=2156](http://research.myfwc.com/features/view_article.asp?id=2156)

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FLAP—Fatal Light Awareness Program—<http://www.flap.org>

FWC—Florida Fish and Wildlife Conservation Commission—[http://www.myfwc.com/WILDLIFEHABITATS/Seaturtle\\_Lighting.htm](http://www.myfwc.com/WILDLIFEHABITATS/Seaturtle_Lighting.htm)  
seaturtle.org—<http://www.seaturtle.org>

**For information on IDA membership and donations, visit our Web site at [www.darksky.org](http://www.darksky.org).**

<http://www.darksky.org/light-pollution-topics/the-environment>



references, pictures, and web resources.

A non-profit member organization that teaches others how to preserve the night sky through facemasks, law

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#### Light Pollution Topics

- Light Pollution Matters
- The Environment
- Ill Health
- Energy Waste
- Lighting, Crime & Safety

<http://www.darksky.org/light-pollution-topics/the-environment>

- Night Sky Heritage
- Take Action!
- IDA Partners**
- International Offices
- IDA Chapter Directory
- IDA Chapter News
- Affiliates
- Related Organizations
- News and Publications**
- Nightscape Newsletter
- E-news
- Press Releases
- Guides to Lighting and Light Pollution**
- General IDA Brochure
- Practical Guides & Brochures
- Specifier Bulletins for Lighting Applications
- Reports and Studies
- Model Lighting Ordinance
- Glossary
- Materials and Outreach**
- IDA Activity Book
- Star Parties
- IDA Displays
- IDA Annual Awards
- Education
- Dark Skies Awareness and IYA2009
- Events**
- Annual Conference
- European Symposium
- International Dark Sky Week
- Event Archives
- Press Room**
- Press Kit
- IDA Fact Sheet
- Multimedia**
- Videos & Podcasts

<http://www.darksky.org/light-pollution-topics/the-environment>

- Dark Sky Ambassadors
- Images
- NeedLess Campaign and Lighting Design Simulator
- Shop IDA**
- IDA Marketplace

## THE ENVIRONMENT

*"When we add light to the environment, that has the potential to disrupt habitat, just like running a bulldozer over the landscape can."* — Chad Moore National Park Service



### Light pollution is a threat to the environment

For billions of years, all life has relied on Earth's predictable rhythm of day and night. It's encoded in the DNA of all plants and animals. Humans have radically disrupted this cycle by lighting up the night.

Plants and animals depend on Earth's daily cycle of light and dark rhythm to govern life-sustaining behaviors such as reproduction, nourishment, sleep and protection from predators.

Scientific evidence suggests that artificial light at night has negative and deadly effects on many creatures including amphibians, birds, mammals, insects and plants.

### Artificial lights disrupt the world's ecosystems

Nocturnal mammals sleep during the day and are active at night. Light pollution radically alters their nighttime environment by turning night into day.



Credit: [Michael Newton](#)

Credit: [Chris Parfitt](#)

According to research scientist Christopher Kyba, for nocturnal animals, "the introduction of artificial light probably represents

<http://www.darksky.org/light-pollution-topics/the-environment>

the most drastic change human beings have made to their environment."

"Predators use light to hunt, and prey species use darkness as cover," Kyba explains "Near cities, cloudy skies are now hundreds, or even thousands of times brighter than they were 200 years ago. We are only beginning to learn what a drastic effect this has had on nocturnal ecology."

Glare from artificial lights can also impact wetland habitats — home to amphibians such as frogs and toads, whose nighttime croaking is part of the breeding ritual. Artificial lights disrupt this nocturnal activity, interfering with reproduction and reducing populations.

#### Artificial Lights Can Lead Baby Sea turtles to their Demise

Sea turtles live in the ocean but hatch at night on the beach. Hatchlings find the sea by detecting the bright horizon over the ocean. Artificial lights draw them away from the ocean. In Florida alone, millions of hatchlings die this way every year.



Glare from artificial lights can also impact wetland habitats — home to amphibians such as frogs and toads, whose nighttime croaking is part of the breeding ritual. Artificial lights disrupt this nocturnal activity, interfering with reproduction and reducing populations.

Migratory birds depend on cues from properly timed seasonal schedules. Artificial lights can cause them to migrate too early or too late and miss ideal climate conditions for nesting, foraging and other behaviors.

#### Artificial Lights have Devastating Effects on Many Bird Species



Birds that migrate or hunt at night navigate by moonlight and starlight. Artificial light can cause them to wander off course and toward the dangerous nighttime landscapes of cities. Every year millions of birds die colliding with needlessly illuminated buildings and towers.

Migratory birds depend on cues from properly timed seasonal schedules. Artificial lights can cause them to migrate too early or too late and miss ideal climate conditions for nesting, foraging and other behaviors.



<http://www.darksky.org/light-pollution-topics/the-environment>

#### Ecosystems: Everything is Connected

Many insects are drawn to light, but artificial lights can create a fatal attraction. Declining insect populations negatively impact all species that rely on insects for food or pollination. Some predators exploit this attraction to their advantage, affecting food webs in unanticipated ways.



#### Resources

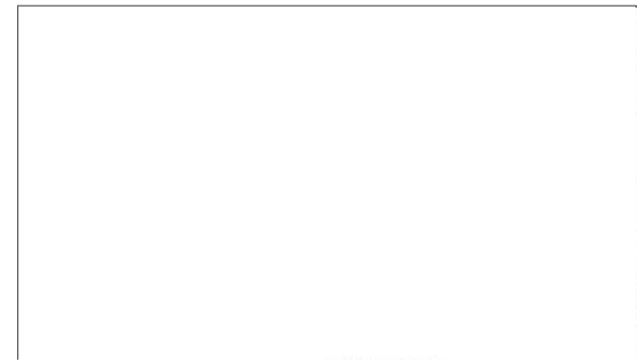
- [IDA Light Pollution & Wildlife brochure](#)
- [IDA Light Pollution & Wildlife Practical guide](#)
- [Audubon Bird-Safe Building Guidelines](#)
- [Wildlife Research](#)

#### For Kids

[Nighttime Activity Book](#)

#### Videos

Dark Ranger, Kevin Poe, explains how light pollution affects baby sea turtles and provides ways in which we can help them successfully make their journey from the shore to the ocean.



Learn in one minute what you can do to protect birds.



<http://www.darksky.org/light-pollution-topics/the-environment>

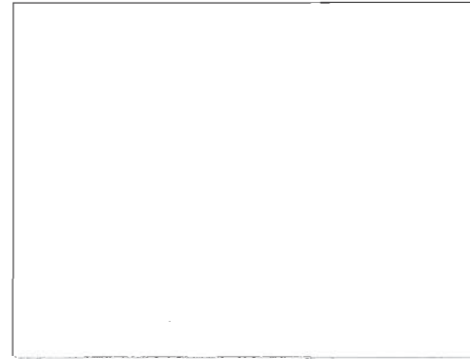


Learn in one minute what you can do to protect wildlife



Watch this video from the Sea Turtle Conservancy on the effect of light pollution on sea turtles.

<http://www.darksky.org/light-pollution-topics/the-environment>



Watch this Science in Seconds video to learn how light pollution negatively affect all types of wildlife.

#### **Recent News Items on Light Pollution & the Environment**

**'Lights Out' seeks to stem bird carnage caused by city skylines** (Washington Post)

Lights Out Baltimore, an organization that started in 2008, scours the streets in the predawn hours to collect birds — dead or stunned — that have collided with windows in the city's corporate canyons. [Read more.](#)

**Light pollution 'affects bats' tropical seed dispersal'** (BBC News)

Light pollution could affect the regeneration of tropical rainforests because it disrupts the behavior of seed dispersing bats, a study suggests. [Read more.](#)

**Birds Killed By Skyscrapers: An Oddly Life-Affirming Photo Essay** (FastCompany)

Nine years ago, artist Lynne Parks got into birdwatching. The Baltimore-based artist, who has suffered from cancer since childhood, found something life-affirming in the birds' energy. [Read more.](#)

**Artificial lighting and noise alter biorhythms of birds** (Science Daily)

Noise from traffic and artificial night lighting cause birds in the city center to become active up to five hours earlier in the morning than birds in more natural areas. [Read more.](#)

**Night light pollution affect songbirds' mating life, research suggests** (Science Daily)

<http://www.darksky.org/light-pollution-topics/the-environment>

In today's increasingly urbanized world, the lights in many places are always on, and according to a new study, that's having a real impact on the mating life of forest-breeding songbirds. [Read more.](#)

**Light at night, melatonin and bird behavior** (Science Daily)

Low light levels, similar to those found in urban areas at night, can have a significant effect on melatonin production in birds at night. This suggests that melatonin could be mediating changes in bird behavior at night. [Read more.](#)

Submission # \_\_\_  
Subject Cedar River Predation

Cedar River Rention, WA Poster - used as display and introduction

The Effect of Light Intensity on Predation of Sockeye Salmon Fry By Cottids in the Cedar River  
Roger Tabor, Gayle Brown, Aaron Hird and Stephen Hager, April 2001

Saving Salmon On The Cedar River - derived from Washington State Department of Transportation Bulletin  
March 23, 2001 No. 01-12

Signals Maintenance Shapes Salmon Solution - Washington State Department of Transportation Bulletin March  
23, 2001 No. 01-12

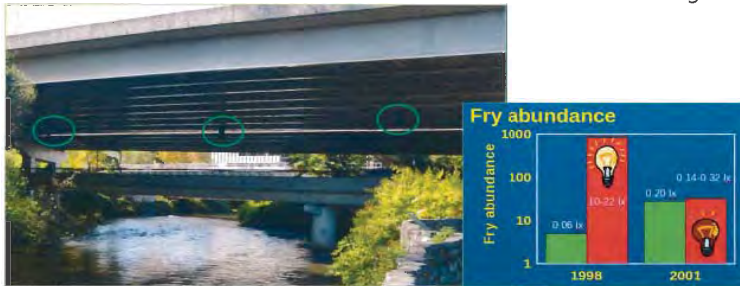
The Effect of Light Intensity on Sockeye Salmon Fry Migratory Behavior and Predation by Cottids in the  
Cedar River, Washington  
R. Tabor, G. Brown, V. Luiting, North American Journal of Fisheries Management 24:128-145, 2004

The Effect of Light Intensity on Predation of Sockeye Salmon Fry By Prickly Sculpin and Torrent Sculpin  
Roger Tabor, Gayle Brown, Victoria Luiting, May 1998

# Cedar River Renton, WA

The Cedar River is where the largest run of sockeye salmon in the lower 48 states begins.

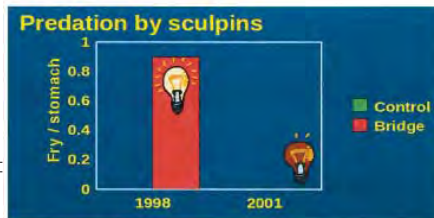
That is, it was before lighting was installed on the Cedar River Trail where it crosses the river below the I-405 bridge.



Light is basically a big stop sign. Sockeye like to migrate at night in the fastest part of the river channel and move to low velocity waters along riverbanks and river bottoms during the day. This way they avoid becoming the prey of fully-grown trout and sculpin, which like to forage at night. But the lights above the trail made the sockeye fry think it was daylight.

The result of shielding the lighting in 1998

The 2000 run was one of the biggest in recent memory, but the year before that was one of the worst, according to Roger Tabor, a fishery biologist with the U.S. Fish and Wildlife Service.



Ref. 1. The Effect of Light Intensity on Sockeye Salmon Fry Migratory Behavior and Predation by Cottids in the Cedar River, Washington, Taabor, Brown, Luiting, 2004  
2. Effects of Artificial Lighting on Juvenile Salmonids: A Review of Research in the Lake Washington Basin, Roger Tabor, Mark Celedonia, USFWS, Gayle Brown, USGS

## THE EFFECT OF LIGHT INTENSITY ON PREDATION OF SOCKEYE SALMON FRY BY COTTIDS IN THE CEDAR RIVER

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April 2001

<sup>1</sup>Present address: Fisheries and Oceans Canada - Coastal BC South, Nanaimo, British Columbia

## ABSTRACT

In the Cedar River, we examined the relationship between light intensity level and migratory behavior of sockeye salmon fry (*Oncorhynchus nerka*) and predation by cottids. Additionally, light intensity readings were taken to document the location of high artificial light intensity levels and determine what atmospheric conditions affect those light levels. The effect of light intensity on sockeye salmon fry was examined with two methods: 1) comparison of lighted and non-lighted areas in the City of Renton; and, 2) experimental trials with standardized amounts of light added to the river.

Within the lower 2.9 kilometers of the Cedar River, there were several locations with high light intensity levels. Most were next to street bridges. The highest light readings recorded were at the I-405 Bridge and the Renton Library. In the lower Cedar River, artificial lighting appeared to come from two major sources: direct lighting and reflected lighting off of the clouds. At locations with minimal direct lighting, the highest light intensity levels occurred on overcast nights due to reflected light. The lowest levels occurred during clear, moonless nights. As far upstream as river kilometer 9.8, we recorded readings during overcast nights that were higher than during a clear night with a full moon.

Experimental trials were done at two locations away from any lights, Lion's Club Park and Elliot Park. Two trials were done at the Lion's Club Park, both following a release of hatchery sockeye salmon fry. Most trials at Elliot Park were conducted below a sockeye salmon spawning channel. At the Lion's Club Park, light intensity treatments were done in two habitat types, gravel shore and rip-rap shore.

At all City of Renton sites examined, the abundance of sockeye salmon fry was substantially higher at sites with high light intensity levels than at nearby sites with low light. Correspondingly, most predation of fry by cottids was observed in the bright light areas. Higher predation rates were observed along the shoreline as well as in the mid-channel area. In relation to other sampling conducted by the U.S. Fish and Wildlife Service, the I-405 Bridge lighted area was the only location we have ever seen any significant predation of fry by cottids in a mid-channel area of a riffle in the Cedar River.

In the experimental trials, we found that the abundance of fry and predation by cottids was related to light intensity levels. In one bright light treatment, we were able to slow the migratory behavior of over 550 sockeye salmon fry within an 8-meter (m) shoreline section. At the Lion's Club Park, gravel shores had five times as many fry as rip-rap shores for a given light intensity level. Gravel shores had a larger low-velocity area than did rip-rap shores. In two experimental trials, we also examined the abundance of fry shortly after the lights were turned off. In all lighted experimental units, the number of fry declined dramatically after the lights were turned off, however, in control units (no light added), the number of fry remained about the same or actually increased slightly. In the experimental trials, we also monitored the abundance of juvenile chinook salmon

(*O. tshawytscha*). Small numbers of chinook were observed. No relationship between chinook salmon abundance and light intensity was detected. In conclusion, our results indicated that any estimation of predation loss needs to assess the light intensity level, as well as fry abundance and shoreline and mid-channel habitat.

## TABLE OF CONTENTS

	<u>Page</u>
Abstract .....	ii
List of Figures .....	v
Introduction .....	1
Study Site .....	1
Methods .....	1
Results .....	4
Discussion .....	8
Acknowledgments .....	11
References .....	12

## LIST OF FIGURES

<u>Figure</u>	<u>Page</u>
1 Map of lower Cedar River and location of study sites .....	14
2 Fry abundance and predation rates (fry/stomach) for three Cedar River sites in Renton, Washington .....	15
3 Sockeye salmon fry abundance (log scale) at three light intensity levels while lights were on and then turned off for two experimental trials in the Cedar River .....	16
4 Sockeye salmon fry abundance and cottid predation of fry at three light intensity levels and two habitat types from March 31, 1999 experimental trial at Lion's Club Park (Rkm 18.3) on the Cedar River .....	17
5 Sockeye salmon fry abundance and cottid predation of fry at four light intensity levels and two habitat types from April 5, 1999 experimental trial at Lion's Club Park (Rkm 18.3) on the Cedar River .....	18
6 Sockeye salmon fry abundance and cottid predation of fry at three light intensity levels and three channel types from April 7, 1999 experimental trial at Elliot Park (Rkm 7.4) on the Cedar River .....	19
7 Sockeye salmon fry abundance (log scale) and cottid predation of fry at three light intensity levels from five nights at the Elliot Park side channel (just below the spawning channel) .....	20
8 Chinook salmon fry abundance at Lion's Club Park and Elliot Park at various light intensity levels .....	21
9 Light intensity readings (lumens/ft <sup>2</sup> ; log scale) during an overcast night (solid line, solid squares) and a clear, moonless night (dashed line, open circles) from the lower 2.9 kilometers of the Cedar River .....	22
10 Light intensity readings (+/- range, vertical line) at three Cedar River locations that have little or no direct artificial lighting .....	23

## INTRODUCTION

After emerging from their redds, most sockeye salmon (*Oncorhynchus nerka*) fry immediately emigrate downstream to a lake environment where they reside for the next year. They reduce their vulnerability to predators by emigrating at night. Results of recent lab experiments indicated that increased light appears to slow or stop emigration of sockeye salmon fry which makes them more vulnerable to capture by predators (Tabor et al. 1998a). The Lake Washington sockeye salmon occur within a large urban area. In some river sections that sockeye salmon fry must migrate through, artificial lighting is present. As part of the mitigation for the recent flood control project, light intensity levels were reduced or proposed to be reduced in some areas of the lower Cedar River to reduce predation. Although reduced lighting appears to benefit sockeye salmon fry, little work has been done to quantify its effect on predation in a field situation. Most earlier work was done under laboratory conditions and results can be difficult to apply to field conditions. In 1998 and 1999, we attempted to quantify the effects of increased light under field conditions in the Cedar River. In 2000, we also took light intensity readings in the lower Cedar River to identify areas with high artificial light levels.

## STUDY SITE

The Cedar River is the main tributary for the Lake Washington basin. The lower 35.1 kilometers are accessible to anadromous salmonids. Landsburg Dam (Figure 1), a water diversion structure, prevents fish from migrating further upstream. The Cedar River is the major spawning area for a large population of sockeye salmon. Runs in excess of 300,000 fish have occurred in some years.

The lower 3 kilometers of the Cedar River occurs within a large flood plain that was the historical Black River flood plain and Lake Washington delta. Presently, the area is the City of Renton (Figure 1) and has numerous artificial light sources due to urban and residential development. Upstream of river kilometer (Rkm) 3, the river is confined in a relatively narrow canyon with some residential development but substantially less artificial light than the Renton area.

## METHODS

We examined the effect of light intensity on sockeye salmon fry with two methods: 1) comparison of lighted and non-lighted areas in the City of Renton; and, 2) experimental trials with standardized amounts of light added to the river. Additionally, we took light intensity readings in the lower Cedar River to document light levels. All light intensity measurements were made with an International Light Inc. model IL1400A radiometer/photometer. Light intensity was measured as lumens/ft<sup>2</sup>.

## PREDATION AND SALMONID FRY BEHAVIOR

### Renton City lights

Four sites were selected in Renton; 1) I-405 Bridge (Rkm 2.7), 2) Renton Library (Rkm 2.5) Williams Avenue Bridge (Rkm 2.0), and South Boeing Bridge (Rkm 1.2). Each had a high light intensity area and a nearby area with similar habitat and substantially lower light intensity levels. Two sites were done in 1998 and the other two were done in 1999. Fry abundance was estimated at each site except the South Boeing Bridge. In 1998, we used a small 2.5-m long by 1-m high beach seine to compare fry abundance. Fry at the 1999 sites were counted by slowly moving along the shoreline using a flashlight. To be consistent between treatments, we only counted fry within the beam of the flashlight. We assumed that the counting had a minimal effect on fry abundance because it was done within a short period of time, approximately 1 minute per shoreline section. Sockeye salmon fry as well as chinook salmon fry (*O. tshawytscha*) were counted. The two species could be easily distinguished based on parr marks and relative size. Chinook salmon fry were considerably larger than sockeye salmon fry. Light intensity measurements (lumens/ft<sup>2</sup>) were taken at the surface of the water in the middle of the area sampled. At three of the four sites, cottids were collected for stomach analysis to compare predation rates. Fish were collected with backpack electrofishing equipment. Cottids were collected along the shoreline and/or in the mid-channel area. Cottids along the shoreline were collected visually with the aid of dip nets. Cottids in the mid-channel area were collected passively with the aid of block nets. After capture, cottids were identified to species and total length (TL) was measured. Afterwards, their stomachs were flushed and salmonid fry were counted. We sampled cottids that were > 49 millimeters (mm) TL. Smaller cottids rarely consume sockeye salmon fry. We assumed that cottids had captured fry in the same general area that they were captured. A Mann-Whitney *U* test was used to compare differences in predation rates between a lighted site and the control site. Data were log-transformed because the data was multiplicative rather than additive (Zar 1984).

### Experimental Trials

Experimental trials were done at two sites in 1999, the Lion's Club Park at Rkm 18.3 and the Elliot Park at Rkm 7.4 (Figure 1). Sites were divided into shoreline sections that had uniform habitat. Two experimental trials were conducted at the Lion's Club Park along a 112-m shoreline section. The upper 56 m had a rip-rap shoreline while the lower 56 m was a gravel shoreline. Both trials were conducted on a night when hatchery sockeye salmon fry were released upstream at Rkm 21.7. On March 31, 1999, 135,000 fry were released, and on April 5, 1999, 57,000 fry were released. The other site at the Elliot Park consisted of three 40-m shoreline sections: 1) main channel, 2) braided channel; and, 3) side channel at the outlet to the spawning channel. Within each section, three experimental light intensity levels were tested. The main channel and braided channel section were only done once due to the low numbers of fry. The side channel was done five times because good numbers of fry were migrating through this section during the study period. Most of the fry in this section were probably migrants from a nearby spawning channel.

Each shoreline section was divided into 8-m long units. Lights were only added to every other unit to insure light from one experimental unit did not affect another one. Treatments were randomly assigned within each shoreline section. Two lights were used for each experimental unit. Lights were mounted at the top of a 2-m pole, placed 1 m from both edges of each unit, and lights were directed towards the middle of the unit. An individual light system consisted of a 60-watt light bulb, a deflector to focus the light, and a dimmer switch to control the light intensity. We used five light intensity levels: 1) control (no lights): 0.0006-0.010; 2) dim: 0.015-0.025; 3) low: 0.045-0.055; 4) medium: 0.10-0.14; and, 5) bright: 1.0-1.4 lumens/ft<sup>2</sup>.

Light intensity measurements were taken at the surface, 2 meters from shore. Generally three measurements were taken, one in the middle and one each from just inside of the upstream and downstream edges. The middle of each experimental unit was the brightest and the upstream and downstream edges were the dimmest. Light intensity was slowly attenuated across the river channel. Lights were turned on shortly after dusk and adjusted to get the appropriate light intensity. Fry were counted with a flashlight, similar to the City of Renton sites. For some experimental trials, we turned off the lights and recounted the number of fry 20 minutes later.

In most experimental trials, we used backpack electrofishing equipment to collect cottids to determine the predation rate. After capture, cottid stomachs were flushed and the number of ingested fry was counted. Fry were categorized as freshly ingested or well digested. Only counts of freshly ingested fry were used. We assumed that freshly ingested fry were consumed during the experiment and well digested fry were consumed the prior night or sometime before the experiment. Since we started the experiments shortly after sunset and cottids are primarily nocturnal, we felt this was a valid assumption.

Differences in fry abundance were tested with a two-way analysis of variance (ANOVA) without replication. A Mann-Whitney *U* test (two samples) or a Kruskal-Wallis test (more than two samples) was used to compare differences in predation rates. Data were log-transformed because the data was multiplicative rather than additive (Zar 1984).

## LIGHT INTENSITY READINGS

Readings of light intensity in the lower Cedar River were done under three scenarios: 1) overcast skies; 2) clear skies, no moon; and, 3) clear skies, full moon. Light readings were taken every 50 m from Rkm 0.9 to 2.9. Below Rkm 0.9 access to the river was limited in many areas. However, additional readings were done at Rkm 0.0, 0.2, 0.3, and 0.7. We also included one site at Rkm 9.8. Additional readings were also taken at major light sources to determine peak light levels. For safety reasons, light readings were taken close to the river bank, approximately 1-5 m from shore. In most locations, the mid-river light reading would be lower than readings taken close to shore because the light source is located on the river bank. At some locations, such as I-405 Bridge and Renton Library, light sources span the entire channel width. At a few sites, we took light readings on the opposite bank from the light source. All readings were taken at the surface of the water. Most readings were taken from the right bank except between the Renton Library (Rkm 2.5) and Houser Way Bridge (Rkm 2.6), where the right bank was difficult to access.

## RESULTS

### SOCKEYE SALMON FRY

#### Renton City Lights

Fry abundance. At all three sites examined, the abundance of sockeye salmon fry was substantially higher at sites with high light intensity levels than at a nearby site with low light (Figure 2). This was particularly apparent at the I-405 site where large numbers of fry were present under the bridge but 180 m upstream we were unable to collect a single fry. Both sites had a large amount of shallow, low velocity water where numerous fry could reside. In contrast, few sockeye salmon fry were observed at the Renton Library. Light levels were lower and there was little shallow, low velocity water along the shoreline. However, all sockeye salmon fry observed were present in the lighted area (Figure 2). The Williams Bridge site was counted on two nights, both having similar results. Most fry were nearest the bridge where the light intensity levels were the highest. At 35 m from the bridge, light levels were greatly reduced (0.012 lumens/ft<sup>2</sup>) and only a couple of fry were observed (Figure 2).

Predation. At both the I-405 Bridge and Renton Library, little predation was observed in control areas with little light, while relatively high predation rates were observed in lighted areas (Figure 2). Fifty-three percent of the cottids in the mid-channel area of the lighted I-405 site had consumed fry (0.9 fry/stomach), while no predation occurred at the control. Predation rates were significantly higher in the lighted area (Mann-Whitney *U* test = 58.5; *P* = 0.002). Preliminary sampling was also done on February 23, 1998, at the I-405 Bridge (the control was not sampled). From 15 cottids collected, a total of 18 sockeye salmon fry were present in the stomach samples (1.2 fry/stomach). At the Renton Library site, cottids were sampled at both the shoreline and mid-channel areas on the same night (March 18, 1999). In the control, no predation was observed in the shoreline area and 1 sockeye salmon fry was observed out of 18 stomach samples from the mid-channel. In the lighted shoreline area, 33% of the cottids had consumed fry (0.6 fry/stomach) but no predation was observed in the lighted mid-channel area (Figure 2). Predation rates were significantly higher in the shoreline of the lighted area than the control area (Mann-Whitney *U* test = 63; *P* = 0.03). Of the cottids (> 49 mm TL) collected at both sites, 95% were coastrange sculpin (*Cottus aleuticus*) and 5% were torrent sculpin (*C. rhotheus*). Predation was observed in both cottid species.

At the South Boeing Bridge site (including control), we collected 105 cottids but only three were > 49 mm TL. No fry was observed in their stomachs. We also flushed the stomachs of four cottids that were 45-49 mm TL. Of these, one torrent sculpin (47 mm TL) that was collected at the bridge had consumed a sockeye salmon fry. No predation was observed at the control site. Light intensity at the South Boeing Bridge was 0.28 lumens/ft<sup>2</sup> and 0.12 lumens/ft<sup>2</sup> at the control.

### Experimental Trials

**Fry abundance.** At Lion's Club Park on March 31 (Figure 3) and April 5, few sockeye salmon fry were observed in all units for the first 45 to 60 minutes. However, within the next 20 minutes the number of fry increased dramatically. For example, in the bright-light experimental unit, the number of fry changed from 27 at 2025 hours, to 577 at 2045 hours. The increase in the number of fry was due to the large number of hatchery fish that had been released earlier that evening. The fry were released at Rkm 21.7 at approximately 2008 hours (90 minutes after sunset). Experimental units with higher light levels had significantly more fry in both experimental trials (ANOVA; March 31,  $P = 0.02$ ; April 5,  $P = 0.005$ ; Figures 4,5). Within each light intensity level, higher numbers of fry occurred in the gravel shore than the rip-rap shore (ANOVA; March 31,  $P = 0.04$ ; April 5,  $P = 0.03$ ; Figures 4,5). On average, gravel shores had five times as many fry as rip-rap shores for a given light intensity level.

Overall, fry abundance results at Elliot Park followed similar patterns as at Lion's Club Park. On April 7, low numbers of fry were observed in every experimental unit. However, the highest numbers of fry occurred in the units with the highest light levels for each channel type (Figure 6). Analysis of variance revealed a significant difference ( $P = 0.003$ ) in fry abundance between light intensity levels. Fry abundance was done on four additional dates in the side channel, however, on May 3, the light system for the medium-light experimental unit malfunctioned, thus we were unable to get a count for that experimental unit (Figure 7). Between the five dates that the side channel was sampled, the abundance of fry varied greatly. Most fry were probably migrants from the spawning channel. Peak outmigration appeared to be around May 3. Analysis of variance revealed a significant difference ( $P < 0.001$ ) in fry abundance between light intensity levels. The highest number of fry was always in the medium light unit (Figure 7). On every date, the dim light unit had more fry than the control unit.

In two experimental trials, we also examined the abundance of fry shortly after the lights were turned off. In all lighted experimental units, the number of fry declined dramatically after the lights were turned off (Figure 3). In control units (no light added), the number of fry remained about the same or actually increased slightly (Figure 3).

**Predation.** In general, predation rates of cottids showed the same trend as fry abundance. The highest predation rates recorded were from experimental units with increased light. This trend was particularly noticeable during the March 31 trial at the Lion's Club Park. No predation was detected in the control units. In contrast, large numbers of fry were found in the stomach samples of cottids collected from the bright-light experimental unit (Figure 4). Three torrent sculpin were collected from this unit with 10 or more fry in their stomachs. The maximum number of sockeye salmon fry consumed by an individual fish was 13 (92 mm TL, torrent sculpin). Differences in predation rates were marginally significant (Kruskal-Wallis test = 5.7,  $P = 0.058$ ) between experimental units but not significant between medium and bright experimental units (Mann-Whitney  $U$  test = 3.5,  $P = 0.23$ ). Predation rates in both lighted rip-rap experimental units were

lower than in units with gravel shores. Differences were significant between the two bright experimental units (Mann-Whitney  $U$  test = 8.0,  $P = 0.03$ ) but not the medium light experimental unit (Mann-Whitney  $U$  test = 3.5,  $P = 0.66$ ).

Predation rates on April 5 were low for all experimental units. Only three out of 42 cottids had consumed sockeye salmon fry. No differences between treatments were detected. However, four of the five fry consumed were from the medium-light experimental units and no predation was observed in the control units (Figure 5).

On April 5, one riffle sculpin (89 mm TL; *C. gulosus*) was collected with 14 yolk-sac sockeye salmon fry. Because these fish were yolk-sac fry, we assumed these were not migrating fish but instead they probably were captured in the substrate. Additionally, many were well-digested and thus were not consumed on the night of our experiment. None of these fry were included in our estimate of predation. Some sculpins such as reticulate sculpin (*C. perplexus*), have been shown to be able to move into the substrate to consume recently-hatched salmonid fry (Phillips and Claire 1966). Additionally, we have collected several riffle sculpin that consumed yolk-sac fry in another location of the Cedar River (R. Tabor, unpublished data).

During the April 7 experimental trial, few predators were collected along the shore in the main channel and braided channel. However, 23 cottids were collected in the side channel. The only experimental unit to have any predation of fry was the medium-light unit. In addition to April 7, side channel predators were sampled two other times. In each trial, the highest predation rates were observed in the medium-light unit; however, there was no significant differences detected between the light intensity levels.

At Lion's Club Park, torrent sculpin made up 91% of the cottids captured, while riffle sculpin made 8% and shorthead sculpin 1% (*C. confusus*). No coastrange sculpin were observed at this site. In the side channel at Elliot Park, 50% of the cottids were torrent sculpin, 26% coastrange sculpin and 24% riffle sculpin.

In addition to cottids, we also collected a few salmonids. The number and species collected included five juvenile coho salmon (*O. kisutch*; range, 74-112 mm FL), eight unidentified trout (range 76-103 mm FL), one cutthroat trout (*O. clarki*; 160 mm FL), and one rainbow trout (*O. mykiss*; 146 mm FL). Almost all were collected at the Lion's Club Park site. The only salmonids observed to have freshly-ingested fry in their stomachs were three juvenile coho salmon. One juvenile coho salmon (109 mm FL) was collected with five freshly ingested sockeye salmon fry. The fish was captured in the bright experimental unit on March 31, 1999. The other two juvenile coho salmon had one fry each in their stomachs. These fish were collected from experimental units with dim and low light intensity levels. Therefore, salmonid predation rates show the same general trend as with cottids but because the sample sizes are small it is difficult to say anything conclusive. Additionally, salmonids are far more mobile than cottids and thus there is a greater chance that they may have consumed their prey at a different location. However, most of the salmonids collected were small and thus, may have a small home range.



## CHINOOK SALMON FRY

Small numbers of chinook salmon fry were also observed along the shoreline. There was no apparent pattern between different light intensity levels (Figure 8). In some cases, chinook salmon were more abundant in treatments with little or no light. For example, at the I-405 bridge site, we collected 3.4 chinook salmon/seine in the control area but only 0.3 chinook salmon/seine in the lighted area. Only one chinook salmon was seen from all the cottid stomachs examined. The cottid was a ruffle sculpin (95 mm TL) captured in the bright section at the Lion's Club Park during the March 31 experiment.

## LIGHT INTENSITY READINGS

Most high light intensity sites were next to street bridges (Figure 9). The Renton Library and a Boeing building at Rkm 1.6 also had high light readings. The highest light readings were at the I-405 Bridge and the Renton Library. Some light sources are typically shut off during the night. The Renton Library closes at 2100 hours. Peak light levels changed from 1.90 to 0.05 lumens/ft<sup>2</sup>. Many of the lights along the Cedar River Trail are turned off at 2300 hours. Most of our readings were taken while the lights were still on.

Near strong light sources, such as street lights near bridges, light intensity levels did not appear to vary greatly between different sky conditions because the artificial lights were far more intense than other lighting sources such as the moon. However, away from these lights, light intensity levels appear to vary greatly depending on cloud cover and the moon. For example, at locations close to the City of Renton, overcast nights had higher light readings than during a full moon. Reflected light off of the clouds from nearby urban areas appears to be the main light source during overcast nights. The lowest readings were during a clear, moonless night.

We examined past readings of light intensity at Rkm 0.3. In addition to readings taken in 2000, readings were also taken in 1997 and 1999. The highest light intensity readings were recorded on overcast nights (Figure 10). Light readings as high as 0.040 lumens/ft<sup>2</sup> were recorded on an overcast night, whereas during clear, moonless nights readings ranged from 0.003-0.005 lumens/ft<sup>2</sup>. Even at upstream locations, reflected light appears to be a major source of lighting. At Rkm 9.8, we detected little or no light on a clear, moonless night, on a full moon night light intensity was 0.008, and on an overcast night it was 0.012 lumens/ft<sup>2</sup> (Figure 10). Upstream of Rkm 10, we did not take any light readings, but we expect that the amount of reflected light would be substantially less due to the lower amount of urban development. In this area, the highest light intensity readings would probably occur during nights with a full moon.

Light intensity readings at Rkm 0.3 were quite variable between overcast nights (Figure 10). Most likely, the thickness of the clouds and the level of the clouds influence to amount of light that is reflected. On March 27, 2000, the clouds appeared to be very thick and low. Light intensity levels on that night were the highest that we have observed.

## DISCUSSION

## SOCKEYE SALMON FRY BEHAVIOR

Results for field observations in Renton and field experiments corroborated results from earlier lab experiments. Increasing light intensity levels have a profound effect on the behavior of sockeye salmon fry. Fry appear to move out of the thalweg and move to low velocity water where they are vulnerable to predators such as cottids. Even small increases in light intensity levels appeared to affect fry behavior. For example, at the Elliot Park side channel we observed differences in fry abundance consistently between the control (0.010 lumens/ft<sup>2</sup>) and the dim light experiment unit (0.020 lumens/ft<sup>2</sup>). Our results suggest that any reductions in light level can be beneficial and the impact of lighting should be considered for any future development project.

We were surprised by the large number (> 550 fry) of sockeye salmon fry that were present within the bright-light experimental unit (sand/gravel shoreline) during the March 31 experiment. Approximately 120,000 fry were released on that date. Assuming a similar per kilometer survival rate as hatchery releases from Landsburg Dam (Seiler and Kishimoto 1997), we estimate that 110,000 fry moved past our experimental site (assumes that the number of wild fry was minimal). Therefore, we were able to delay 0.5% of the release group within a 8 m shoreline section with two small lights. This suggests that several large lights spread out over a long section of shoreline and across the channel with sand/gravel substrate and a low sloping bank could have a strong effect on the behavior and survival of the entire run of out-migrating fry. McDonald (1960) was able to experimentally stop the nightly movement of sockeye salmon fry with artificial lighting of 3.0 lumens/ft<sup>2</sup>, however, other levels of light intensity levels were not tested. Our bright-light experimental unit was 1.0 - 1.4 lumens/ft<sup>2</sup>.

Experiments at the Lion's Club Park demonstrated that habitat can have an important effect on the number of sockeye salmon fry attracted to the lights. The effect was probably due in part to the amount of low velocity habitat as well as to substrate size. Light causes sockeye salmon fry to move to low velocity areas. The rip-rap banks were steeper and had a narrower area of low velocity water than did the gravel shoreline. Differences in substrate size between the two habitat types may also have resulted in differences in predator abundance, which could influence the number of sockeye salmon fry. Typically, the number of large cottids is higher in larger substrates than smaller substrates (Tabor et al. 1999b). Other predators such as rainbow trout were probably higher near the rip-rap. The presence of predators has also been shown to increase the downstream movement of sockeye salmon fry (Ginetz and Larkin 1976; Tabor et al. 1998a) and brown trout fry (*S. trutta*; Gaudin and Caillere 1985; Bardonnnet and Heland 1994).

In all of our experimental trials, we only examined the abundance and predation of fry along the shoreline. Results indicate that lights cause fry to delay their migration and move to the shoreline to an area of low velocity. Another area of low velocity water is typically very close to the substrate across the entire channel. Results from the I-405 bridge site suggest that fry move to the shore as well as move to the substrate in mid-channel areas. The I-405 bridge site has strong lights all the way across the channel. Although, we have never directly observed sockeye salmon

fry close to the substrate in the mid-channel, we did observe much higher predation rates than in similar areas with little or no light. Following 1998 and 1999 hatchery releases, we sampled a total of 10 mid-channel sites with little or no light. Out of 109 cottid stomachs examined, only one salmonid fry was seen. At the I-405 bridge site, a total of 33 fry were observed from 33 cottid stomach samples.

The use of the mid-channel substrates in lighted areas by sockeye salmon fry may be more common in areas with boulders and cobble than areas with smaller substrates. Larger substrates will create a more roughened river channel and have low velocity locations for sockeye salmon fry. Unfortunately these same sites will probably have a higher abundance of cottids > 49 mm TL. At South Boeing Bridge, the substrate was mostly small gravel and few cottids > 49 mm TL were collected and those that were > 49 mm TL were much smaller than those from the I-405 bridge which had some cobble and large gravel. Little predation was documented at the South Boeing Bridge. In the Cedar River, the number of cottids > 49 mm TL was shown to be related to the substrate size (Tabor et al. 1998b).

An important factor that probably affects the impact of artificial lighting is streamflow. The survival of hatchery sockeye salmon fry has been shown to be profoundly affected by streamflow conditions (Seiler and Kishimoto 1997). At lower flows, fry migration time is increased (Seiler and Kishimoto 1996) and they become more vulnerable to predators (Tabor et al. 1998). Fry typically migrate in the thalweg or the fastest part of the channel. During low streamflow conditions, mid-channel velocities are reduced and fry will move through a lighted area slower and thus they may be more likely to be influenced by light. In fact, at streamflow levels over 1,500 cubic feet per second (cfs), approximately 10% of the sockeye salmon fry will migrate during the day (Seiler and Kishimoto 1997). Streamflow levels at Renton for the March 31 and April 5 experiments were 800 and 670 cfs, respectively (USGS, unpublished data). Base streamflow levels are 375 cfs during the fry outmigration period. Thus, we would predict that at lower streamflows more fry would be delayed in our experimental units.

Turbidity will have a large effect on light intensity levels in the water column. Light will not penetrate as well during turbid conditions. Turbidity is often related to streamflow, particularly after rain events. Fry may migrate faster during turbid conditions and visual predators such as trout will have reduced foraging success (Barrett et al. 1992; Vinyard and Yuan 1996).

## PREDATION

The size of the experimental units (8 m shoreline length) appeared to work well for detecting differences in fry abundance, but it may have been too small for estimating predation rates. We were able to detect differences between lighted areas and control areas but we were often unable to detect differences between light intensity levels. Few or no predators were collected in some experimental units. Also, the diets of cottids can vary between individual fish. Even when fry are abundant, many cottids will not consume them. Each site will have a variety of other prey types such as aquatic insects or oligochaetes. Also, many of the male cottids may be guarding egg nests and probably will not be actively searching for prey. In most areas, a 20-30 m shoreline would

probably be adequate to collect enough cottids to get an accurate estimate of predation. Additionally, our experiments only lasted for a few hours. Had we extended the experiments over the entire night we may have seen more predation and thus better able to detect differences between treatments. Similarly, for City of Renton light comparisons, large numbers of cottids may be needed to detect differences between light levels.

Based on earlier lab experiments, increased light levels have a profound effect on the behavior of sockeye salmon fry (Tabor et al. 1998a), however, the effect on predator behavior is not well understood. In the Cedar River, cottids appear to exhibit a functional response due to an increase in the abundance of fry but we did not observe any type of numerical response. However, our experiments were done over a short period of time and a numerical response may take several days or weeks. In Lake Iliamna, cottids exhibited a strong numerical response in relation to the abundance of sockeye salmon eggs but cottid movements to the spawning sites takes place over a period of three weeks (Foote and Brown 1998). Therefore, cottids may exhibit a numerical response to an increase in fry availability near permanent light structures. However, there are several alternative prey types in the Cedar River and cottids may not show a strong numerical response such as in Lake Iliamna, which is an oligotrophic system and alternative prey may be limited. Additionally, cottids may naturally avoid lighted areas because they may become more vulnerable to predators. Movement into lighted areas may be a tradeoff for cottids and thus they must balance increased predation risk with increased prey availability.

Cottids are generally considered nocturnal fish; they appear to hide during the day and move out from cover at night to feed. The distance they move away from their daytime cover and the relationship to light levels is not known. If they only move a short distance on a given night then the only cottids that can take advantage of the increase in fry abundance are those that have nearby cover. The number of cottids > 49 mm TL increases as the substrate size is increased (Tabor et al. 1998b). Therefore, in sand or gravel areas where fry may be abundant, cottids may have low abundance.

## CHINOOK SALMON FRY

Like sockeye salmon, many chinook salmon out-migrate to the lake as fry (D. Seiler, WDFW, unpublished data), however, while sockeye salmon fry typically use the river channel only as a migratory corridor, chinook salmon fry and juveniles may inhabit the shoreline habitat for an extended period of time (R. Peters, U.S. Fish and Wildlife Service, unpublished data). Chinook salmon may avoid lighted areas while they are inhabiting the shoreline but may become more vulnerable to predation as they move downstream through lighted areas. Nevertheless, given the low number of chinook salmon fry observed, it is problematic to make any conclusions concerning the effect of lights on chinook salmon. Further work directed at chinook salmon is needed to reach any conclusions.

## LIGHT INTENSITY READINGS

The location with the most potential for predation appeared to be the area between the I-405

Bridge and the Renton Library. The highest light levels were recorded in this area. There was also good pool habitat where fry could be consumed by large trout as well as cottids. Additionally, the mid-channel substrate is composed of cobble and gravel which was inhabited by cottids > 49 mm TL. Downstream of the Renton Library between Rkm 2.5 and 0.9 there was little pool habitat and the mid-channel substrate was predominantly gravel. Cottids may be abundant but few are > 49 mm TL.

In the lower Cedar River, artificial lighting appears to come from two major sources; direct lighting and reflected lighting off of the clouds. Direct lighting is intense lighting that occurs in a relatively small area and occurs every night and usually all night. Whereas, reflected light is not very intense but spread out over a much larger area and varies greatly with the weather. Direct lighting probably have strong localized effects on sockeye salmon fry and reflected lighting probably has weak effects over a large area. Which has more overall effect of sockeye salmon fry is difficult to assess. However, reducing direct lighting is much easier to address than reducing reflected light. Direct lighting can be turned off, redirected, or perhaps shielded (such as by trees). Reducing reflected light would be a much larger and far more difficult management objective.

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## Saving Salmon On The Cedar River

**Signals Maintenance Shapes Salmon Solution**  
Washington State Department of Transportation  
Northwest Region, March 23, 2001 BULLETIN No. 01-12

They hung on the light fixtures above the Cedar River Trail southwest of downtown Renton like black rubber lampshades. Users of the trail, which crosses above the river and under I-405, may wonder about the purpose of the pieces of rubber matting. The simple answer is that they are what they appear to be - black rubber lampshades. The more complex answer is in the river below. What does this have to do with WSDOT? Find out below.

The Cedar River is where the largest run of sockeye salmon in the lower 48 states begins. Each year between January and June, several million salmon fry migrate from their spawning grounds east of Maple Valley to Lake Washington. The 2000 run was one of the biggest in recent memory to Roger Tabor, a fishery biologist with the U.S. Fish and Wildlife Service. Tabor has been working with federal, state, local and tribal governments to determine the reason for the decline in the sockeye run. His research brought him to the Cedar River underneath I-405, where he noticed a problem. The light that WSDOT installed to help keep trail users safe posed a threat to the sockeye salmon fry.

*"Light is basically a big stop sign," Tabor said. Sockeye like to migrate a night in the fast part of the river channel and move to low velocity waters along riverbanks and river bottoms during the day. This way they avoid becoming the prey of fully-grown trout and sculpin, which like to forage at night. But the lights above the trail make the sockeye fry think it was daylight.*

*"We were doing a great job of lighting the stream and an inadequate job of lighting the walkway," said Northwest Region Signals Superintendent Kurt Schleichert.*

The end result was that thousands of sockeye moved to shallow areas along the riverbank, making them easy prey for trout and sculpin looking for a late-night snack. Tabor estimated the lighting on the river resulted in several thousand salmon fry being eaten at this location in each spring migration period.

Word of the problem reached Gary Davis, a biologist at Northwest Region headquarters in Shoreline who has been working to coordinate WSDOT's salmon recovery efforts with other agencies in King, Pierce, and Snohomish counties. Davis said the agency wanted to help in whatever way it could.

Schleichert, Tabor, Davis and a representative from the city of Renton visited the site last June. It was immediately obvious that the lighting system wouldn't work as it was set up - too much light was shining on the river. One solution, a complete retrofit of the lighting system, wasn't feasible. Schleichert estimates the retrofit would have cost in excess of \$100,000, mainly because it would have required drilling holes in the concrete pathway above the environmentally-sensitive river.

Another solution, at the extreme opposite end of the cost spectrum, beckoned to Schleichert as he examined the light fixtures above the pathway. Why not equip the fixtures with some kind of shield so the light would shine down on the path, but

# Northwest Region

Washington State Department of Transportation

March 23, 2001

## BULLETIN

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not on the river? Schleichert set South Signal Supervisor John Merryman to work on the task. Merryman enlisted the help of Rich Loucks, a Traffic Signal Technician 3 and Mark Wolff a Traffic Signal Technician 2, who fabricated shields out of rubber matting. The shield had to be custom made for each fixture, because the lights were mounted in different locations in reference to the walkway and the river. Loucks and Wolff installed six shields in late January and two more just this week for a total cost of less than \$100!

After the first six shields were mounted, it was necessary to see if they were doing the job for which they were designed. In early February Tabor and Loucks measured light levels on the river in the area of the trail light fixtures. The results were dramatic. Light readings showed that levels were similar to other nearby areas of the Cedar River that have no direct lighting.

The next evaluation was to see if the reduction of light led to a reduction in salmon fry on the riverbank. Again, the results were remarkable. In late February, Tabor and others counted salmon fry along the shoreline. In one location they counted only 23 fry where there had been more than 1000 in 1998. The 2001 and 1998 counts were conducted under similar conditions and on similar dates and time of the day. Tabor said the shields that WSDOT mounted on the light fixtures likely made the difference.

The Northwest Region is committed to being a responsible environmental partner. Our effort to reduce lighting along the Cedar River is a small, but important example of this commitment. Sockeye salmon is not an endangered or even threatened species, but as the challenges posed by the Endangered Species Act loom, solutions like the one used on the Cedar River will become more common and more necessary.

By - Greg Phipps

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## SIGNALS MAINTENANCE SHAPES SALMON SOLUTION

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Washington State Department of Transportation



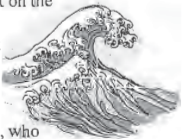
"We were doing a great job of lighting the stream and an inadequate job of lighting the walkway," said Northwest Region Signals Superintendent **Kurt Schleichert**.

The end result was that thousands of sockeye moved to shallow areas along the riverbank, making them easy prey for trout and sculpin looking for a late-night snack. Tabor estimated the lighting on the river resulted in several thousand salmon fry being eaten at this location in each spring migration period.

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"The fry moved through the bridge quickly and were not delayed by the lights," he said. "Fry counts along the shore are usually related to the light intensity level."

The Northwest Region is committed to being a responsible environmental partner. Oureffort to reduce lighting along the Cedar River is a small, but important example of this commitment. Sockeye salmon is not an endangered or even threatened species, but as the challenges posed by the Endangered Species Act loom, solutions like the one used on the Cedar River will become more common and more necessary.

—Greg Phipps



## BUILDING TRUST 2001

On Monday, March 12, the Northwest Region hosted an all-day session with the staff from northwest regional offices of the Washington State Department of Ecology and the Washington State Department of Fish and Wildlife. Dubbed "Building Trust 2001", the meetings presented major 2001 construction projects with potential substantial erosion control and storm water issues. The strategic objective of this meeting was to jointly develop approaches to best address environmental issues that may emerge during the delivery of 2001 construction program. This gathering was in line with the region's business plan to deliver its products and services in such a way that it acts and is recognized as a responsible environmental partner.

WSDOT provided an overview of 32 projects and their unique challenges to the agencies. The meeting was also an opportunity for the department to listen to resource agencies' concerns about WSDOT projects and erosion control issues. Project offices and field staff heard firsthand management commitment to environmental compliance.

The session was a big hit with the two resource agencies. Reprinted below are excerpts from rave reviews they sent to Regional Administrator John Okamoto:

- John—The joint meeting between our staffs went very well I thought. Thank you for hosting it and all the work your crew put into the preparations. Our biologists were impressed with the discussion and really appreciated the heads up on each districts work plan. Please express my gratitude to Dave (Dye) and the rest of your staff for creating a very productive session. We are already looking forward to a follow up this fall.  
*Bob Everett, Regional Director, WSDFW*
- Thanks to you and DOT for hosting the gathering, John. And thanks to Dave (Dye) and Lorena (Eng) for setting the stage for a very open, inviting and positive meeting. Our staff appreciated the chance to meet with so many of your

(Continued on Page 3)

## The Effect of Light Intensity on Sockeye Salmon Fry Migratory Behavior and Predation by Cottids in the Cedar River, Washington

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**Abstract.**—We examined the relationship between light intensity, migratory behavior of sockeye salmon *Oncorhynchus nerka* fry, and predation by cottids *Cottus* spp. We tested the hypothesis that above-natural intensities of nighttime light would increase cottid predation of sockeye salmon fry. In circular tank experiments under controlled laboratory conditions, we tested the ability of cottids to prey on sockeye salmon fry under six different light intensities using minimal water circulation to separate the effect of the migratory behavior of fry from the ability of cottids to capture them. We found that cottids preyed most effectively in complete darkness, whereas the lowest predation occurred at the brightest light intensity. We next tested the predation ability of cottids at four light intensities in a pair of artificial streams to simulate more natural conditions. In experiments without cottids, the majority of fry passed quickly through the artificial streams under complete darkness, but as light intensity was increased, fewer fry emigrated and did so at a slower rate. With cottids present and increased light intensity, even fewer fry emigrated but they did so at a faster rate than did those in the stream without cottids. We determined that cottids probably consumed about 5% of the sockeye salmon fry under complete darkness and ate about 45% of the fry at the brightest light intensity tested. In experimental field trials, the shoreline abundance of fry and predation by cottids increased as light intensities increased. Using two small lights within an 8-m shoreline section on the Cedar River, Washington, we delayed as many as 550 sockeye salmon fry and observed predation of as many as 7.6 fry/cottid. At the end of the experiment, we turned the lights off and noted that the shoreline abundance of fry declined dramatically. At two locations on the Cedar River lit by city lights, the abundance of sockeye salmon fry and predation by cottids was substantially greater than at nearby sites with low light. Also, we demonstrated at one site that reducing light intensity substantially reduced predation on sockeye salmon fry. Overall, we conclude that increased light intensity appears to slow or stop out-migration of fry, making them more vulnerable to capture by predators such as cottids.

After emerging from their redds, most sockeye salmon *Oncorhynchus nerka* fry immediately emigrate downstream at night to a lake environment, where they reside for the next year. However, during this brief (usually one or two nights) out-mi-

gration period, predation by other fishes can be an important source of mortality (Foerster 1968; Beauchamp 1995). Fry presumably reduce their vulnerability to predators by emigrating at night and selecting areas of the river channel with the fastest current velocities (McDonald 1960). The downstream migration of sockeye salmon fry is closely related to light intensity (McDonald 1960). The nightly downstream migration is initiated after the light intensity is less than 0.1 lx. Therefore, increased light intensity from artificial lighting may alter the migration patterns of sockeye salmon fry and change their vulnerability to predation.

The few studies that have examined predation

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on juvenile salmonids under different light intensities have had variable results. Ginetz and Larkin (1976) found that predation of sockeye salmon fry by rainbow trout *O. mykiss* in artificial streams increased as light intensity was increased under low light conditions (<0.1 lx); at high light intensities (0.5–3.0 lx), however, predation decreased as the light intensity was increased. Predation of chum salmon *O. keta* fry by staghorn sculpin *Leptocottus armatus* increased with increased light intensity at night but decreased with increased light intensity during the day (Mace 1983). Patten (1971) found that predation on coho salmon *O. kisutch* fry was greater on moonlit nights than on moonless nights; their results may have been biased, however, by differences in water temperature between treatments. In contrast, Petersen and Gadomski (1994) found that predation on chinook salmon *O. tshawytscha* smolts by northern pikeminnow *Pychocheilus oregonensis* increased as light intensity decreased from 215 to 0.01 lx.

With increased urbanization and development of the Pacific Northwest, the amount of artificial lighting has increased on many streams. The effects of artificial lighting on salmonid populations is poorly understood. In Washington, the Lake Washington sockeye salmon are found within a large urban area. The major spawning tributary to Lake Washington is the Cedar River, some sections of which are exposed to artificial lighting and also present migration routes for sockeye salmon fry. In recent years, sockeye salmon production has declined in the Cedar River; increased predation on migrating sockeye salmon fry as a result of increased nighttime lighting may be one factor in the decline of the Cedar River sockeye salmon population.

The objective of this study was to determine the effect of light intensity on the migratory behavior of sockeye salmon fry and on the predation of fry by cottids *Cottus* spp. in the Cedar River.

#### Study Site

The Cedar River, the main tributary for the Lake Washington basin (Figure 1), is the major spawning area for sockeye salmon. The lower 35.1 km are accessible to anadromous salmonids. Landsburg Dam, a water-diversion structure, prevents fish from migrating farther upstream. The lower 3 km of the Cedar River flows through a large, heavily urbanized floodplain. This river section is within the City of Renton, Washington, and has numerous sources of artificial light from urban and residen-

tial development. Upstream of river kilometer (rkm) 3, the river valley has some residential development but artificial light is substantially less than in the Renton area. Historically, the Cedar River did not flow into Lake Washington but flowed south as part of the Duwamish River. In 1917, however, the Cedar River was diverted into Lake Washington and a ship canal was constructed to connect the lake to Puget Sound. The historical abundance of sockeye salmon in the Cedar River is poorly understood, although the current sockeye salmon population in the Cedar River appears to be derived principally from introductions between 1937 and 1945 of fry from Baker Lake, Washington (Hendry et al. 1996).

Lake Washington, a large monomictic lake with a total surface area of 9,495 ha and a mean depth of 33 m, sits within a large urban area that includes both Seattle and Renton. More than 78% of the shoreline is given over to residential land use. The lake supports a large run of sockeye salmon. Some years have seen adult returns in excess of 350,000 fish, with most of the adult fish spawning in the Cedar River.

After emerging from the gravel, sockeye salmon fry immediately migrate downstream to Lake Washington, where they reside for the next year. They migrate primarily at night but some daytime migration can occur, particularly during high-flow events with increased turbidity (Seiler and Kishimoto 1997; Hensleigh and Hendry 1998). Fry generally take one or two nights to reach the lake (Seiler and Kishimoto 1997). In the Cedar River, sockeye salmon fry are vulnerable to predation from rainbow trout (both resident and steelhead; Beauchamp 1995), cutthroat trout *O. clarki*, juvenile coho salmon, and four cottid species: coast-range sculpin *Cottus aleuticus*, prickly sculpin *C. asper*, riffle sculpin *C. gulosus*, and torrent sculpin *C. rhotheus* (Tabor et al. 1998).

Prickly sculpin is the largest cottid in Lake Washington and the Cedar River, reaching more than 225 mm total length (TL). Prickly sculpin that prey on sockeye salmon fry in the Cedar River are generally 50–150 mm TL (R. Tabor, unpublished data). Larger prickly sculpin mostly consume larger prey such as lamprey (adults and ammocoetes) *Lampetra* spp., adult longfin smelt *Spirinchus thalichthys*, other cottids, and signal crayfish *Pacifastacus leniusculus*. Found in quiet areas of the lower 5 km of the Cedar River, prickly sculpin are also the dominant cottid in the benthic areas of Lake Washington (Eggers et al. 1978).

Torrent sculpin and riffle sculpin are widespread

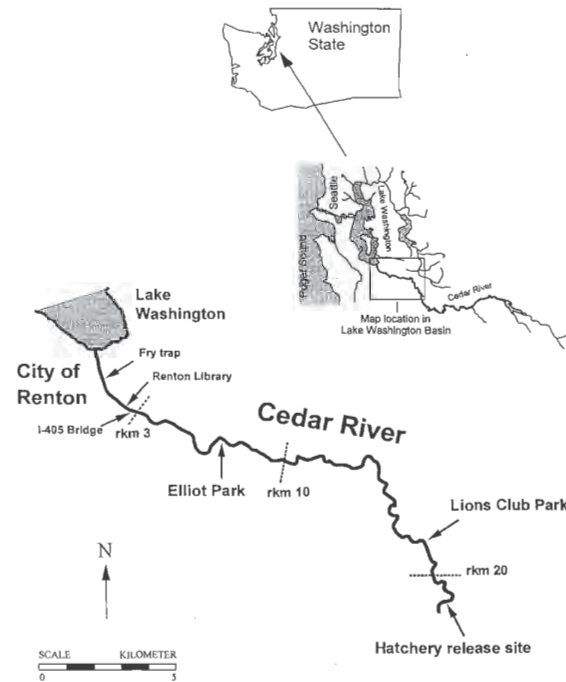


FIGURE 1.—Map of the lower Cedar River, showing the two experimental field trial sites (Lions Club Park and Elliot Park) and the two Renton city light sites (Renton Library and I-405 bridge). The locations of the release site for hatchery sockeye salmon fry and the fry enumeration trap are also shown. rkm = river kilometer.

in the Cedar River, inhabiting the lower 55 km of the river and several small tributaries. Coastrange sculpin occur primarily in the lower 21 km of the river. Torrent sculpin as large as 150 mm TL have been found in the Cedar River. Because of their high abundance and relatively high predation rates, torrent sculpin appear to be the most important cottid predator of sockeye salmon fry in the Cedar River (Tabor, unpublished data). Sizes of riffle sculpin and coastrange sculpin in the Cedar River are generally similar, both reaching approximately 120 mm TL. Riffle sculpin are typically found in

low-velocity areas along the shore of the Cedar River. Coastrange sculpin are usually found in riffles; however, large individuals are often found in pools.

#### Methods

To determine the effect of light intensity on the migratory behavior of sockeye salmon fry and on the predation of fry by cottids, we conducted several laboratory experiments and field studies (Table 1). We also measured light intensity at sites along the Cedar River to document the amount of

TABLE 1.—List of various study components used to examine the relationship between light intensity and sockeye salmon fry migratory behavior and predation by cottids. All field studies were conducted on the Cedar River. The cottid species of the field studies are listed in order of abundance; river km is distance from the mouth of the river.

Study component	River km	Dates	Cottid species
<b>Laboratory experiments</b>			
Circular tank experiments		May 1997	Prickly and torrent sculpin
Artificial stream experiments		May, Jun 1997	Prickly sculpin
<b>Field Studies</b>			
<b>Experimental field trials</b>			
Lions Club Park	18.3	Mar, Apr 1999	Torrent and riffle sculpin
Elliot Park	7.4	Apr, May, Jun 1999	Torrent, coastrange, and riffle sculpin
<b>Renton city lights</b>			
Renton Library	2.4	Mar 1999, Feb 2001	Coastrange sculpin
I-405 bridge	2.7	Feb 1998, Feb 2001	Coastrange and torrent sculpin
<b>Light intensity readings</b>			
City of Renton	0.0–2.9	Mar, Oct 2000	
Non-lighted areas	0.5–13.2	Feb, Apr 2001	

artificial lighting present and to assess how much the moon and cloudy nights affect light intensity levels. We used cottids to test the effect of increased light intensity on predation of sockeye salmon fry because cottids readily adapt to laboratory conditions, are abundant, and are important predators of sockeye salmon fry in the Cedar River (Tabor et al. 1998). Prickly sculpin and torrent sculpin were used in the laboratory experiments; torrent sculpin, coastrange sculpin, and riffle sculpin were collected at the field study sites.

#### Laboratory Experiments

We took a dual experimental approach to determine whether cottids prey more effectively at the light intensities generated by standard artificial light sources. Because cottids and sockeye salmon fry may alter their behavior in relation to light intensity, the sensory abilities of one to detect the other may be differentially affected by light intensity. We first tested predation of cottids in the simplistic environment of circular hatchery tanks with minimal water flow, to allow us to separate the effect of the changes in fry migratory behavior that might occur under different light intensities from the ability of cottids to prey on them. To assess the effect of light intensity on sockeye salmon fry behavior, we performed a second experiment, using artificial streams under more natural conditions that allowed fry to migrate downstream. The sockeye fry released upstream in these trials could behave more naturally in this environment than in a hatchery tank in relation to the light intensities used in our treatments; that is, they could migrate quickly through the artificial stream

or delay their passage by stationing in eddies or burying in the gravel substrate.

During May–June 1997, we conducted experiments at the Western Fisheries Research Center, U.S. Geological Survey, Seattle, Washington. Prickly sculpin (74–103 mm TL) and torrent sculpin (74–98 mm TL) collected from the Cedar River and Lake Washington by electrofishing were transported to the laboratory, where they were maintained in circular holding tanks in size-sorted (small: 70–79 mm TL; medium: 80–89 mm TL; and large sculpin: 90–99 mm TL) and species-specific groups. The sizes of cottids collected are representative of those that commonly consume sockeye salmon fry in the Cedar River (Tabor, unpublished data). Sockeye salmon fry were obtained periodically from the Washington Department of Fish and Wildlife fry enumeration trap located near the mouth of the Cedar River. The mean fork length (FL) of the fry was 28.4 mm ( $N = 90$ ; SE, 0.18; range, 26–34 mm FL). The fry were presumably both migration- and predator-experienced. After transport to the laboratory, the fry too were held in circular holding tanks. Fry were fed commercial fry food daily throughout the experimental period. Most fry were used in experiments within 5 d after they were collected; however, some fry used in the last experiments were held as long as 14 d. Sculpin were fed available salmonid fry before the experiment.

The light intensities used in the experiments represent the range of values observed during field measurements in the lower Cedar River. All light intensity measurements were made with an International Light, Inc., model IL1400A radiometer/

photometer. The light source consisted of one or two strings of small ornamental lights (small, clear, holiday tree lights) taped to the underside of the lids of the tanks and the artificial streams and suspended directly above the water. Each light string was connected to an outlet box and a dimmer switch. Predation trials in both experiments were run during daylight hours. Testing environments were covered with layers of black sheeting to exclude all light except that produced by our artificial light source.

**Circular tank experiments.**—The tank experiments were conducted in three 1.2-m-diameter circular tanks. Water depth was maintained at 30 cm and water temperature was approximately 12°C. We tested six light intensities (0.00, 0.03, 0.06, 0.11, 1.08, and 10.8 lx) during the predation experiments. For each trial, we randomly selected one of these treatment light intensities. We carefully adjusted the lights to maintain that intensity in each of the three replicate test tanks before each experimental trial. In each trial we used single-species groups of 20 sculpin (three large, nine medium, and eight small fish randomly sampled from the size-sorted holding tanks) and 100 fry. We performed six replicate trials for each light intensity with both prickly sculpin and torrent sculpin. The fry were given 15 min to adjust to the experimental setup before the sculpin were added. Two black Plexiglas shelves within each tank served as a refuge/hiding place for the sculpin during the experiments. After addition of the sculpin, each trial lasted 40 min. Trial starting times were staggered for the three test tanks to allow sufficient time for recovery of all fish with a small aquarium net and flashlight. Predation was determined as the number of sockeye salmon fry lost during a trial. Results of the light intensity experiment were analyzed with one-way analysis of variance (ANOVA) tests and post hoc Tukey's Honestly Significant Difference (HSD) tests.

Prickly and torrent sculpin were used on alternate days to allow adequate digestion time between trials. The stomach contents of three replicate groups of cottids from both the 0.00 and 10.8 lx light intensities ( $N = 60$  for each light treatment and cottid species combination) were removed by gastric lavage to confirm consumption of fry, determine the percent of sculpin that consumed fry, and confirm the absence of previously consumed fry. Light et al. (1983) found gastric lavage was 100% effective for removing stomach contents of slimy sculpin *C. cognatus*.

**Artificial stream experiments.**—Sockeye salmon

fry migration/behavior experiments were done in two identical artificial streams containing natural river gravel substrate. Each stream was 9 m long by 1.5 m wide and was contained within a fiberglass trough. We used only a 3-m section of each stream to allow enough space downstream to set up a fish trap for collecting the fry. Each experimental section consisted of a 2.5-m-long pool and a short riffle section. The riffles had a 2% gradient and a water depth of 18 cm. The maximum depth of each pool was approximately 75 cm. Surface velocities ranged from 0.37 m/s near the inflow to 0.12 m/s at the outflow. Near the bottom of each pool the water velocity was negligible. The light intensity was measured approximately 10 cm below the surface of the water in both streams. For the predator trials, 20 prickly sculpin (mean, 86.5 mm TL; range, 75–99 mm TL) were placed in each artificial stream, where they remained throughout the duration of the experiment. We performed trials once every 2–3 d to allow the sculpin enough time to digest fry from the previous trial.

At the start of each trial, 125 fry were transferred from the laboratory, where they had been held in low light intensity, and were released at the upstream end of each experimental section. Trials started immediately with the addition of fry, and the fry traps were checked with a flashlight at 20 min and after 2, 4, and 6 h. Any fry caught in the fry trap were removed with a small aquarium net and counted. After 6 h, all lights were turned off and the fry were given 12–16 h (overnight) to migrate through the streams to the trap. Again, any fry in the trap were removed and a final count was made. We did not try to collect any fry possibly remaining in the artificial streams because preliminary work had indicated the fry were extremely difficult to locate and capture. In nonpredator trials, the number of fry not accounted for by the beginning of the next trial was added to the number of fry released (125) at the start of that next trial. Consequently, the results are presented as a cumulative percentage of the total fry in each stream that migrated downstream to the fry trap within the trial periods. In the predator trials, we assumed that the fry not accounted for were all consumed by sculpin. Because few fry migrated overnight in the predator trials when the streams were darkened, this appears to be a valid assumption.

The artificial stream trials were conducted in two parts. No predators were used in the first part, in which two replicates of each of three light intensities (0.00, 1.08, and 5.40 lx) were tested. In the second part, predators were present in one



stream and absent in the other, and four light intensities were tested (0.00, 0.22, 1.08, and 5.4 lx). Two replicates of each level were tested except that time constraints allowed only one trial at 0.22 lx. On each trial date, the same randomly selected light intensity treatment was used in both the predator and nonpredator artificial stream.

#### Field Studies

**Experimental field trials.**—We performed experimental field trials at two sites on the Cedar River, the Lions Club Park at rkm 18.3 and the Elliott Park at rkm 7.4 (Figure 1). The Lions Park site, with a 112-m shoreline section, had two distinct habitat types: The upper 56 m had a riprap shoreline (steep sloping banks), whereas the lower 56 m had a gravel shoreline with gradually sloping banks. The Lions Club Park was the site of two experimental trials, both conducted on nights when hatchery sockeye salmon fry had been released upstream at rkm 21.7. On March 31, 1999, 135,000 fry were released at approximately 2015 hours and on April 5, 1999, 57,000 fry were released at approximately 2115 hours. Most of the fry appeared to reach the fry trap at rkm 1.2 between 2300 and 0000 hours on March 31 and between 0000 and 0100 hours on April 6 (D. Seiler, Washington Department of Fish and Wildlife, unpublished data).

The other site, at Elliott Park, consisted of a side channel immediately downstream from the outlet of a spawning channel. We sampled the side channel five times from April 7 to June 14, 1999, during the fry out-migration period. Fry observed at this site most likely originated from the spawning channel, because no hatchery fry were released during these dates. The Elliott Park site consisted of one 40-m-long sand/gravel shoreline section.

Shoreline sections at both sites were divided into 8-m-long units. Lights were added only to every other unit to ensure that light from one experimental unit did not affect the adjacent units. Treatments were randomly assigned within the alternate shoreline sections. Two lights were used for each experimental unit, each mounted at the top of 2-m-tall poles that were placed at the far ends of each unit; there, the lights were directed toward the middle of the unit. Each light was set up as an individual light system consisting of a 60-W light bulb, a deflector to focus the light, and a dimmer switch to control the light intensity. We used different combinations of five light intensities: (1) control (no lights), 0.01–0.11 lx; (2) dim, 0.16–0.27 lx; (3) low, 0.48–0.59 lx; (4) medium, 1.08–1.51 lx; and (5) bright, 10.80–15.10 lx. Light

intensity was measured at the surface of the water, 2 m from shore. Generally, we took three measurements, one in the middle and one each from just inside the upstream and downstream edges. The middle of each experimental unit was the brightest, and the upstream and downstream edges were the dimmest; moreover, light intensity attenuated across the river channel. We turned on the lights shortly after dusk and adjusted their settings to get the appropriate light intensity.

Experiments lasted 2–3 h. At both sites, sockeye salmon fry abundance was estimated by counting fry along the shoreline. Fry were counted by an observer using a flashlight, who slowly walked along the shoreline in a systematic pattern to ensure that the area out to 2 m from shore was completely covered. To be consistent between treatments, we counted only fry within the beam of the flashlight. Preliminary observations indicated that fry were in shallow water and close to the surface of the water, tended to hold their position facing into the current, and did not move appreciably. Thus, fry could be easily counted and fish counts between different shoreline types (gravel shore and rip-rap) could be compared. In subsequent electrofishing after the experimental trials, we found no evidence that sockeye salmon fry were hidden within the riprap. We assumed that the counting had a minimal effect on fry abundance because it took only a short time, approximately 1 min per shoreline section. Fry were counted every 15 min at the Lions Club Park. At Elliott Park, we only did two counts, one shortly after the experiment was started and another at the end of the experiment. For some experimental trials, we recounted the number of fry present 20 min after the lights had been turned off.

After the lights had been turned off, we used backpack electrofishing equipment to collect cottids along the shoreline to determine the level of predation. We assumed there was little movement of sculpin between sections because of the relatively short duration of each experiment (approximately 2 h) and the 8-m gap between sections. We also considered it unlikely that a sculpin from one section could flee into another section because there was a gap between sections and because we sampled in an upstream direction, from the downstream end to the upstream end. Stunned fish were collected with the aid of dip nets and a spot light. After capture, cottids were identified as to species and measured for total length. Cottids of 50 mm TL or larger were anesthetized and their stomach contents were removed by gastric lavage. Because

small cottids rarely consume sockeye salmon fry (Tabor, unpublished data), we did not check the contents of their stomachs. Ingested fry were counted and categorized as freshly ingested or well digested. Only counts of freshly ingested fry were used in the analyses. We assumed that freshly ingested fry were consumed during the experiment, whereas well-digested fry had been consumed the previous night or sometime before the experiment. Because we started the experiments shortly after sunset and because cottids are primarily nocturnal and sockeye salmon fry migrate primarily at night, we deem this a valid assumption.

We tested differences in fry abundance with a two-way ANOVA without replication. Data were log-transformed because the data were multiplicative rather than additive (Zar 1984). The two factors paired for testing were light intensity and habitat type for the Lions Club Park data and light intensity and date for the Elliott Park data. Several cottids did not consume any fry, meaning that the predation data were not normally distributed; therefore, we used nonparametric procedures to compare predation, a Mann-Whitney *U*-test (two samples) or a Kruskal-Wallis test (more than two samples).

**Renton city lights.**—Two sites were selected in Renton, the Renton Library and the I-405 bridge (Figure 1), as having an area of high light intensity and a nearby area with similar habitat and substantially lower light intensity. Abundance of sockeye salmon fry and predation of fry by cottids were monitored on nights when hatchery sockeye salmon fry were released so we could ensure that a large number of fry were available. The Renton Library sits 5 m above the Cedar River, spanning the entire width of the river and covering a 28-m-long section of the river. We compared the findings for a 22-m-long river section under the library, where no artificial lights were present, with those for a 22-m-long river section 3 m downstream of the library and characterized by several artificial lights spanning the width of the river. The library site was sampled once in 1999 and once in 2001. The I-405 bridge had several lights under the bridge to illuminate a walkway that spans the river. The control site for this location was 180 m upstream from the bridge, where no direct lighting was present. Both sites were 20 m long. Sampling was conducted once in 1998 and again in 2001. Sampling in 2001 was conducted after artificial lights had been shielded and light intensities along the river had been substantially reduced from 9.7–21.5 lx in 1998 to 0.14–0.32 lx in 2001. In the

TABLE 2.—River conditions and the number of emigrating sockeye salmon fry on three dates used to examine the difference in predation of sockeye salmon fry by cottids before and after lights at the I-405 bridge were shielded. Streamflow and water temperature data were taken by U.S. Geological Survey at rkm 2.2. Fry abundance estimates were obtained from fry trap data (D. Seiler, Washington Department of Fish and Wildlife, unpublished data). The fry trap was located at rkm 1.6 (from the mouth of the river). Catch efficiency of the fry trap on the dates listed ranged from 9.6% to 10.2%.

Date	Fry abundance		Streamflow (m <sup>3</sup> /s)	Temperature (°C)
	Sample night	Prior night		
Feb 23, 1998	296,800	318,000	16.7	7.3
Feb 25, 1998	537,900	434,000	18.6	7.2
Feb 21, 2001	684,000	557,000	10.0	7.7

2001 sampling, streamflow was lower, water temperature was slightly higher, and fry abundance was greater than during the 1998 sample (Table 2). Therefore, predation in 2001 was expected to be as high or higher than during sample dates in 1998. Sockeye salmon fry abundance at all sites was estimated by counting fry along the shoreline, similar to the experimental field trials. Light intensity was measured at the surface of the water in the middle of the area sampled.

At both sites, cottids were collected with backpack electrofishing equipment and analyzed for stomach content to compare the extents of predation of fry. At Renton Library, cottids were sampled along the shoreline and were collected visually with the aid of dip nets and a spot light. At the I-405 bridge site, cottids were collected in the mid-channel area because few cottids were present along the shore of the control site. Stunned cottids in the mid-channel area were collected passively with the aid of block nets. After capture, cottids were identified to species and TL was measured. Afterwards, their stomach contents were removed by gastric lavage and consumed sockeye salmon fry were counted. We assumed that cottids had consumed fry in the same general area where we captured them. We included counts of all sockeye salmon fry ingested because the artificial lighting was consistent from night to night. A Mann-Whitney *U*-test was used to compare differences in predation between the lighted site and the control site.

**Light intensity readings.**—In 2000 we assessed the artificial lighting along the lower 3 km of the Cedar River, taking light readings every 50 m over rkm 0.9–2.9. Below rkm 0.9, access to the river was limited in many areas, so additional readings were only made at rkm 0.0, 0.2, 0.3, and 0.7. All

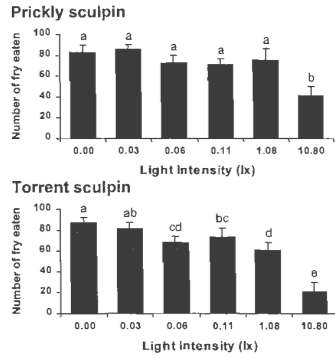


FIGURE 2.—Number of sockeye salmon fry eaten ( $\pm$ SD) by prickly sculpin and torrent sculpin in 40-min trials in circular tanks at different light intensities. Each bar is the mean of six trials. Groups of bars with different letters are significantly different (ANOVA and Tukey's HSD;  $P < 0.05$ ).

readings were taken close to the riverbank, approximately 1–5 m from shore, and at the surface of the water. At major light sources, we took an additional reading to determine the maximum light intensity. Besides identifying sources of direct lighting, we also measured light intensity in other natural lighting conditions—(1) overcast skies; (2) clear skies, no moon; and (3) clear skies, full moon—at five locations without artificial lighting: rkm 0.5, 3.1, 6.9, 9.8, and 13.2.

**Results**

*Laboratory Experiments*

Prickly sculpin and torrent sculpin displayed similar amounts of predation with respect to increasing light intensity in tank experiments. Both species captured more fry under low light conditions than under the highest light intensity (Figure 2). Prickly sculpin captured a mean of 82.3 fry ( $SD = 7.4$ ) at 0.00 lx compared with a mean of 41.5 fry ( $SD = 8.7$ ) at 10.80 lx. Torrent sculpin captured a mean of 86.8 fry ( $SD = 5.3$ ) at 0.00 lx and a mean of 21.3 fry ( $SD = 8.3$ ) at 10.80 lx. A separate one-way ANOVA was performed on untransformed data of number of fry eaten for the two sculpin species. The ANOVA tests indicated significant differences among the six light intensities tested for both prickly sculpin ( $P < 0.001$ ) and torrent sculpin ( $P < 0.001$ ).

Results from a post hoc Tukey's HSD test for prickly sculpin showed significantly less fry consumption at the highest light intensity but no difference among the other five light levels (Figure 2). Torrent sculpin indicated more differences among the six light intensities although, as with prickly sculpin, predation at the highest light intensity differed from that at the other five. The other five levels showed significant differences between treatments ( $P < 0.05$ ), but there was no consistent trend from the lowest intensity to the highest one. In general, however, the number of fry eaten by torrent sculpin decreased as the light intensity increased.

Gastric lavage of three replicate trials of 20 sculpins each (total, 60 sculpin per species) from the trials at 0.00 and 10.80 lx verified that both prickly sculpin and torrent sculpin consumed more sockeye salmon fry at the lowest light intensity than at the highest light intensity. Ninety-five percent of the prickly sculpin had consumed at least one fry at 0.00 lx, whereas only 87% consumed fry at 10.80 lx. Thirty-eight percent of the prickly sculpin had consumed more than four fry at 0.00 lx, but only 5% had consumed more than four fry at 10.80 lx. The maximum number consumed by a prickly sculpin was nine fry (0.00 lx). Ninety-two percent of the torrent sculpin had consumed at least one fry at 0.00 lx, but only 68% had consumed fry at 10.80 lx. Fifty-two percent of the torrent sculpin had consumed more than four fry at 0.00 lx, whereas only 7% had consumed more than four fry at 10.80 lx. The maximum number of fry consumed by a torrent sculpin was 12 fry (0.00 lx).

We also verified that 2 d was sufficient time for digestion of previously consumed fry (and therefore, resumption of predatory motivation) in these experiments because only freshly consumed fry were recovered in the gastric lavage contents.

*Artificial Stream Experiments*

The first set of experimental trials, conducted with no predators present, indicated that sockeye salmon fry migrated through the stream at a faster rate under complete darkness (0.00 lx) than in the other two light intensities (1.08 and 5.4 lx). Under complete darkness, 74% ( $SD = 4.5\%$ ) of the fry migrated downstream within the first 20 min of the trials, and an additional 25% migrated downstream over the course of the next 24 h. Results were similar for the two treatments with light present but differed from those with light absent. In the 1.08 and 5.40 lx trials, 32% ( $SD = 8.6\%$ ) and 34%

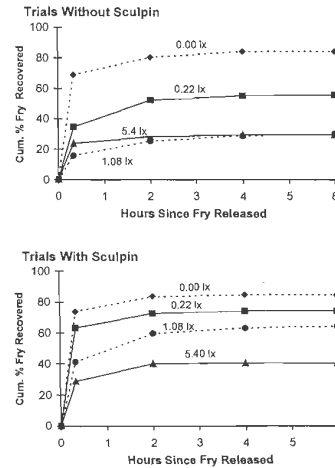


FIGURE 3.—Cumulative percent of total sockeye salmon fry recovered after release in artificial streams under four different light intensities. Each line is the mean of two trials, except that only one trial was conducted for the 0.22-lx experiment. The top and bottom panels show the results for trials when fry emigrated in the absence or in the presence of prickly sculpin, respectively.

( $SD = 7.8\%$ ), respectively, of the fry migrated downstream within the first 20 min, and an additional 52% and 56%, respectively, migrated downstream within the next 24 h.

The second set of experimental trials was conducted with sculpin present in one stream and not in the other. These predation plus out-migration trials showed several strong patterns, even with only two trials completed at each of four light levels (Figure 3). First, as in the earlier trials, fry readily emigrated through the artificial streams under complete darkness but increasingly delayed passage as the light increased. Second, fry emigrated faster in all nondark trials when sculpin were present. Third, and most crucial, a greater proportion of fry were never recovered in the stream trials with sculpin present and the proportion missing was related directly to the light intensity (Table 3). Even though fry migrated more quickly with sculpin present than when the pred-

TABLE 3.—Percentage of sockeye salmon fry not recovered from outmigration trials in the artificial streams in the presence or absence of prickly sculpin under different light intensities. Estimates of the percent eaten were derived by subtracting the mean percent fry not recovered from the trials with no sculpin (mean = 10.0%) from each mean of percent fry not recovered with sculpin present.

Light level (lx)	Percent fry not recovered (SD)		Estimated percent eaten	Number of trials
	Sculpin absent	Sculpin present		
0.00	8.1 (2.2)	15.2 (2.3)	5.2	2
0.22	13.4	38.4	28.4	1
1.08	10.0 (1.7)	34.0 (6.2)	24.0	2
5.40	8.5 (1.5)	55.2 (13.6)	45.2	2

ators were absent, the fry were apparently more vulnerable to predation with increasing light intensity. At the most intense light tested (5.4 lx), subtracting the average number of fry unaccounted for in all trials with no sculpin present (10%) indicates that about 45% of the fry in the trial were probably consumed by sculpin. At 0.22 lx, about 28% of the fry became prey, and only about 5% were likely prey to the sculpin in the dark trials. Finally, our results consistently showed that fry not recovered in the first 2 h of a trial including sculpin were never recovered.

*Field Studies*

*Experimental field trials.*—At Lions Club Park on March 31 and April 5, 1999, few sockeye salmon fry were observed in all units for the first 45 min to 1 h. Within the next 20 min, however, the number of fry increased dramatically. For example, in the brightest light experimental unit, the number of fry changed from 27 at 2025 hours to 577 at 2045 hours. This increase in the number of fry most probably resulted from the large number of hatchery fish released earlier that evening. Experimental units with greater light intensities had significantly more fry in both experimental trials (ANOVA; March 31,  $P = 0.02$ ; April 5,  $P = 0.005$ ; Figure 4). Moreover, within each light intensity trial, more fry were found in the gravel shore than on the riprap shore (ANOVA; March 31,  $P = 0.04$ ; April 5,  $P = 0.03$ ; Figure 4). On average, gravel shores had 5 times as many fry as riprap shores for a given light intensity.

Overall, fry abundance results at the Elliot Park side channel followed patterns similar to those at Lions Club Park. Fry counts were conducted on five dates; on May 3, 1999, however, the light system for the medium-light experimental unit

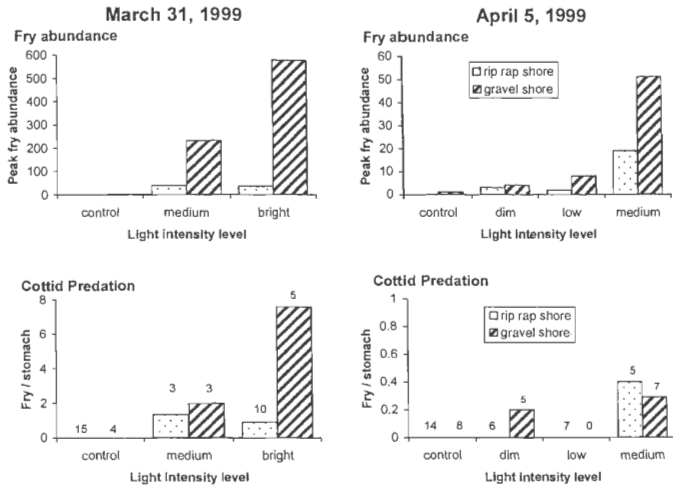


FIGURE 4.—Sockeye salmon fry abundance and cottid predation of fry at various light intensities and two habitat types from two experimental trials at Lions Club Park (rkm 18.3) on the Cedar River in 1999. Numbers above the bars indicate the number of cottid stomachs examined. Only freshly ingested sockeye salmon fry were counted as indicators of recent ingestion.

malfunctioned, and we were unable to get a fry count for that part of the experiment (Figure 5). The abundance of fry in the side channel varied greatly on the five dates sampled and most probably consisted of migrants from the spawning channel. Peak out-migration appeared to occur around May 3. An ANOVA revealed a significant difference ( $P < 0.001$ ) in fry abundance between light intensity values and between sampling dates ( $P < 0.001$ ). The most fry were always in the medium-light unit, the dim-light unit always had the second most numerous fry, and the control unit always had the least (Figure 5).

In two experimental trials, we also examined the abundance of fry shortly after the lights were turned off. In all the lighted experimental units, the number of fry decreased dramatically after the lights were turned off (Figure 6). In control units (no light added), the number of fry decreased slightly or actually increased. The lighted shoreline sections averaged a 93% reduction in fry

abundance at Lions Club Park and a 88% reduction at Elliot Park.

In general, predation of fry by cottids showed the same trend as fry abundance. The most predation took place in experimental units with increased light. This trend was particularly noticeable during the March 31, 1999, trial at the Lions Club Park. Whereas no predation was detected in the control units, large numbers of fry were found in the stomach samples of cottids collected from the bright-light experimental unit (Figure 4). Three torrent sculpin collected from this unit had 10 or more fry in their stomachs. The maximum number of sockeye salmon fry consumed by an individual fish was 13 (92 mm TL, torrent sculpin). Differences in predation were marginally significant (Kruskal-Wallis test = 5.7,  $P = 0.058$ ) between experimental units but were not significant between medium and bright experimental units (Mann-Whitney  $U$ -test = 3.5,  $P = 0.23$ ). Predation in both of the lighted riprap experimental units

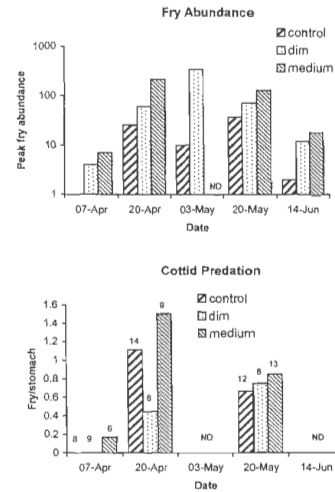


FIGURE 5.—Abundance of sockeye salmon fry (log scale) and extent of cottid predation of fry at three light intensity values on five nights in 1999 at the Elliot Park side channel (just below a spawning channel). Numbers above the bars indicate the number of cottid stomachs examined. Only freshly ingested sockeye salmon fry were counted as indicators of recent ingestion. ND = no data.

was less than in units with gravel shores; these differences were significant between the two bright experimental units (Mann-Whitney  $U$ -test = 8.0,  $P = 0.03$ ) but not in the medium-light experimental unit (Mann-Whitney  $U$ -test = 3.5,  $P = 0.66$ ).

Predation of fry on April 5, 1999, was low for all experimental units. Only 3 of the 42 cottids analyzed had consumed sockeye salmon fry. Although we detected no differences between treatments, four of the five fry consumed were from the medium-light experimental units and no predation was observed in the control units (Figure 4).

Cottids were collected on three occasions at the Elliot Park side channel. In each trial, the most predation was observed in the medium-light unit

(Figure 5); however, no significant differences between the light intensity units were detected.

At Lions Club Park, torrent sculpin made up 92% of the cottids captured, riffle sculpin 8%. At the Elliot Park side channel, 50% of the cottids were torrent sculpin, 26% were coastrange sculpin, and 24% were riffle sculpin. Predation was observed in all cottid species present at both sites.

**Renton city lights.**—At both locations examined, the abundance of sockeye salmon fry along the shoreline was substantially greater at sites with high light intensity than at a nearby site with low light (Figures 7 and 8). Additionally, little predation was observed in control areas with low light intensity, whereas relatively high predation was observed in lighted areas. At the Renton Library, predation on both sample dates was significantly higher in the lighted area than in the control area (Mann-Whitney  $U$ -tests: March 18, 1999,  $U = 63$ ,  $P = 0.03$ ; February 21, 2001,  $U = 247$ ,  $P = 0.002$ ). Combined, 53% of the cottids in the lighted area had consumed sockeye salmon fry, whereas only 3% had in the control site. All of the cottids collected at the library location were coastrange sculpin.

At the lighted I-405 site on February 25, 1998, 53% of the cottids had consumed fry (0.9 fry/stomach), but no predation had occurred at the control site. Predation was significantly greater in the lighted area (Mann-Whitney  $U$ -test = 58.5;  $P = 0.002$ ) than in the control area. Preliminary sampling was also done at the I-405 bridge on February 23, 1998 (the control site was not sampled). From 15 cottids collected, a total of 18 sockeye salmon fry was found in the stomach samples (1.2 fry/stomach). Shielding lights under the I-405 bridge greatly reduced light intensities in the river, consequently greatly decreasing the shoreline abundance of fry and the predation of fry. In 2001, in contrast to the sampling in 1998, the number of fry at the bridge was similar to the number at the control site (Figure 8). We sampled 22 cottids from the I-405 bridge site and 14 cottids from the control site and observed no predation at either site. Predation of fry was significantly less at the I-405 bridge site when the lights shielded than on two dates in 1998 when the lights were shining directly on the river (Mann-Whitney  $U$ -test = 319;  $P < 0.001$ ). Of all the cottids collected at the bridge and control site, 96% were coastrange sculpin and 4% were torrent sculpin; both species were observed to have ingested sockeye salmon fry.

**Light intensity readings.**—Surveys of the lower 3 km of the Cedar River indicated that most of

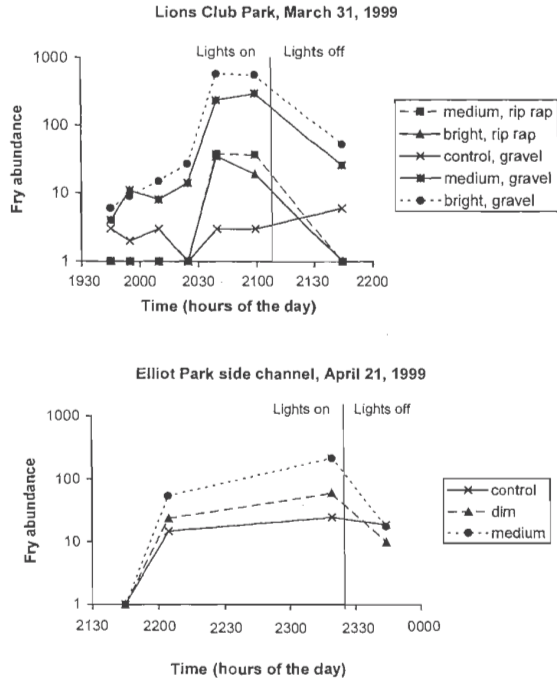


FIGURE 6.—Abundance of sockeye salmon fry (log scale) at three light intensity values in two experimental trials in the Cedar River, 1999, in which artificial lights that were on at dusk were later turned off. Vertical lines indicate when the lights were turned off. The March 31 trial was done at two habitat types, riprap and gravel shore. No fry were seen in the control riprap unit, so that site is not plotted on the graph.

this area has light intensity values (>0.2 lx) exceeding natural amounts (0.0 lx). Within the lower Cedar River, nine locations had light intensity greater than 1.1 lx. At six of these sites, the light was from street lights at bridges; at the other three, the light was associated with a building adjacent to the river. The highest light readings recorded were at the I-405 bridge (21.5 lx) and the Renton Library site (20.4 lx). Between rkm 0.9 and 2.9, the median light intensity level was 0.37 lx on a clear, moonless night but 0.94 lx on a cloudy night.

Light readings of areas with no direct lighting in the lower 13 km of the Cedar River indicated that light reflected off clouds was greatest near the mouth of the river and gradually decreased at upstream locations (Figure 9). Light intensities on cloudy nights in the lower 9 km of the river exceeded those on a clear night with a full moon. As expected, light intensity readings during clear skies were similar between locations. Observations from a plane at night suggest that most of the reflected light comes from the City of Renton

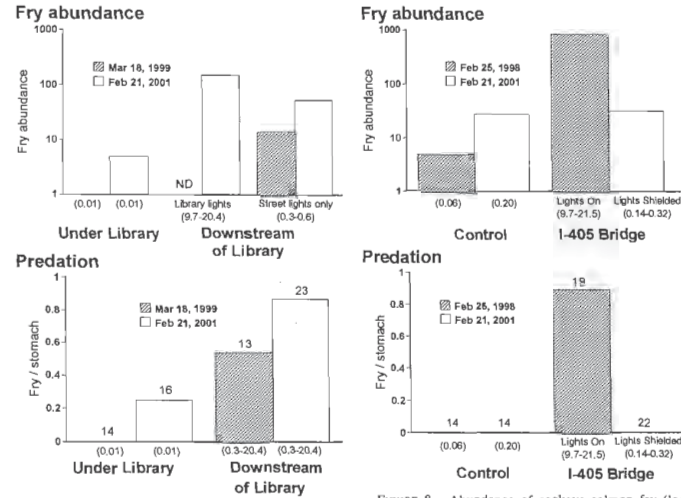


FIGURE 7.—Abundance of sockeye salmon fry (log scale) and extent of predation of fry by cottids at the Renton Library, City of Renton, Washington. The library lights were on for approximately 3 h after sunset and then turned off, whereas the street lights remained on all night. The abundance of fry was the number along a 22-m shoreline section at each site. Light intensities (in lux) are indicated in parentheses. In 1998, the lights under the I-405 bridge shone directly on the river; in 2001, the lights were shielded so that they shone primarily on a walkway and not on the river. The control site was located 180 m upstream of the bridge. The number of cottids examined for fry consumption is given above each bar. ND = no data.

and from a large industrial area just south of Renton. Upstream of the City of Renton, no significant lighting sources were apparent that would increase the amount of reflected light along the river during cloudy nights.

Discussion

Fry Behavior

Increasing light intensity appeared to affect greatly the behavior of sockeye salmon fry. Sockeye salmon fry usually emigrate at night, when light levels are less than 0.1 lx, and select areas of the river channel that have the fastest current velocities (McDonald 1960). Our experimental field trials demonstrated that if fry encounter lighted areas, many will hold their position in low-

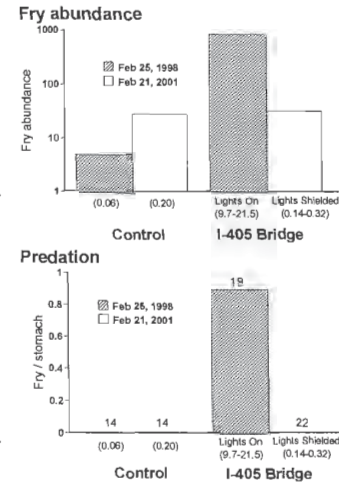


FIGURE 8.—Abundance of sockeye salmon fry (log scale) and predation of fry by cottids at two Cedar River sites with various light intensity values near the I-405 bridge, City of Renton, Washington. The abundance of fry was the number counted along a 20-m shoreline section at each site. Light intensities (in lux) are indicated in parentheses. In 1998, the lights under the I-405 bridge shone directly on the river; in 2001, the lights were shielded so that they shone primarily on a walkway and not on the river. The control site was located 180 m upstream of the bridge. The number of cottids examined for fry consumption is given above each bar.

velocity water and delay their migration. McDonald (1960) also observed that sockeye salmon fry stopped swimming downstream when they encountered a light. Shoreline observations in the Cedar River indicated that fry were in shallow water close to the surface of the water and tended to hold their position facing into the current without moving appreciably. Our behavioral observations at lighted areas were similar to daytime observations of Hartman et al. (1962), who found that sockeye salmon fry accumulate and hold along the stream edges and invariably remain in the top 0.15 m of the water. Hensleigh and Hendry (1998) experimentally found that most fry moved down-

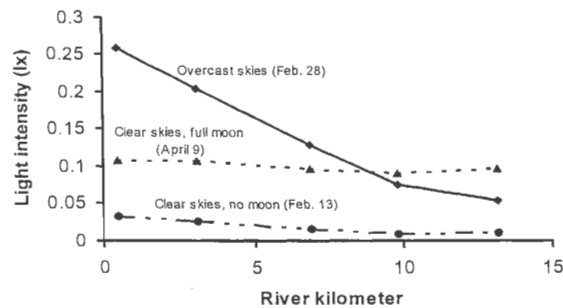


FIGURE 9.—Nighttime light intensities at five locations on the lower Cedar River as determined in 2001 under three different scenarios. Light readings were taken close to the surface of the water at locations with no direct lighting. The dates on which the light readings were taken are indicated in parentheses.

stream in the dark but tended to hold their positions or move slightly upstream in the light.

As shown by counts of fry along the shoreline of the Cedar River, the abundance of sockeye salmon fry that were delayed appeared to be positively related to the light intensity. Even small increases in light intensity seemed to affect fry behavior. At Elliot Park, for example, we consistently observed differences in fry abundance between the control (0.11 lx) and the dim-light experimental unit (0.22 lx). In the Cedar River, other variables such as total number of nightly migrants, water velocities, shoreline type, substrate type, streamflow, and turbidity will probably also influence the number of fry delayed. If these other variables could be held constant the number of fry delayed will probably be closely related to light intensity values.

We were surprised by the large number (>550 fry) of sockeye salmon fry present within the bright-light experimental unit (sand and gravel shoreline) during the March 31, 1999, experiment. Approximately 120,000 fry had been released on that date. Assuming a similar per kilometer survival rate as those in hatchery releases from Landsburg Dam (Seiler and Kishimoto 1997) and if the number of wild fry was minimal, we estimate that 110,000 hatchery fry moved past our experimental site. Therefore, we were able to delay 0.5% of the release group within an 8-m-long shoreline section with two small lights. Near the shoreline, the light intensity level was 11–15 lx, but in the middle of the channel, where most fry would be, we would expect the light intensity to be only 0.1 lx. This

suggests that several large lights spread out over a long section of shoreline and across the river channel could strongly affect the behavior of migrating fry.

The duration of delay for an individual sockeye salmon fry is unclear. We assumed that once a fry is delayed in a lighted area, it may be delayed for a considerable period of time. At the I-405 bridge site (before the lights were shielded), we routinely observed large numbers of fry at different hours of the night, from shortly after dusk to shortly before dawn. Although there may have been some level of turnover of individuals, we think it reasonable that many were delayed for several hours. Because fry only take one or two nights to reach Lake Washington, a delay of a few hours may markedly increase their risk to predation. McDonald (1960) was able to completely stop the nightly movement of sockeye salmon fry with artificial lighting (30 lx) that was kept on all night. In other experimental trials, McDonald (1960) turned the lights off at different times of the night and observed that immediately afterwards the migration of fry commenced. In our experimental field trials, the fry appeared to resume their migration shortly after the lights were turned off. Further experiments are needed to determine how long fry are delayed.

In addition to increased shoreline abundance of sockeye salmon fry, increased light intensity may also cause fry to move into low-velocity areas along the bottom of the river channel. Once fry encounter artificial lighting, they reverse their di-

rection and face upstream into the current (McDonald 1960); they will either stay in fixed position above the substrate or seek cover in the substrate. Given the high current velocities in the Cedar River, the only locations where fry could easily maintain their position in the current would be along the shore or on the bottom of the river channel. We were able to directly estimate the number of fry along the shoreline but not the number of fry along the bottom of the river channel. However, we were able to measure this number indirectly by examining predation by cottids in the midchannel area of a riffle at the I-405 site. Because of the high incidence of predation at this lighted site, we believe many sockeye salmon sought cover in the substrate and became vulnerable to predation by cottids. In all, we found 33 fry in 33 cottid stomach samples. Under similar conditions at a nearby control site, as well as at nine other sites further upstream with little lighting, only one salmonid fry was found in the stomachs of 109 cottids examined (Tabor, unpublished data). Similarly, in 2001, after the lights at the I-405 site were shielded, we observed no predation.

#### Predation of Fry

Under natural nighttime light intensity, sockeye salmon fry and cottids are probably spatially segregated because the fry occupy areas of faster water velocity (McDonald 1960), whereas cottids stay in close contact with the substrate and thus occupy areas with substantially slower water velocities. By selecting fast-flowing water areas, fry are able to move quickly downstream and reduce the likelihood of encounter with predators (Ginetz and Larkin 1976). Increased light causes fry to delay migration and to move to low-velocity water, where one would expect more frequent rates of encounter with cottids. Other research on predation of fry by cottids in the Cedar River has indicated that predation occurs primarily in low-velocity habitats such as pools and side channels (Tabor et al. 1998). Also, predation rates appear to be negatively related to streamflow. In addition, investigators have found that survival of juvenile salmonids is positively related to streamflow, which is probably related to reduced amounts of predation (Cada et al. 1997; Seiler and Kishimoto 1997).

Predation of fry by cottids appeared to be closely related to fry density at all field sites. As light intensity increased, the shoreline density of fry increased and subsequently the amount of predation increased. Cottids appeared to exhibit some

type of functional response related to an increase in the abundance of fry. Because we conducted a variety of different field studies, it would be difficult to determine the exact type of functional response. Cottids may have a lesser ability to consume fry as light intensity increases, as demonstrated in the circular tank experiments, but the number of fry available to them at brighter light intensities will be substantially higher and thus overall predation should be greater, as was observed at field sites. Woodsworth (1982; prickly sculpin and sockeye salmon fry), Mace (1983; staghorn sculpin and chum salmon fry), and Jones (1986; prickly sculpin and chum salmon fry) studied the functional response of cottids feeding on salmonid fry. They all found that the functional response appeared to reach an asymptote at intermediate prey densities and then increase again at high prey densities. This may explain why we did not detect any differences in predation at Elliot Park. Jones (1986) also described a gorging behavior by prickly sculpin at high prey densities, wherein they would consume substantially more fry than the expected maximum ration. This may be similar to what we observed at high-light conditions at Lions Club Park, where fry were abundant and torrent sculpin of 90, 92, and 102 mm TL consumed 10, 13, and 12 fry, respectively.

Based on results from the artificial stream experiments and the Cedar River, increased light intensities greatly affect the behavior of sockeye salmon fry; however, the effect on predator behavior is not well understood. In field experiments, cottids appeared to exhibit a functional response in relation to an increase in the abundance of fry but did not exhibit any type of aggregative response (Sutherland 1996). However, our experiments were done over a short time and an aggregative response may take several days or weeks. In Lake Iliamna, Alaska, cottids exhibited a strong aggregative response in relation to the abundance of sockeye salmon eggs, but cottid movements to the salmon spawning sites took place over 3 weeks (Foote and Brown 1998). Therefore, cottids may exhibit an aggregative response to an increase in fry availability near permanent light structures. However, several alternative prey types exist in the Cedar River and cottids may not show a strong aggregative response such as that seen in Lake Iliamna, which is an oligotrophic system and perhaps limited in alternative prey. Jones (1986), in experimental studies with prickly sculpin, found that the abundance of alternative prey (amphipods and isopods) appeared to have almost as much

influence as the abundance of the principal prey (chum salmon fry). In addition, cottids themselves may naturally avoid lighted areas because they too may become more vulnerable to predators. Movement into lighted areas may be a tradeoff for cottids, such that they have to balance increased risk of predation with increased prey availability.

Besides cottids, sockeye salmon fry in the Cedar River are also vulnerable to predation by salmonids, including rainbow trout (Beauchamp 1995), cutthroat trout, and juvenile coho salmon (Tabor et al. 1998). How increased light intensity affects predation of fry by salmonids is unclear. We used cottids for our laboratory experiments and field studies because they are an abundant predator in the Cedar River, are easy to collect, adjust readily to laboratory conditions, and are not as mobile as salmonids. Because salmonid predators are primarily visual predators, the effect of light intensity may be more pronounced when salmonids are present. Unlike cottids, salmonids may forage more effectively at higher light intensities. Predation of sockeye salmon fry by rainbow trout in artificial streams increased with increasing light intensity at intensities of less than 0.1 lx (Ginetz and Larkin 1976). Alternatively, salmonids are typically nocturnal during this time of the year (Riehle and Griffith 1993; Contor and Griffith 1995) and thus may avoid lighted areas. Additional field sampling needs to be undertaken to understand how increased light intensity would change the predation rate of fry by salmonid predators.

Tank and artificial stream experiments produced contrasting results. Tank experiments indicated that predation of sockeye salmon fry increased as light intensities decreased, whereas artificial stream experiments indicated the opposite. The reason for this large discrepancy is probably differences in current velocities. The artificial stream experiments were done in a flow-through system with strong current velocities (midchannel surface velocities ranging from 0.37 to 0.12 m/s), which created a fast-water refuge from cottids. In contrast, the tank experiments were done with little flow and no opportunity for the fry to emigrate downstream. In the tank experiments, predator and prey both occupied the same habitat and the reduction in predation with increased lighting probably reflects both the foraging ability of the sculpin and the ability of the fry to avoid them. The circular tank experiment made clear that both prickly sculpin and torrent sculpin can be highly effective predators in complete or near-complete darkness and that increased ambient light does not neces-

sarily enhance their ability to prey on sockeye salmon fry. Hockstra and Janssen (1985) demonstrated that blinded mottled sculpin *C. bairdi* were able to feed on mobile prey just by using their lateral line system.

In contrast to our results, Ginetz and Larkin (1976) found that predation of sockeye salmon fry by rainbow trout in artificial streams decreased as light intensity increased from 0.5 to 3.0 lx. Discrepancies between their experiments and this study are probably attributable to the predators used, the current velocities, and the size of the artificial stream. Ginetz and Larkin (1976) used a 0.6-m-wide experimental stream and rainbow trout, a highly mobile predator. Our experimental stream was 1.5 m wide and the predator we used was prickly sculpin, a substantially less mobile species. The current velocities used by Ginetz and Larkin were 0.12 m/s, which means there was probably no location where rainbow trout could not forage effectively. McDonald (1960) found that most sockeye salmon fry migrate in current velocities greater than 0.65 m/s, which may be too high for rainbow trout and other predators to forage effectively. Other researchers have also conducted light experiments with juvenile salmonids in which there is little or no current velocity (Patten 1971; Mace 1983; Petersen and Gadomski 1994). Their results may not apply to emigrating fish in natural situations if high current velocities are available. In those controlled experiments, predators usually had easy access to prey and the experiments may not have adequately simulated natural conditions, where high current velocities are available that create a fast-water refuge. In our artificial stream, current velocities were probably high enough to create such a refuge from prickly sculpin.

The size of the experimental field units (8 m shoreline length) appeared to work well for detecting differences in fry abundance but may have been too small for estimating predation rates. We could detect differences in predation between lighted areas and control areas at Lions Club Park, but we were often unable to detect differences in results between different light intensities. In some experimental units few predators were collected. Also, the diets of cottids can vary between individual fish; even when fry are abundant, many cottids will not consume them, and each site will include a variety of other prey types such as aquatic insects or oligochaetes. If many of the male cottids are guarding egg nests, they may not be actively searching for prey. In mottled sculpin, the

male may spend 8 weeks fanning and protecting eggs and young (Downhower and Brown 1980). In most areas, a 20–30 m shoreline would probably be adequate to collect enough cottids to get an accurate estimate of predation. Additionally, had we extended the experiments—which lasted for only a few hours—over the entire night we may have seen more predation and thus been better able to detect differences between treatments.

Experiments at the Lions Club Park demonstrated that shoreline habitat type can have an important effect on the number of sockeye salmon fry delayed in their emigration and the subsequent predation that ensues. This effect was probably in large part attributable to water velocities as well as substrate type. Light caused sockeye salmon fry to move to low-velocity areas. The riprap banks were steeper and had a narrower area of low-velocity water than did the gravel shoreline. The two habitat types may also have had differences in predator abundance, which could influence the number of sockeye salmon fry. The results of our laboratory experiments and other studies (Ginetz and Larkin 1976; Gaudin and Caillere 1985; Bar-donnet and Heland 1994) have demonstrated that the presence of predators increases the downstream movement of salmonid fry. Typically, large cottids are more numerous in larger substrates such as riprap than in smaller substrates (Tabor et al. 1998). The abundance of other predators such as rainbow trout may also be greater near a riprap bank (Lister et al. 1995).

The substrate type across the channel width may also have an important effect on predation in a lighted area. Larger substrates will create a rougher river channel and may have more abundant low-velocity locations for sockeye salmon fry. However, these same sites will probably also have more large cottids. In riffles of the Cedar River, the abundance of cottids larger than 50 mm TL was greatest in areas with large substrates such as cobble (Tabor et al. 1998). At the I-405 bridge site, the substrate consisted primarily of cobble and large gravel; there we were able to collect several cottids larger than 50 mm TL. At another lighted bridge site in the Cedar River, however, the substrate was mostly small gravel, and few cottids larger than 50 mm TL were collected; thus, the overall predation at that site was probably minimal (Tabor, unpublished data).

#### Management Implications

In the lower Cedar River, nighttime lighting appears to come from three major sources: direct

artificial lighting, the moon, and reflected lighting off of clouds. Direct lighting is intense lighting that occurs in a relatively small area every night and usually all night. In contrast, reflected light and moonlight are not very intense but they are spread over a much larger area and vary greatly with the weather and moon phase. Direct lighting probably has strong localized effects on sockeye salmon fry, whereas reflected lighting and moonlight probably have weak effects over a large area. Which of these has more overall effect on sockeye salmon fry is difficult to assess. However, it is much easier to reduce direct lighting than to address reducing reflected light. Direct lighting can be turned off, redirected, or shielded. Reducing reflected light would be a much larger and far more difficult management objective.

Overall, our results suggest that reductions in light intensity can be beneficial for emigrating sockeye salmon fry and that the impact of lighting should be considered for any future development project. For example, by reducing the lighting at the I-405 bridge site, we substantially reduced predation on sockeye salmon fry. Attempting to keep light values below 0.1 lx appears to be a prudent management goal.

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THE EFFECT OF LIGHT INTENSITY ON PREDATION OF SOCKEYE SALMON FRY BY PRICKLY SCULPIN AND TORRENT SCULPIN

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## Abstract

Recent dramatic declines in sockeye salmon (*Oncorhynchus nerka*) in Lake Washington, WA, have caused considerable alarm among concerned managers, scientists and citizens. Many factors may be involved, however, one possibility is that the increasing incidence of residential and commercial nighttime lighting along the lower portions of the Cedar River, the major sockeye producing tributary of Lake Washington, has led to substantially increased predation on emigrating fry by nocturnal predators. Freshwater sculpins are a major predator of sockeye salmon fry and are also the most abundant predator in the Cedar River. Previous research has shown that sculpin predation on salmon fry is greater under high levels of natural nighttime light (i.e., under moonlight). We tested the hypothesis that above-natural nighttime light levels further increase sculpin predation of sockeye salmon fry.

Light may differentially affect behavior of both sockeye fry and sculpin. Thus, we first tested the ability of sculpin to prey on sockeye fry under six light levels (0.0-1.0 lm/ft<sup>2</sup>) in laboratory tanks with minimal water circulation to separate the effect of the migratory behavior of the fry from the ability of sculpin to capture them. The two species of sculpin most abundant in the lower portions of the Cedar River, *Cottus asper* and *C. rhotheus*, were each tested separately in groups of 20 by exposing them to 100 sockeye fry for 40 min. This experiment showed that both species preyed effectively on sockeye fry but surprisingly, that they preyed most effectively in complete darkness, capturing an average of 82 and 87% for *C. asper* and *C. rhotheus*, respectively (N = 6 trials each). As light level was increased, predation rate declined for both species with least predation occurring at the highest light level (42 and 21% for *C. asper* and *C. rhotheus*, respectively). Additional trials at 1.0 lumens/ft<sup>2</sup> with one of the species, *C. rhotheus*, given shorter, longer, and the same duration trials as used in the first experiment, showed that similar numbers of fry were captured regardless of trial duration. This suggested that reduced predation with increased light was likely due to enhanced ability of the fry to detect and avoid sculpin, rather than increased inhibition of sculpin predatory behavior.

We next tested the predation ability of sculpin at four light levels (0.0-0.5 lumens/ft<sup>2</sup>) in a pair of artificial streams which simulated more natural conditions. One contained no sculpin and the other *C. asper*. In this environment, fry were released at the upstream end of the streams and successful emigrants were recovered in a trap in the downstream end during the next six hours. Fry were recovered in the trap and counted after 20 minutes, and at 2, 4, and 6 hours. Trials without sculpin showed results consistent with other studies, i.e., the majority of fry passed quickly through the streams under complete darkness but fewer fry emigrated and at a slower rate as light level was increased. The trials with sculpin showed that with increased light even fewer fry emigrated but they did so at a faster rate than did fry in the stream without sculpin. The difference between trials with sculpin and those without indicated that sculpin probably preyed on about 5% under complete darkness and about 45% at the highest light level tested.

Taken together, our results show that sculpin can capture sockeye fry even in complete darkness. They also indicate that under conditions where fry can behave naturally and sculpin are camouflaged against natural substrate, increased light, especially that above natural levels, appears to slow or stop emigration of fry which makes them more vulnerable to capture by sculpin. Existing conditions in the lower Cedar River may mitigate some sculpin predation under higher than natural nighttime light levels. However, artificial lighting should not be ignored as a factor contributing to increased predation by sculpin and other aquatic predators.

## Table of Contents

	<u>Page</u>
Abstract .....	ii
List of Tables .....	iv
List of Figures .....	iv
Introduction .....	1
Experimental Design and Methods .....	2
Results .....	4
Discussion .....	7
Acknowledgments .....	10
References .....	10



## List of Tables

<u>Table</u>		<u>Page</u>
1	Percentage of sockeye salmon fry not recovered from emigration trials in the artificial streams in the presence or absence of prickly sculpin under different light intensities .....	12

## List of Figures

<u>Figure</u>		<u>Page</u>
1	Number of sockeye salmon fry eaten by prickly sculpin and torrent sculpin in 40 min trials in circular tanks at different light intensities .....	13
2	Frequency of occurrence (percent) of the number of sockeye salmon fry consumed by prickly sculpin and torrent sculpin in circular tanks at two light intensity levels .....	14
3	Mean number of sockeye salmon fry eaten by torrent sculpin in circular tank trails of different duration .....	15
4	Mean number and percent of sockeye salmon fry eaten by prickly sculpin in circular tanks trials of two densities of fry .....	15
5	Cumulative percent of total sockeye salmon fry recovered after release in the artificial streams for three light intensity levels, May 24-29, 1997 .....	16
6	Cumulative percent of total sockeye salmon fry recovered after release in the artificial streams, June 4-23, 1997 .....	16

## Introduction

The few studies that have examined predation rates on juvenile salmonids under varying light intensities have generally shown that within the natural range of light intensities occurring at night (e.g., from overcast, moonless nights to clear, moonlit nights), predation increases with increasing light (Patten 1971; Ginetz and Larkin 1976; Mace 1983). This has led to the speculation that with the increasing occurrence of high intensity artificial nighttime lighting near waterways through which juvenile salmonids migrate, predation may increase substantially beyond natural levels. Sockeye salmon, *Oncorhynchus nerka*, production has declined dramatically in the Cedar River, Washington, in recent years coincidentally with increased use of residential and industrial lighting. Concerned managers and scientists have considered that increased predation on migrating sockeye fry due to this increased nighttime lighting may be one of numerous possible factors in the decline of Cedar River sockeye salmon.

Field studies have shown that four sculpin species of the genus *Cottus* are the most abundant piscivores in the Cedar River, and also are frequently captured with sockeye salmon fry in their stomachs (Tabor and Chan 1996a, b). Increased light intensity would presumably allow sculpin to better see sockeye salmon fry. However, the sensory mechanism by which cottids are able to effectively capture sockeye salmon fry is not well understood. The importance of vision in locating prey for cottids is not known. Patten (1971) and Mace (1983) speculated that increased predation rates with increased light intensities were due to increased visual acuity of sculpin. The lateral line system and olfaction also appear to be important for cottids to locate their prey. Hoekstra and Janssen (1985) found that blinded mottled sculpin (*C. bairdi*) primarily used their lateral line system to feed on a variety of motile prey. Cottids also appear to use olfaction to detect immobile prey such as salmon eggs (Dittman et al. in press).

Besides the foraging ability of sculpin, changes in light intensity may also alter the behavior of sockeye salmon fry. Increased light intensity may cause sockeye salmon fry to migrate slower and be closer to the bottom and thus become more vulnerable to predation. McDonald (1960) found that the downstream migration of sockeye salmon fry was closely related to light intensity. The nightly downstream migration was initiated after light intensity was < 0.01 lumens/ft<sup>2</sup>. This migration was almost completely stopped with the addition of artificial lights (3 lumens/ft<sup>2</sup>).

The objective of our study was to determine the effect of light intensity on predation of sockeye salmon fry by two species of sculpin in the Cedar River, prickly sculpin, *Cottus asper*, and torrent sculpin, *C. rhotheus* (Tabor and Chan 1996a). Because sculpins and sockeye fry may alter their behavior in relation to light intensity, and the sensory abilities of one to detect the other may be differentially affected by light intensity, we took a dual experimental approach to answer the question of whether sculpins prey more effectively at light levels generated by standard artificial light sources. We first tested predation rates of sculpin in circular hatchery tanks with minimal water flow to separate the effect of changes in the migratory behavior of fry from the ability of sculpin to prey on them. To assess the effect of light intensity on sockeye

salmon fry behavior, a second experiment was done in artificial streams under more natural conditions which allowed fry to migrate downstream.

## Experimental Design and Methods

During May-June 1997, experiments were conducted at the Northwest Biological Science Center, U.S. Geological Survey. Prickly and torrent sculpin were collected from the Cedar River and Lake Washington by electrofishing and transported to the lab, where they were kept in circular holding tanks. Lengths ranged from 74-103 mm TL for prickly sculpin and from 74-98 mm TL for torrent sculpin. Sockeye salmon fry were obtained periodically from the Washington Department of Fish and Wildlife fry enumeration trap located near the mouth of the Cedar River. Fry were presumably both migration- and predator-experienced. Fry were transported back to the lab where they were also held in circular holding tanks. After collection, a subset of 30 fish from each batch of fry was measured for average total length. Fry were fed commercial fry food daily throughout the experimental period. Sculpin were fed available salmonid fry prior to the experiment. Sculpin were divided into three size classes: large (90-99 mm TL), medium (80-89 mm), and small (70-79 mm).

Light intensity levels used in the experiments represent a range of levels observed from field measurements in the lower Cedar River. All light intensity measurements were made with an International Light Inc. model IL1400A radiometer/photometer. Light intensity was measured as lumens/ft<sup>2</sup>. The light source consisted of one or two strings of small ornamental lights (small clear Christmas tree lights) taped to the underside of lids for the tanks and artificial streams. Lights were suspended directly above the water. Each light string was connected to an outlet box and a dimmer switch. Predation trials in both experiments were run during daylight hours. Testing environments were covered with layers of black sheeting to exclude all light except that produced by our artificial light source.

**Circular tank experiments.**-- Because both sculpins and sockeye fry may alter their behavior in relation to light intensity, we took a dual experimental approach to better understand the change in behavior of both predator and prey. We first tested predation rates of sculpins in circular hatchery tanks with minimal water flow. The purpose of this experiment was to separate the effect of changes in the migratory behavior of fry in relation to light from the ability and motivation of sculpins to prey on them. The second set of experiments was done in artificial streams to simulate natural conditions. The sockeye fry released upstream in each trial could behave more naturally in this environment in relation to our treatment light levels, i.e., they could migrate quickly through the artificial stream or they could delay their passage by stationing in eddies or burying in the gravel substrate. We compared the number of fry recovered at timed intervals from a trap in the downstream end of each of two artificial streams which were identical except that one stream contained sculpin and one did not.

The tank experiments were conducted in 1.2 m-diameter circular tanks. Water depth averaged 30 cm. Throughout the study, water temperature in the tanks was maintained at approximately 12°C. We tested six light intensities (0.000, 0.003, 0.006, 0.010, 0.100, 1.000 lumens/ft<sup>2</sup>) during the predation experiments. Prior to each experimental trial, the light level was randomly selected and measured in each of the three replicate tanks. Three large, nine medium, and eight small sculpin were randomly selected for each predation trial from holding bins of each size class. We used single-species groups of 20 sculpin and 100 fry in each trial. Six replicates for each light intensity level were done for both prickly sculpin and torrent sculpin. The fry were given 15 minutes to adjust to the experimental setup prior to the addition of the sculpin. The sculpin were provided with two black Plexiglas shelves within each tank to serve as a refuge/hiding place during the experiments. Upon addition of the sculpin, each trial lasted 40 minutes. The addition and removal of both fry and sculpin were staggered to facilitate collection of all fish with a small aquarium net and flashlight. The predation rate was determined as the number of sockeye salmon fry lost during the experiment. Prickly and torrent sculpin were utilized on alternate days in order to allow adequate digestion time between trials. The stomach contents of three replicate groups of sculpins from both the 0.000 and 1.000 lumen/ft<sup>2</sup> light intensities were removed by gastric lavage in order to establish whether predation rates differed with sculpin size and to confirm digestion of previously consumed fry. Results of the light intensity experiment were analyzed with one-way analysis of variance (ANOVA) tests and post-hoc Tukey's Honestly Significant Difference (HSD) tests.

Six additional experimental trials were done to determine if more time is necessary for sculpin to 'settle down' and initiate predatory behavior at the highest level of light intensity (1.0 lumens/ft<sup>2</sup>). These trials were only done with torrent sculpin. Two replicates of 20-, 40-, and 60-minute trials were conducted. Three other experimental trials were conducted to determine if additional fry would be consumed if 200 fry were added instead of 100 fry. In these trials we used prickly sculpin and the lowest light intensity level (0.000 lumens/ft<sup>2</sup>).

**Artificial stream experiments.**-- Sockeye salmon fry migration/behavior experiments were done in two identical artificial streams. Each stream is 9 m long by 1.5 m wide and contained within a fiberglass trough. We only used a 3 m section of each stream in order to allow enough space downstream for a fish trap to collect the fry. Each experimental section consisted of a 2.5 m long pool and a short riffle section. Riffles had a 2% gradient with a water depth of 18 cm. The maximum depth of each pool was approximately 75 cm. Surface velocities ranged from 0.37 m/s near the inflow to 0.12 m/s at the outflow. Near the bottom of each pool the water velocity was negligible. The light level was measured approximately 10 cm below the surface of the water in both streams. One hundred and twenty five fry were released at the upstream end of each experimental section and allowed to move downstream. The fry traps were checked with a flashlight at 20 minutes, and at 2, 4, and 6 hours; the fry were then removed with a small aquarium net and counted. After six hours, all lights were turned off and the fry given 12-16 hours (over night) to migrate through the streams to the trap. We did not collect the remaining fry. Preliminary work indicated that the fry were extremely difficult to capture in the artificial streams. In non-predator trials, the number of fry not accounted for by the beginning of the next trial was added to the number of fry released (125) at the start of the next trial. Consequently, the

results are presented as a cumulative percent of the total fry in each stream which migrated downstream to the fry trap within the trial periods. In the predator trials, we assumed that the fry not accounted for were all consumed by sculpin. Because very few fry migrated overnight in the predator trials when the streams were darkened, this appeared to be a valid assumption. For the predator trials, twenty prickly sculpin were placed in the artificial stream. These sculpin remained in the stream throughout the duration of the experiment. Trials occurred once every 2-3 days to allow the sculpin enough time to digest fry from the previous trial.

The artificial stream trials were conducted in two parts. The first part occurred with no predators present. Two replicates of three light intensities (0.000, 0.100, and 0.500 lumens/ft<sup>2</sup>) each were tested. In the second part, predators were present in one stream and absent in the other. Two replicates of four light intensities (0.000, 0.020, 0.100, and 0.500 lumens/ft<sup>2</sup>) each were tested. We were unable to evaluate additional light levels due to time and fry supply limitations.

## Results

**Circular tank experiments.**-- Prickly sculpin and torrent sculpin displayed similar predation abilities with respect to increasing experimental light intensity. Both species captured greater mean numbers of fry under low light conditions than under the highest light level (Figure 1). Prickly sculpin captured a mean of 82.3 fry (SD = 7.4) at 0.000 lumens/ft<sup>2</sup>, whereas they captured a mean of 41.5 fry (SD = 8.7) at 1.0 lumens/ft<sup>2</sup>. Torrent sculpin captured a mean of 86.8 fry (SD = 5.3) at 0.000 lumens/ft<sup>2</sup> and a mean of 21.3 fry (SD = 8.3) at 1.0 lumens/ft<sup>2</sup>. A separate one-way ANOVA was performed on untransformed data of number of fry eaten for the two sculpin species. The ANOVA indicated a significant difference among the six light levels for both species. The results from a post-hoc Tukey HSD test for prickly sculpin showed no difference in fry consumption among light levels 1-5 but substantially and significantly lower fry consumption at 6, the highest light level, compared to the other five (Figure 1). The same test for the torrent sculpin indicated more differences among the six light levels. As with the prickly sculpin, treatments 1-5 all differed from 6. In addition, all non-adjacent means differed significantly from each other ( $p < 0.05$ ). Adjacent means did not differ significantly (e.g., 1&2, 2&4, 4&3, 3&5). Overall, it is clear from this experiment that sculpin of both species can be highly effective predators in complete or near complete darkness and increased ambient light does not necessarily enhance their ability to prey on sockeye fry.

Comparison of counts of fry found in stomach samples and those determined from the number of fry missing from live fry counts indicated there was usually some small error in our counts. Only one of the 12 counts were in agreement. However, 10 of the 12 counts compared were within two fry of each other. One count was off by three fry and the other was off by six fry. The error in the counts would probably be due to: 1) miscounting the number of fry that are added or recovered from the tanks; 2) overlooking fry at the end of each trial; and/or 3) gastric flushing was < 100% and some fry remained in the stomachs. Nine of the twelve trials had more

fry found in the stomach samples than was determined from live fry counts, which would indicate that one or two extra fry were often used in each trial. This seems reasonable because sockeye salmon fry are quite small. However, the error associated with our counting was quite small and we don't believe it affected the results.

Gastric flushing of three replicate trials of 20 sculpins each (total, 60 sculpin per species) from the 0.000 and 1.000 lumens/ft<sup>2</sup> trials verified that both prickly sculpin and torrent sculpin consumed more sockeye salmon fry at the lowest light intensity than at the highest light intensity. Ninety-five percent of the prickly sculpin had consumed at least one fry at 0.000 lumens/ft<sup>2</sup>, while 87% consumed fry at 1.000 lumens/ft<sup>2</sup> (Figure 2). Thirty-eight percent of the prickly sculpin had consumed more than 4 fry at 0.000 lumens/ft<sup>2</sup>, whereas only 5% had consumed more than 4 fry at 1.000 lumens/ft<sup>2</sup>. The maximum number consumed by a prickly sculpin was 9 fry (0.000 lumens/ft<sup>2</sup>). Ninety-two percent of the torrent sculpin had consumed at least one fry at 0.000 lumens/ft<sup>2</sup>, while only 68% consumed fry at 1.000 lumens/ft<sup>2</sup> (Figure 2). Fifty-two percent of the torrent sculpin had consumed more than 4 fry at 0.000 lumens/ft<sup>2</sup>, whereas only 7% had consumed more than 4 fry at 1.000 lumens/ft<sup>2</sup>. The maximum number consumed by a torrent sculpin was 12 fry (0.000 lumens/ft<sup>2</sup>).

At the highest light intensity, 1.000 lumens/ft<sup>2</sup>, large prickly sculpin (N = 9) consumed a mean of 3.1 fry (SD = 1.8) while medium (N = 27) and small (N = 24) prickly sculpin consumed a mean of 1.9 fry (SD = 1.4) and 1.6 fry (SD = 0.9), respectively. In contrast, fry consumption was more evenly distributed among the prickly sculpin size classes in complete darkness. Both large and medium prickly sculpin consumed similar numbers of fry, 4.3 fry (SD = 2.4) for large prickly sculpin and 4.7 fry (SD = 2.4) for mediums. Small prickly sculpin consumed a mean of 2.9 fry (SD = 1.9) at the lowest light intensity.

Differences in size seemed to have less effect on the predation rate of torrent sculpin at the highest light intensity, 1.0 lumens/ft<sup>2</sup>. Large torrent sculpin consumed a mean of 1.8 fry (SD = 1.5) while the medium and small torrent sculpin consumed a mean of 1.3 fry (SD = 1.6) and 1.3 fry (SD = 1.1), respectively. Consumption of fry by torrent sculpin was also more evenly distributed among the size classes at the lowest light intensity. Large torrent sculpin consumed a mean of 4.2 fry (SD = 2.9) while medium and small torrents consumed a mean of 5.4 fry (SD = 2.9) and 3.6 fry (SD = 2.5), respectively.

An experiment with different groups of torrent sculpin given either 20, 40, or 60 minutes (1.0 lumens/ft<sup>2</sup>) to prey on 100 fry indicated most predation occurs in the first 20 minutes (Figure 3). A similar and low number of fry were captured in all trials regardless of duration, suggesting that sculpin quickly captured vulnerable fry and then were unable to catch the others. This result, and our observations of the willingness of sculpin to attack fry even under brightly lit conditions, indicate that fry are better able to avoid sculpin with increased light. Results also indicate that sculpin need little time to 'settle down' and initiate predatory behavior.

An additional experiment to look at predation rates of prickly sculpin given 200 fry (0.000 lumens/ft<sup>2</sup>) indicated they were capable of consuming an excess of 100 fry. An average

of 123.3 fry (SD = 12.9; Figure 4) were consumed for the three trials. Sixty-two percent of the fry were consumed, whereas in earlier trials of the same sculpin species and light intensity, 82% of the fry were consumed. In earlier trials that had few remaining fry, there may have been a depletion effect. When fry numbers are reduced to just a few individuals, sculpin may have difficulty locating and capturing fry. Differences between some light intensity levels may be difficult to detect if 100 fry and 20 sculpin are used.

**Artificial stream experiments.**-- The first set of experimental trials was conducted without any predators present. Two replicates of three light intensity levels each were done. Sockeye salmon fry migrated through the stream at faster rate under complete darkness (0.000 lumens/ft<sup>2</sup>) than at the other two light intensity levels (0.100 and 0.500 lumens/ft<sup>2</sup>). Under complete darkness, 74% (SD = 4.5%) of the fry migrated downstream within the first twenty minutes of the trials, while only an additional 25% migrated downstream over the course of the next 24 hours (Figure 5). In contrast, under the greatest light intensity, 34% (SD = 7.8%) of the fry migrated downstream within the first twenty minutes while an additional 52% migrated downstream over the course of the next 24 hours. Trials conducted at the intermediate light intensity of 0.100 lumens/ft<sup>2</sup> provided results similar to those at 0.500 lumens/ft<sup>2</sup>. During the first twenty minutes, 32% (SD = 8.6%) of the fry migrated downstream while an additional 56% migrated downstream over the course of the next 24 hours.

The second set of experimental trials was conducted with sculpin present in one stream and not in the other. Predation/emigration trials showed several strong patterns even with only two trials completed at each of four light levels (Figure 6). First, similarly to earlier trials, fry readily emigrated through the artificial streams under complete darkness but increasingly delayed passage as light level increased. Second, a greater proportion of the fry emigrated faster through the stream in all non-dark trials when sculpin were present. Third, and most crucial, a greater proportion of fry were never recovered in the stream trials with sculpin and this proportion related directly to light level (Table 1). At the highest light level tested (0.5 lumens/ft<sup>2</sup>), an average of 55% fry were not accounted for. If the average number of fry unaccounted for in all trials without sculpin (10%) is subtracted from this value, then about 45% of the fry were likely preyed upon by sculpin. At 0.020 lumens/ft<sup>2</sup>, the light level approximating that along the urbanized sections of the Cedar River, about 28% of the fry became prey. Only about 5% were likely prey to the sculpin in the dark trials. Our results consistently indicated that fry not recovered in the first two hours of a trial with sculpin were never recovered.

## Discussion

Results of the tank experiments indicated that prickly sculpin and torrent sculpin were able to forage effectively in complete darkness. Thus sculpin must use some other sensory mechanism besides vision. Most likely sculpin used their lateral line system to detect the movements of fry. Hoekstra and Janssen (1985) demonstrated that mottled sculpin (*C. bairdi*) were able to feed on mobile prey with just their lateral line system. Night snorkeling observations of sculpin in the Cedar River, also indicated that sculpin seem to react to movements of fry. In Elliot spawning channel and Cavanaugh Pond, fry were often quite numerous yet sculpin did not appear to pursue fry if they were motionless. However, when the fry were startled by the light and darted away, sculpin would become very active and strike at moving fry.

Differences in predation between light intensity levels of the tank experiment may not reflect changes in the foraging ability of sculpin but rather the ability of fry to avoid them. At higher light levels, fry may have been better able to see approaching sculpin and more effective in avoiding them. Additionally, fry may also have formed schools at higher light intensity levels and thus sculpin may have had more difficulty in pinpointing individual fry to consume. Schooling has been shown to be related to light for several freshwater species (Emery 1973).

In the tank experiments, we were unable to detect differences between most light levels. However, this may have been due to a depletion effect. As fry numbers are reduced to just a few individuals, the behavior of fry and sculpin can be altered. Locating prey at low densities may be difficult for sculpin. Additional trials done with 200 fry instead of 100, indicated 20 prickly sculpin were able to consume an excess of 100 fry. A prey to predator ratio of 10:1 would probably have been better than the 5:1 ratio we used. Differences between some light intensity levels may be difficult to detect if a 5:1 ratio is used. In designing the experiments, we underestimated the capabilities of the sculpin to prey on sockeye salmon fry. Ideally prey need to be replaced as they are consumed so the density does not change (Petersen and Gadomski 1996). However, we felt this was impractical in our experiment. We had hoped that at least 40-50% of the fry would be remaining at the end of each trial. We were better able to detect differences between light levels in torrent sculpin trials, possibly because torrent sculpin consumption rates were lower than prickly sculpin. Thus, the density of fry did not change as dramatically as in the prickly sculpin trials.

Overall consumption rates of fry by torrent sculpin were lower than prickly sculpin. The smaller mean size of the torrent sculpin probably best explains the differences. If increasing light does enhance the ability of sockeye fry to escape predation by the sculpin as we suggested above, then smaller body size correlated with reduced swimming ability would explain the reduced consumption by torrent sculpin. Torrent sculpin may also be more behaviorally inhibited at the higher light levels than prickly sculpin and take more time to adjust and 'settle down'. However, our experiment with different groups of torrent sculpin given either 20, 40, or 60 minutes to prey on 100 fry showed that there was no increase in fry consumed beyond the 20-

minute trial length. Thus, torrent sculpin appeared to adjust quickly to the tank conditions. The relative ability of torrent and prickly sculpin to prey on salmonids is unknown. However, torrent sculpin predation rates did appear to be lower than that of prickly sculpin at the highest light intensity level (1.000 lumens/ft<sup>2</sup>). For example, only 68% of the torrent sculpin consumed any fry, whereas 87% of the prickly sculpin consumed fry at that light level. Both are capable of consuming large numbers of sockeye salmon fry in some situations (Tabor and Chan 1996a,b). Northcote (1954) found that both species are highly piscivorous at sizes > 70 mm TL. Differences in the consumption of salmonids may have more to do with habitat selection and prey availability than differences between the species. Prickly sculpin do, however, grow to a much larger size than torrent sculpin. The maximum size observed in the Lake Washington system is 239 mm TL for prickly sculpin and 155 mm TL for torrent sculpin. However, large prickly sculpin rarely consume salmonids, instead they usually prey on benthic fishes and crayfish (Tabor and Chan 1996a,b).

Earlier research on the effects of light intensity on sculpin predation (Patten 1971; Mace 1983) was conducted under different conditions than our study and thus the results are difficult to apply to our research. The authors speculated that increased predation rates with increased light intensities were due to increased visual acuity of sculpin. Both studies were conducted in flow-through systems and the fry were not allowed to outmigrate. Additionally, both studies were done with different salmonid prey (chum salmon, *O. keta*, and coho salmon, *O. kisutch*, fry) and the study of Mace (1983) focused on predation by staghorn sculpin. These predators and prey may behave differently than the fish that we used. Sockeye salmon fry and different salmon species may behave differently under varying light conditions (Ali 1959).

Experiments of Patten (1971) and Mace (1983) were also done in field enclosures and, because of large variations in environmental conditions, their work may have had biased results. First, the results of Patten (1971) confounded potential effects of light intensity with water temperature. Results showed greater predation on coho salmon fry during moonlit nights compared to moonless nights but the former trials occurred at higher water temperatures (8.5 vs 5.5 C) and this alone may have accounted for the increased predation observed during brighter nights. In addition, changes in spawning behavior of torrent sculpin could also have biased the results. Experiments of Mace (1983) were done in an estuary. Throughout the experiments, the tidal level changed, which caused changes in water depth, flow, and possibly turbidity.

Although increased light intensities did not improve the foraging ability of sculpin, it did have a pronounced effect on the movement of sockeye salmon fry. Sockeye fry moved through experimental streams at a faster rate under complete darkness than under bright lights. Increased ambient light appears to inhibit the migratory movement of the fry. McDonald (1960) found that the nightly movement of sockeye salmon fry was not initiated until light intensity was <0.01 lumens/ft<sup>2</sup>. The author was able to experimentally stop the nightly movement with artificial lighting of 3.0 lumens/ft<sup>2</sup>. Other levels of light intensity levels were not tested. Fraser et al. (1994) found that the movement of Atlantic salmon fry (*Salmo salar*) away from their redds did not differ between 0.0 and 0.7 lumens/ft<sup>2</sup>. However, at 2.0 lumens/ft<sup>2</sup>, movements were significantly reduced. In our experiments, we were able to detect differences as low as 0.020 lumens/ft<sup>2</sup>.

The presence of sculpin also appeared to influence the movement of sockeye salmon fry. A greater proportion of the fry emigrated faster through the stream in all non-dark trials when sculpin were present. This result has also been reported in another experimental study of sockeye salmon fry with rainbow trout predators (*O. mykiss*; Ginetz & Larkin 1976). Increased downstream movement due to the presence of predators has also been found in brown trout fry (*S. trutta*; Gaudin and Caillere 1985; Bardonnnet and Heland 1994).

We used sculpins for our experiments because they are an abundant predator in the Cedar River, they are easy to collect, and they adjust readily to laboratory conditions. Other predators of sockeye salmon fry in the Cedar River include cutthroat trout (*O. clarki*), rainbow trout (including juvenile steelhead), juvenile coho salmon (Tabor and Chan 1996a), and potentially some species of birds. These predators are primarily visual predators and thus the effect of light intensity may be more pronounced when these predators are present. Unlike sculpin, they may forage more effectively at higher light intensity levels.

The importance of increased light intensity on sockeye salmon fry survival in the lower Cedar River is unclear. The greatest nighttime light intensity levels occur in the lower four kilometers, as the river flows through the city of Renton. Light intensity levels as high as 1.45 lumens/ft<sup>2</sup> have been recorded in this stretch of river. However, most light intensity levels appear to be between 0.010 and 0.020 lumens/ft<sup>2</sup>. Under current conditions in the lower 3 km, the only area where predators appear to be abundant is along the shoreline. The substrate of most of the lower 3 km is gravel which appears to support few sculpin that are large enough to consume sockeye salmon fry. Further upstream, where large gravel and cobble are present, larger sculpin are substantially more abundant. Additionally, most of this river stretch is riffle (high velocity) type habitat with few areas of low-velocity habitat (side channels and pools). Most predation of fry appears to occur in low-velocity areas. Increased light intensity levels may cause fry to be delayed and move to areas of lower water velocities where they are more vulnerable to predators. This may be particularly important during periods of low discharge. A recently proposed flood control project in the lower Cedar River would reduce velocities in much of the lower 1.5 kilometers. Under these conditions, artificial lighting may be more of a factor in fry survival. However, because predation of sockeye salmon fry is also influenced by other factors, such as discharge, depth, and habitat complexity, it will be difficult to ascertain the overall importance of increased light intensity. It does appear that reducing artificial light would benefit sockeye salmon. Of course, any reduction of lighting must be balanced with safety and other concerns.

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Table 1. Percentage of sockeye salmon fry not recovered from emigration trials in the artificial streams in the presence or absence of prickly sculpin under different light intensities.

Light Level (lumens/ft <sup>2</sup> )	Percent Fry Not Recovered (SD)		Estimated % Eaten *	N Trials
	Sculpin Absent	Sculpin Present		
0.00	8.1 (2.2)	15.2 ( 2.3 )	5.2	2
0.02	13.4 ( -- )	38.4 ( -- )	28.4	1
0.10	10.0 (1.7)	34.0 ( 6.2 )	24.0	2
0.50	8.5 (1.5)	55.2 (13.6)	45.2	2

\* Note: Estimate derived by subtracting the mean percent fry not recovered from the trials with no sculpin (mean = 10.0%) from each mean of percent fry not recovered with sculpin present.

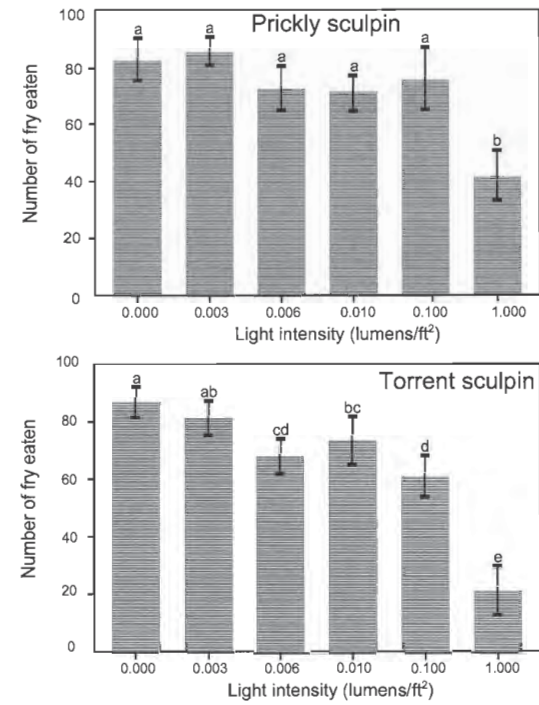


Figure 1. Number of sockeye salmon fry eaten by prickly sculpin and torrent sculpin in 40 min trials in circular tanks at different light intensities. Each bar is the mean of 6 trials. Error bars represent the standard deviation. Groups of bars with different letters are significantly different (ANOVA and Tukey HSD: P<0.05).

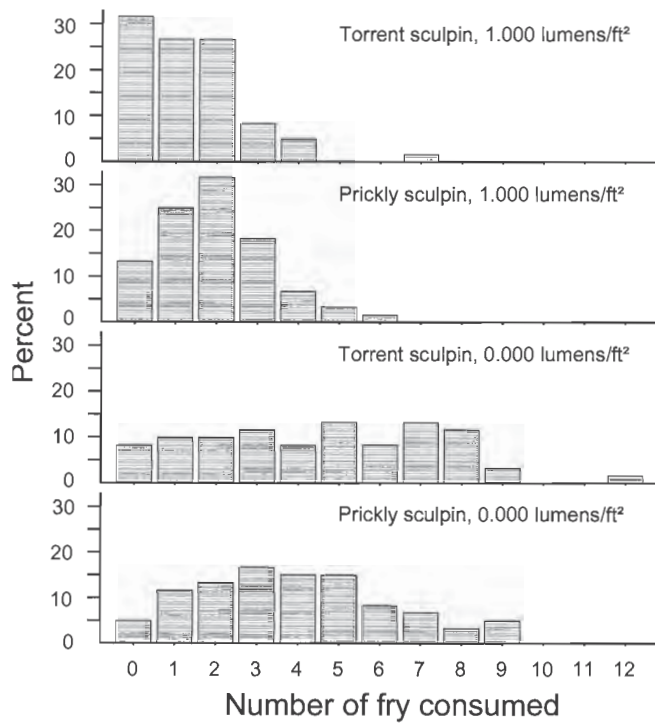


Figure 2. Frequency of occurrence (percent) of the number of sockeye salmon fry consumed by prickly sculpin and torrent sculpin in circular tanks at two light intensity levels. Numbers for each graph are based on a total of 60 sculpin from three replicates (20 sculpin each).

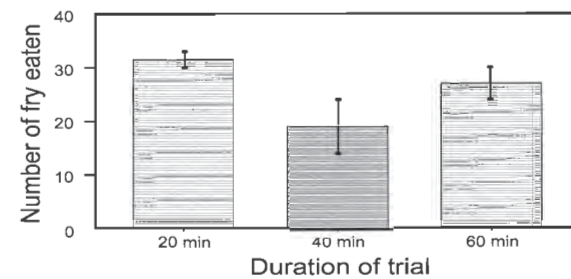


Figure 3. Mean number of sockeye salmon fry eaten by torrent sculpin in circular tank trials of different duration. Numbers are based on two replicates. Trials were all done with 100 fry and 20 sculpin; light intensity was 1.000 lumens/ft². Error bars represent the range of observations.

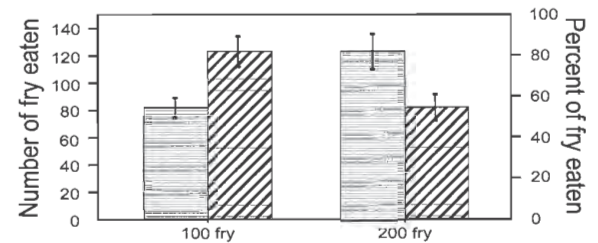


Figure 4. Mean number (shaded bars) and percent (hashed bars) of sockeye salmon fry eaten by prickly sculpin in circular tank trials of two densities of fry. Numbers for 100 fry density are based on six replicates and 200 fry density are based on three replicates. Trials were all done with 20 sculpin and light intensity of 0.000 lumens/ft². Error bars represent the standard deviation.



Submission # \_\_\_\_\_  
 Subject Lake Washington, Poster - used as display and introduction

Effects of Artificial Lighting on Juvenile Salmonids A Review of Research in the Lake Washingtonian Basin  
 Roger Tabor, Mark Celedonia, USFWS, Gayle Brown, USGS (PDF of Power Point) Oregon AFS Meeting October, 2010

Chinook Salmon Smolt Behavior in Lake Washington and the Ship Canal: 2004-2008 Acoustic Tracking Studies  
 Roger Tabor, Mark Celedonia, USFWS Power Point Slide 1 and Slide 31

Movement and Habitat Use of Chinook Salmon Smolts in the Lake Washington Ship Canal 2007-2008 Acoustic Tracking Studies May 2011  
 Roger Tabor, Mark Celedonia, et al USFWS ( Selected pages referencing "lighting" )

Movement and Habitat Use of Chinook Salmon Smolts, Northern Pikeminnow, and Smallmouth Bass Near the SR 520 Bridge 2008 Acoustic Tracking Study December 2011  
 Roger Tabor, Mark Celedonia, et al USFWS ( Selected pages referencing "lighting" )

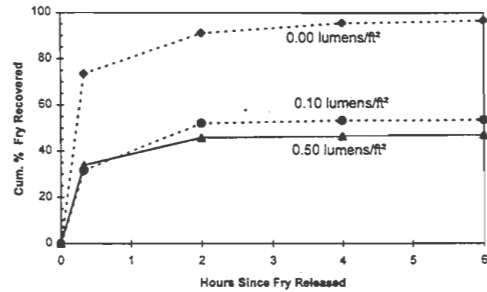


Figure 5. Cumulative percent of total sockeye salmon fry recovered after release in the artificial streams for three light intensity levels (lumens/ft<sup>2</sup>), May 24-29, 1997. Each line is the mean of two trials. All trials were done in the absence of predators.

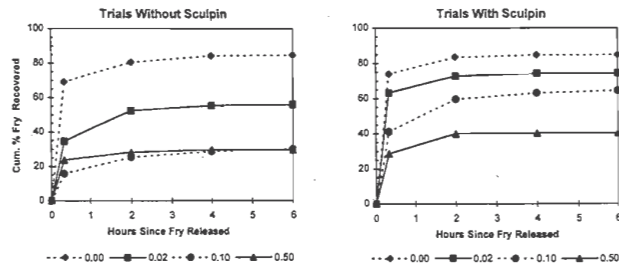


Figure 6. Cumulative percent of total sockeye salmon fry recovered after release in the artificial streams, June 4-23, 1997. Each line is the mean of 2 trials. The left and right panels show the results for trials when fry emigrated in the absence or presence of prickly sculpin, respectively. Trials were conducted at 4 light intensities shown below each panel in lumens/ft<sup>2</sup>.

# Lake Washington

Lake Washington is a rearing area and migratory path for salmon runs that include Cedar and Sammamish Rivers, Kelsey, Bear Creek, Issaquah, Ebright, and Pipers Creeks. All these runs must also funnel through the Ballard Locks.

Acoustic tracking has been used extensively in research on these salmon runs. *While not the primary focus, these studies have shown conclusively that light on the waterway slows or stops outward migration of juvenal salmon, thus increasing predation.*

***"Light is basically a big stop sign" Roger Tabor USFWS***

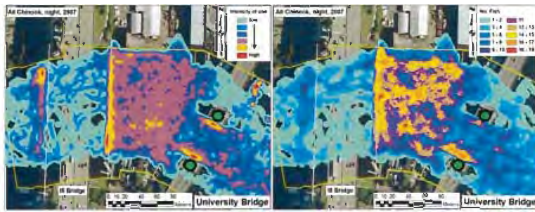


FIGURE 47. Distribution of tagged Chinook salmon at night at the University Bridge study site, June-July, 2007. Density plot (left) shows intensity of fish use for all tracked fish (weighted by time), and spatial frequency distribution (right) shows number of fish tracked by area. The white lines parallel to the I-5 bridge show the location of the light/shadow edge created by artificial lighting on the I-5 bridge deck (see Figure 48). Light levels were 1.6-2.0 lx (measured at 3 points) within 1 m of this line on the light side, and were 0.2-0.5 lx (measured at 6 points) in the shadow area between the lines. Green circles show approximate locations of lights beneath the University Bridge (see Figure 50).



FIGURE 48. Artificial lighting on the I-5 bridge deck spanning the Lake Washington Ship Canal (looking north).



FIGURE 50. Artificial lighting under the University Bridge. Lighting is directed down onto the water surface. Light on the north bridge support structure is pictured. Light on the south support structure is similar. These lights correspond with green circles in Figure 47.



## Effects of Artificial Lighting on Juvenile Salmonids: A Review of Research in the Lake Washington Basin

Roger Tabor, Mark Celedonia, USFWS  
Gayle Brown, USGS (Fisheries and Oceans Canada)

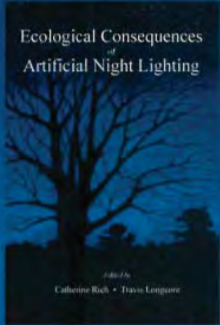
## Uses of Artificial Lighting

- Kona's Manta Rays
- Lake Tanganyika's clupeid fishery

Ref. 1. Movement and Habitat Use of Juvenile Chinook Salmon Smolts in the Lake Washington Ship Canal: 2007-2008 Acoustic Tracking Studies Celedonia, M. T., Z. Li, S. Sanders, R. Tabor, S. Damm, D. Lantz, and B. Price, 2011  
2. Effects of Artificial Lighting on Juvenile Salmonids: A Review of Research in the Lake Washington Basin, Roger Tabor, Mark Celedonia, USFWS, Gayle Brown, USGS

## Artificial Lighting

Ecological Consequences  
of  
Artificial Night Lighting



## Lake Washington Basin



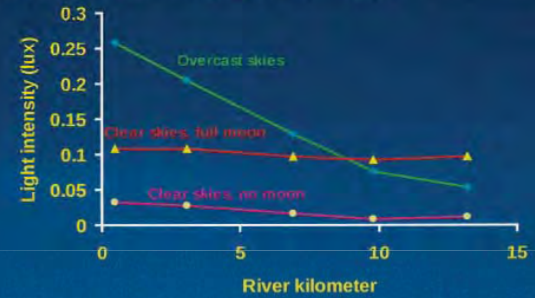
## Pacific Northwest



## Light Sources

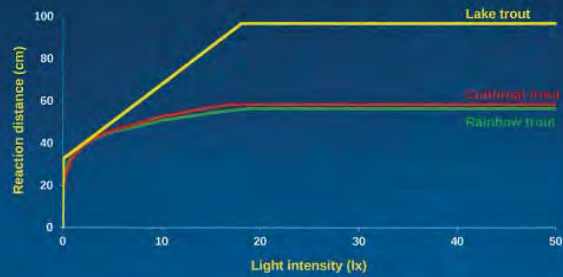
Office: 600 lux  
Sunlight: 50,000 lux

A) No direct artificial lighting – Cedar River



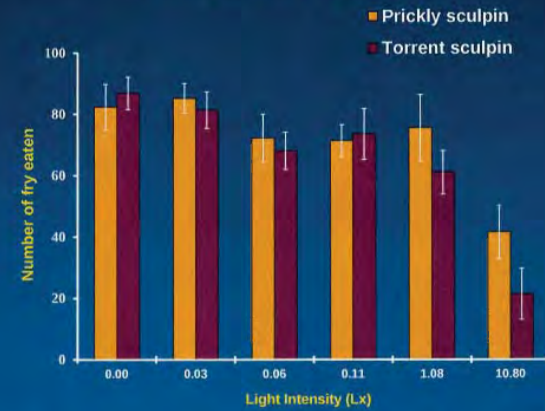
B) Direct artificial lighting: 0.2 – 60 lux

## Prey Detection of Piscivorous Salmonids



Mazur and Beauchamp, 2003. Visual prey detection among species of piscivorous salmonids. Environmental Biology of Fishes 67:397-405.

## Tank Experiments

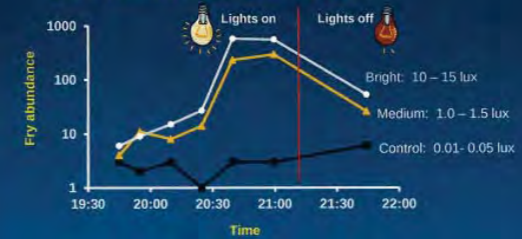


## Cedar River Sockeye salmon fry and Sculpin Study

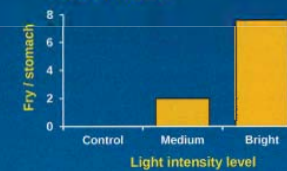
- Sockeye salmon fry
  - Migrate at night
  - One or two nights to reach the lake
  - Select mid-channel areas with high velocities
- Sculpin
  - Predator of sockeye fry
  - Abundant
  - Easy to work with in lab
  - Sedentary



## Cedar River field experiment - March 1999



## Cottid Predation



## I-405 Bridge Walkway



## I-405 Bridge Walkway

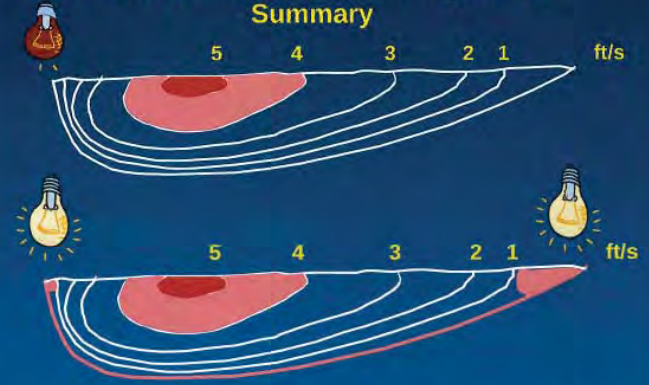
### Fry abundance



### Predation by sculpins

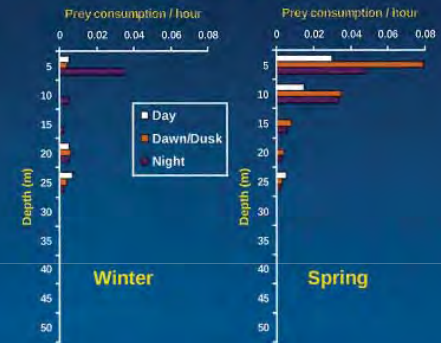


## Sockeye salmon fry migration Summary



Tabor, Brown, and Luiting. 2004. The effect of light on sockeye fry migratory behavior and cottid predation. North American Journal of Fisheries Management 24:128-145.

## Cutthroat Trout - Lake Washington Visual Foraging Model



Mazur and Beauchamp. 2006. Linking piscivory to fish distributions with a visual foraging model. Journal of Fish Biology 69:151-175.

## Cedar River/Lake Washington Juvenile Chinook Salmon

- Juveniles rear in Cedar River or Lake Washington
- Inhabit shallow shoreline areas from January to May



## Chinook Salmon Smolts

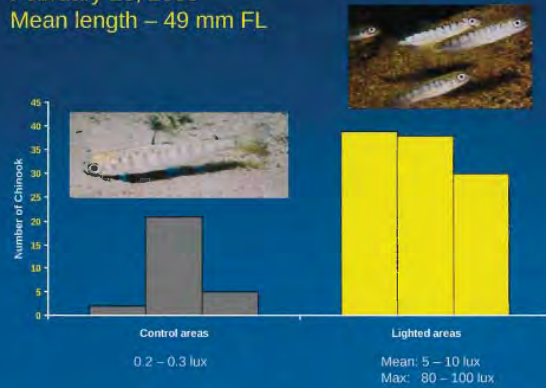
- Outmigrate from Lake Washington and through Ship Canal in May-July
- Migrate along shoreline



## Artificial Lighting Experiment

February 23, 2005

Mean length – 49 mm FL



## Fine-scale Acoustic Tracking - HTI

Simplified System Schematic

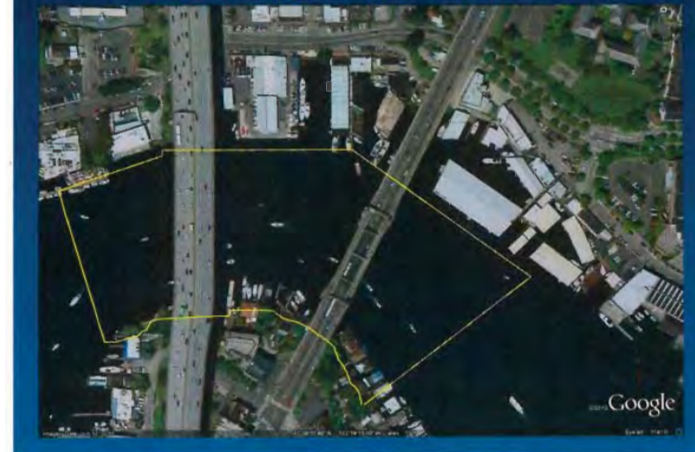
≥ 4 hydrophones



SR 520 Bridge – west end

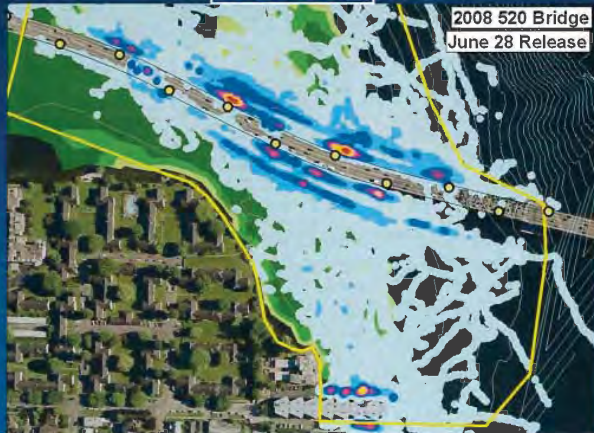


I-5 / University Bridges – Ship Canal



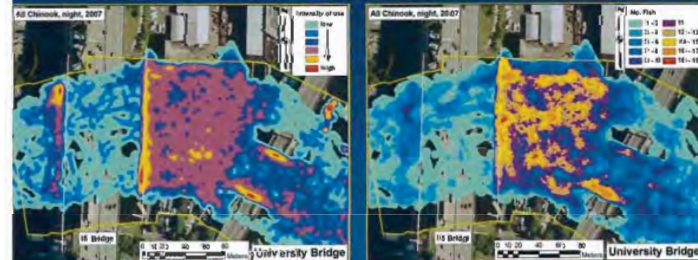
SR 520 Bridge – west end - June 26th release group

0.2-0.9 lux ambient  
2.1-20.0 lux near lights



2008 520 Bridge  
June 28 Release

I-5 / University Bridges – Ship Canal  
June-July 2007



0.2-0.5 lux in shadow  
1.6-2.0 lux along light edge

## Ballard Locks 2007-2008



0.0-0.2 lux ambient  
3-32 lux in heavy Chinook areas

Celedonia et al. Draft report. Movement and habitat use of Chinook salmon smolts at the SR 520 Bridge.

Celedonia et al. Draft report. Movement and habitat use of Chinook salmon smolts in the Ship Canal.

## Potential Predators



## Conclusions

- Nighttime lighting can have a strong effect on fish behavior and may increase their vulnerability to predation
- Light is an important element of predator - prey relationships
- Assessments on the effects of lighting need to examine the behavior of both predator and prey under natural conditions
- Environmental assessments need to include the effects of artificial lighting

## Acknowledgements

- Seattle Public Utilities – SPU
- US Army Corps of Engineers – COE
- City of Renton
- Washington Department of Fish and Wildlife – WDFW
- King County
- University of Washington – UW
- Washington State Department of Transportation – WSDOT
- Hydroacoustic Technology Inc. – HTI
- U.S. Geological Survey - USGS
- USFWS Employees



## Chinook Salmon Smolt Behavior in Lake Washington and the Ship Canal: 2004-2008 Acoustic Tracking Studies



Mark T. Celedonia & Roger A. Tabor

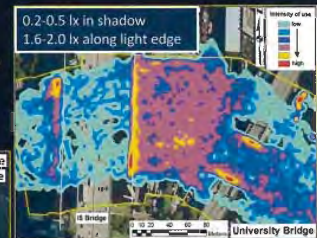


U.S. Fish & Wildlife Service  
Washington Fish & Wildlife Office  
510 Desmond DR., SE  
Lacey, WA 98503

Slide 1

### Holding (not actively migrating) Chinook Salmon smolts are attracted to artificial light at night

- Neither Smallmouth Bass nor Northern Pike minnow showed an affinity for artificial light
- Other predators? (Cutthroat Trout)
- How do these behaviors affect predation rate?



Slide 31



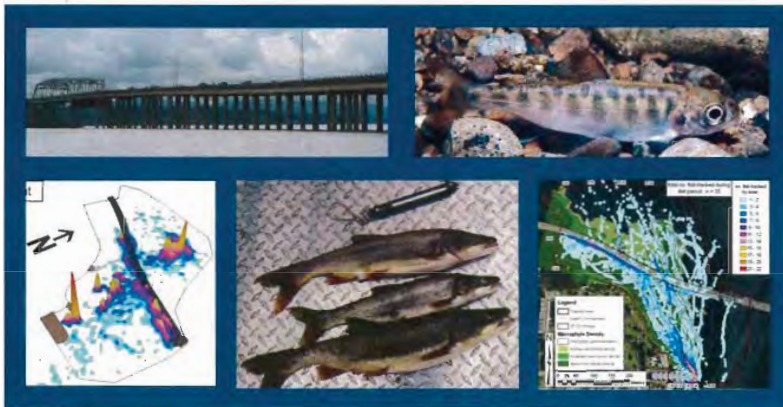
U.S. Fish and Wildlife Service

# Movement and Habitat Use of Chinook Salmon Smolts, Northern Pikeminnow, and Smallmouth Bass Near the SR 520 Bridge

*2008 Acoustic Tracking Study*

December 2011 By Mark T. Celedonia, Roger A. Tabor,  
Steve Damm, Daniel W. Lantz, Terence M. Lee,  
Zhuozhuo Li, Benjamin E. Price, William Gale,  
Kenneth Ostrand

U.S. Fish and Wildlife Service  
Washington Fish and Wildlife Office  
Lacey, Washington



Funded by the Washington State Department of Transportation

MOVEMENT AND HABITAT USE OF CHINOOK SALMON SMOLTS,  
NORTHERN PIKEMINNOW, AND SMALLMOUTH BASS NEAR THE  
SR 520 BRIDGE

2008 ACOUSTIC TRACKING STUDY

by

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December 2011

## EXECUTIVE SUMMARY

This study continued and extended research performed in 2007 by the Washington State Department of Transportation (WSDOT) and the U.S. Fish and Wildlife Service (USFWS) to evaluate influence of the SR 520 bridge (the bridge) on behavior and habitat use of Chinook salmon *Oncorhynchus tshawytscha* smolts and piscivorous fish. Results obtained in 2007 suggested that the bridge was having some influence on migration, movement, and habitat use of Chinook salmon, and that at least one potential predator - smallmouth bass *Micropterus dolomieu* - often used the bridge as selected habitat. Further study was needed due to high variability in Chinook salmon behavior, uncertainty with regard to important causal factors, and low sample sizes of predators (namely northern pikeminnow *Ptychocheilus oregonensis*). Results will help guide design and construction of the new bridge to minimize impacts to Chinook salmon.

The primary objectives of the 2008 study were to: 1) increase the sample size of Chinook salmon used for evaluating migrational delay at the bridge; 2) evaluate interannual variability in fish behavior relative to the bridge; 3) collect additional ancillary data to help understand observed fish behavior patterns; 4) increase sample sizes of tagged northern pikeminnow and smallmouth bass; and, 5) explore potential predation consequences of the bridge on Chinook salmon. In order to meet these objectives, the 2008 study largely replicated the 2007 acoustic tracking study design. Components added for 2008 included: 1) Chinook salmon smoltification (gill Na<sup>+</sup>, K<sup>+</sup> ATPase) sampling; 2) zooplankton sampling; 3) predator abundance and diet sampling.

Four groups of 27-53 tagged Chinook salmon smolts were released between June 12 and July 10, 2008, and 75-85% of tagged fish were tracked at the study site. Overarching patterns in Chinook salmon smolt behavior were similar to those observed in 2007. Behaviors were generally similar within release groups and varied considerably between release groups. The first three release groups primarily exhibited holding behaviors at and near the study site. The fourth release group represented a unique case: most fish (93%) actively migrated through the site in one of two schools.

As in 2007, fish response to the bridge was at least partially dependent upon whether fish were actively migrating or holding. Behaviors of actively migrating fish were similar in both years, although few independent observations were obtained in 2008 (n=11). Combining both years (n=57), 35% of actively migrating smolts showed minimal or no response to the bridge, 42% paralleled the bridge before passing underneath, and 23% paralleled the bridge and milled near the bridge before passing underneath. Median delay was 63 seconds (range 6 seconds to 19 minutes) for paralleling fish, and 22 minutes (range 3-46 minutes) for paralleling and milling fish.

The bridge appeared to attract some Chinook salmon that exhibited a holding behavior. Holding fish spent 2 hours to 11 days on and near the study site, and median 51% of this time was spent on-site. When on-site, fish most commonly selected for areas near the bridge (within 20 m of the bridge edge) and the condo on the south side of the site. Of secondary importance were areas directly beneath the bridge and areas with moderately dense to dense vegetation not

near the bridge. During the day, fish selected more offshore areas when near the bridge (5-7 m bottom depth) or condo (7-8 m bottom depth) than when they were not near either structure (2-5 m bottom depth). Similar observations were made in 2007. Data suggested that the bridge may provide a source of nearby cover and thus function as a corridor to deeper water where there is a better foraging base and occasionally more favorable water temperatures.

At night, Chinook salmon were attracted to areas where street lamps on the bridge cast light into the water. A reevaluation of 2007 data found that it occurred then also. Bridge lighting thus appears at least partially responsible for the nighttime selection of near bridge areas by Chinook salmon. Neither smallmouth bass nor northern pikeminnow appeared particularly attracted to the lights. Other studies suggest that predation rate may be higher in lighted areas even if predators on the whole do not select for these areas. Any potentially negative consequences to Chinook salmon might be minimized by reducing the intensity of light reaching the water surface.

We tagged 21 northern pikeminnow and 10 smallmouth bass at the study site, and obtained extensive tracking results on 8 northern pikeminnow and 7 smallmouth bass. Results for both species were similar in 2007 and 2008; therefore, data were combined to provide more robust analyses. This yielded sample sizes of 15 northern pikeminnow and 19 smallmouth bass (> 240 mm FL).

Northern pikeminnow were primarily concentrated at 4-6 m depth during all diel periods. Moderately dense vegetation, which occurs at 4-6 m depth, was the most commonly used habitat type. The small pier at the Madison Point Condominiums was used extensively. During each diel period, less than 50% of northern pikeminnow showed positive selection for the bridge or areas near the bridge. Overall, we did not document a strong affinity for the bridge. Instead, the bridge was generally used in proportion to its availability.

Smallmouth bass showed a strong affinity for overwater structures, including the bridge. Smallmouth bass were often closely associated with bridge columns. At dawn, they often moved into sparse vegetation and the offshore edge of vegetation. These movements are probably indicative of foraging activity. Additionally, they occasionally used dense and moderately dense vegetation, primarily at dusk and night. In both years, smallmouth bass were primarily concentrated in water 4-8 m deep during all diel periods.

We set a series of gill nets at five locations (the bridge, two sites north of the bridge, and two sites south of the bridge) on a weekly basis during the study period to determine the relative abundance and diet of northern pikeminnow and smallmouth bass. We collected a total of 135 northern pikeminnow and found no evidence that northern pikeminnow were congregated at the SR 520 bridge in comparison to four nearby sites. Additionally, there was no evidence to suggest that juvenile salmonids were preyed upon at a higher rate by northern pikeminnow near the bridge. Juvenile salmonids (Chinook salmon and unidentified salmonids) made up 35% of the overall diet of all sites combined. One important observation was the prevalence of river lamprey *Lampetra ayresi* in the diet of northern pikeminnow. Previous studies of northern pikeminnow in Lake Washington have rarely found river lamprey in their diet.

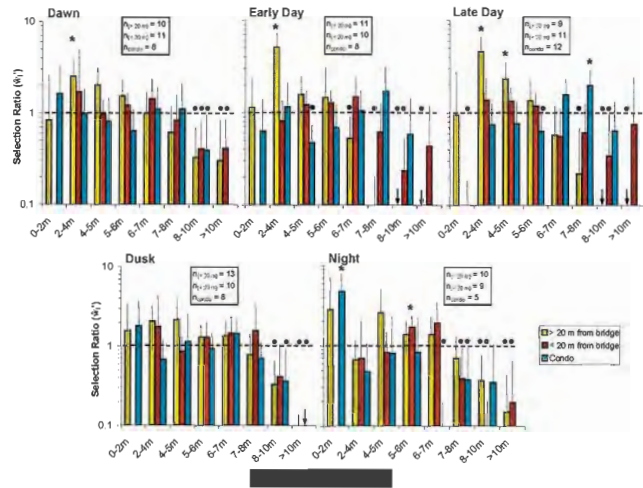


FIGURE 25. Diel bottom depth selection ( $\hat{w}_i$ , selection ratio; log scale) of Chinook salmon released on June 12, 2008. Selection is for the entire water column and not for the position of the fish within the water column. Depth selection was determined for three distinct areas: 1) directly beneath bridge and within 20 m of the bridge edge; 2) > 20 m from bridge edge; and, 3) within 20 m of the edge of the Lakeshore West Condominiums. Error bars represent Bonferroni-adjusted 90% confidence intervals. Error bars indicate if selection for (>1) or against (<1) a water column depth occurred. An asterisk (\*) denotes selection for a depth and a circle (o) denotes selection against. Each area contained all depth categories, except minimum depth near bridge was 2-4 m and maximum depth near the condo was 8-10 m.

At night, areas where fish spent a greater proportion of time near the bridge coincided with locations of street lights on the bridge (Figure 28). This suggested that fish were attracted to areas with artificial lighting. Street lights appeared to attract fish in two general areas. The strongest area of attraction was directly adjacent to a street light on the same side of the bridge as the light. Most street lights had high concentrations of fish use near them (Figure 28). A weaker yet still apparent association was observed in 2007 (Figure 29). High concentration areas were on the same side of the bridge as the light. Areas on the opposite side of the bridge from the light usually did not show elevated fish usage. A weaker area of fish attraction appeared as a line of elevated fish usage running parallel with the bridge approximately 15-27 m from both the northern and southern edges. This appeared in both the June 12 and June 26 releases (Figure 28). This may be caused by lights on the opposite side of the bridge. The distance from the bridge where these lines occurred may correspond with the bridge shadow created by lights on

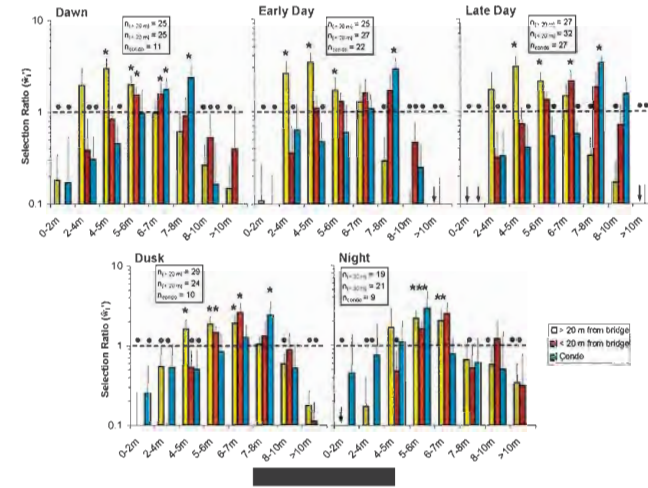


FIGURE 26. Diel bottom depth selection ( $\hat{w}_i$ , selection ratio; log scale) of Chinook salmon released on June 26, 2008. Selection is for the entire water column and not for the position of the fish within the water column. Depth selection was determined for three distinct areas: 1) directly beneath bridge and within 20 m of the bridge edge; 2) > 20 m from bridge edge; and, 3) within 20 m of the edge of the Lakeshore West Condominiums. Error bars represent Bonferroni-adjusted 90% confidence intervals. Error bars indicate if selection for (>1) or against (<1) a water column depth occurred. An asterisk (\*) denotes selection for a depth and a circle (o) denotes selection against. Each area contained all depth categories, except minimum depth near bridge was 2-4 m and maximum depth near the condo was 8-10 m.

the opposite side of the bridge. That is, lights on the north side of the bridge were about 14.5 m from the southern edge of the bridge. Therefore, the shadow cast by the bridge would lie not only directly beneath the bridge, but would also be cast some distance from the bridge. We did not measure light levels in any of these areas.

Washington and the LWSC. Water clarity was generally lower in the LWSC than along the western shore of Lake Washington during the study period. Turbidity and light intensity can substantially alter juvenile fish habitat use patterns (Gregory 1993; Miner and Stein 1996; Abrahams and Kattenfeld 1997; Reeb 2002). In general, predation risk declines in turbid conditions allowing prey species to abandon anti-predator behaviors. For example, in clear water small bluegill remain in shallow areas when predators are present, but spend substantial proportions of time (> 80%) in deepwater habitat under turbid conditions (Miner and Stein 1996). Similarly, Gregory (1993) observed that juvenile Chinook salmon concentrated in one part of a test arena under clear conditions, but that fish distributed more evenly throughout the arena under turbid conditions. Higher water clarity in Lake Washington may force Chinook salmon closer to shore, and diminished clarity in the LWSC may allow fish to utilize open water areas during the day and take advantage of presumably better foraging opportunities as well as lower, more favorable water temperatures.

In both years of the SR 520 bridge studies, holding Chinook salmon smolts showed significant selection for and/or considerable use of the SR 520 bridge edge and the condo edge, and selected for deeper water when near these structures than when they were away from the structures. Chinook salmon and other salmonids have also been observed at high densities along outside edges of overwater structures in Puget Sound (Toft et al. 2007). In 2007, we hypothesized that during the day holding Chinook salmon have a positive selection for deep waters near the bridge, which may be related to access to preferred foraging locations and/or cooler, more favorable water temperatures. This hypothesis can also be extended to the condo. Specifically, the bridge, the condo, and other overwater structures extending into deeper littoral and pelagic zones may provide a source of cover or refuge from open water predators, thus allowing juvenile Chinook salmon to access areas that they would otherwise avoid.

The depths selected by smolts near the 520 bridge and the condo corresponded with elevated *Daphnia* abundance. Zooplankton typically avoid nearshore areas and are instead found in greatest abundance farther from shore (Wetzel 1975; Hall et al. 1979; Naud and Magnan 1988; Werner and Hall 1988; Tabor and Wurtsbaugh 1991; Diehl and Eklöv 1995). The width of the nearshore zone of low abundance depends on elevation of the horizon, position of the sun, and differential light levels nearshore compared with offshore (Wetzel 1975). In 2008, our zooplankton sampling at the SR 520 study site showed zooplankton mass substantially higher at areas where the bottom depth was  $\geq 7$  m than at areas with bottom depths  $\leq 5$  m, suggesting that the zone of low abundance extended from the shoreline to 5-7 m bottom depth. Chinook salmon smolts selected for depths within the zone of low zooplankton abundance when not near the bridge or condo during the day: daytime depth selection of Chinook salmon smolts was highest for 2-5 m and typically quite low for depths  $> 7$  m when not near the bridge or condo. When at the bridge edge, however, daytime depth selections were typically highest for 5-7 m - the transitional area between low and high *Daphnia* abundance - and deeper depths consistently showed higher selection ratios when fish were near the bridge than when they were not (condo excluded). When at the condo edge, daytime depth selections were highest for 7-8 m depth.

birds, and other fishes (Woodhead 1966). Artificial lighting may allow juvenile Chinook salmon to feed actively at night. Commonly, small zooplanktivorous fishes feed heavily at dawn and dusk and do not feed much at night (Hall et al. 1979; Wurtsbaugh and Li 1985). However, they may feed throughout the night during full moon conditions (Gliwicz 1986). Artificial lighting generally reduces the abundance of *Daphnia* in surface waters (Moore et al. 2000); however, other components of the zooplankton community such as larval fishes (Gregory and Powles 1985) may be more abundant and vulnerable to predation by juvenile Chinook salmon.

Lighted areas may allow zooplanktivorous fishes an opportunity to forage throughout the night but their increased abundance may attract their predators (Nightingale et al. 2006). Even if piscivorous fishes are not attracted to lighted areas, the predation rate by piscivorous fishes that inhabit the lighted area may be dramatically higher than that in other areas (Tabor et al. 2004a). Research at petroleum platforms has shown that artificial lighting allows fish to feed on zooplankton that have concentrated in the light field; however, they may be more vulnerable to large piscivorous fishes (Stanley and Wilson 1997; Keenan et al. 2003). In Lake Tanganyika in Africa, fishermen use lights to attract zooplanktivorous fishes, which in turn attract large piscivorous fishes (Coulter 1990). In Lake Washington, we have observed great blue herons and western grebes feeding around lights but no information is available on their nighttime diet. Piscivorous fishes may also be attracted to lighted areas due to an aggregation of small fishes like juvenile Chinook salmon. Cutthroat trout appear to feed heavily at night in Lake Washington because of reflected artificial lighting from surrounding urbanized areas (Mazur and Beauchamp 2006). Obviously artificial lighting on the bridge is important for safety concerns; however, lighting should be designed to minimize the amount of light that reaches the water surface.

Gill ATPase sampling suggested that the physiological smoltification process was dampened or muted in our study fish. This may explain the predominance of holding behaviors observed: lacking sufficient physiological cues, fish may be more prone to holding than actively migrating seaward. However, ATPase activity may not be a good predictor of predisposal to migrate seaward. Seaward movement can occur without elevated ATPase activity (Ewing et al. 1980a; Tiffan et al. 2000), and, conversely, slow moving fish can have high levels of ATPase activity (Tiffan et al. 2000). Nonetheless, the general suppression of ATPase activity in our study fish was curious because ATPase should peak at some point during the outmigration season. ATPase suppression can be associated with adverse or stressful conditions, such as elevated water temperatures (Marine and Cech 2004), low levels of food abundance (Ewing et al. 1980b), high levels of suspended sediment (Shrimpton et al. 2007), and high rearing densities (Strange et al. 1978). Shrimpton et al. (1994) found ATPase activity suppressed in hatchery-reared coho salmon and speculated that stressful hatchery rearing conditions may have been to blame. Release from the hatchery environment can stimulate smoltification (McCormick et al. 2003) assuming release occurs within the environmental smolt window.

#### *Northern pikeminnow*

Results of 2008 northern pikeminnow tracking appeared to be similar to 2007 results. Both depth selection and habitat use of northern pikeminnow appeared to be similar between years. In both years they were primarily concentrated in 4-6 m depth interval during all diel periods. At

Although northern pikeminnow did not strongly use the bridge structure, several used the Madison Point Condominium pier. Within our study area, there were four overwater structures from a small pier (Edgewater Apartments) in shallow water to the large bridge structure. The Edgewater Apartment pier was probably in too shallow of water to attract northern pikeminnow. The Madison Point Condominium pier is a narrow pier but extends out into the water depths (4-5 m) preferred by northern pikeminnow. It is unclear why they would prefer this small pier over the two larger structures (Lakeshore West Condominiums and SR 520 bridge). The Madison Point pier may enable pikeminnow to observe approaching prey (i.e., juvenile Chinook salmon) from a variety of directions and still provide overwater cover from their predators such as piscivorous birds. Also, vegetation under the pier may be denser and more preferred by northern pikeminnow. Perhaps this site attracts northern pikeminnow because of some other type of forage. Northern pikeminnow often consume plant material and dead animal remains (Tabor et al. 1993; Petersen et al. 1994; Shively et al. 1996; Tabor et al. 2004b). If condominium residents regularly discard fish or shellfish remains at this pier or another source of plant or animal material is present, northern pikeminnow may congregate here.

Substrate selection by northern pikeminnow was markedly different between day and night. Differences may reflect their foraging strategies and prey availability. Northern pikeminnow are opportunistic predators with a wide range of prey types. During the day they may attempt to prey on diurnally-active prey (e.g., juvenile salmonids, threespine stickleback, and other littoral fishes) near macrophyte beds where silt substrates predominate. At night, they may attempt to prey on nocturnally-active prey such as sculpin and crayfish which are often more abundant in areas with larger substrates (Mueller 2002; Tabor et al. 1998).

Northern pikeminnow showed a slight attraction to street lights on the SR 520 bridge. Because juvenile Chinook salmon congregate near the lights, pikeminnow may in turn be attracted to the increased density of potential prey. Northern pikeminnow actually appear to prey more effectively on juvenile salmonids at extremely low light levels than at high light levels (Petersen and Gadomski 1994). However, the increased density of juvenile salmonids could result in higher predation rates by northern pikeminnow. Similarly, sockeye salmon fry are more vulnerable to sculpin predation at street lights because of the increase in density of fry even though sculpin are more effective at preying on fry at extremely low light levels (Tabor et al. 2004a).

#### *Smallmouth bass*

In 2008, we were able to track an additional eight large smallmouth bass. In general, results of these fish appeared to be similar to 2007 smallmouth bass tracking results. Combined, they showed a strong affinity for overwater structures. In both years, they were primarily concentrated in 4-8 m depth interval during all diel periods. At dawn, they often moved into sparse vegetation and the offshore edge of vegetation. Additionally, they occasionally used dense and moderately-dense vegetation, primarily at dusk and at night.

Unlike northern pikeminnow, we were able to effectively track most tagged smallmouth bass. Smallmouth bass usually have a defined home range (Kraai et al. 1991; Ridgway and Shuter 1996; Hodgson et al. 1998; Cole and Moring 1997) and may not be as mobile as northern

At dawn and dusk, some smallmouth bass made forays along the shore or into deeper waters. These movements may have been movements to actively search for prey. Piscivores, such as smallmouth bass, are well adapted to feed in dim light and are often more active during crepuscular periods because they have the greatest advantage over prey species. Results of two smallmouth bass implanted with depth tags at the SR 520 bridge site showed crepuscular activity patterns (Celedonia et al. 2008a). In the Columbia River, smallmouth bass show a crepuscular feeding pattern, but it is not pronounced (Vigg et al. 1991). An extended period of morning feeding has also been observed. Emery (1973) also found peak feeding was at dawn and dusk and they fed opportunistically during the daytime. In the Snake River, smallmouth bass were most active in the early morning (Munther 1970). In laboratory experiments, Reynolds and Casterlin (1976) also found smallmouth bass displayed a crepuscular activity pattern.

Most smallmouth bass did not appear to be active at night. Other studies have also found they are inactive at night and rest on the bottom near some type of cover such as large woody debris (Munther 1970; Emery 1973). During our snorkeling in Lake Washington and the LWSC, we often encountered smallmouth bass that were motionless and appeared to be resting on the bottom (R. Tabor, unpublished data). Our tagged smallmouth bass were mostly inactive at night, however there were some exceptions. Nighttime activity may be related to artificial lighting or moonlight. Some of the night-active smallmouth bass in Portage Bay and at a site near the Seattle Tennis Club in Lake Washington were near artificial lighting (Celedonia et al. 2008b). In laboratory experiments, Reynolds and Casterlin (1976) found smallmouth bass were often active at night. Largemouth bass, which have similar crepuscular activity patterns (Reynolds and Casterlin 1976), can feed at night especially under full moon light conditions (McMahon and Holanov 1995).

Restricted movement at night by smallmouth bass is most likely indicative of resting behavior; whereas restricted movement throughout the day may be related to either resting behavior, typical behavior of an ambush predator, or related to spawning activity. During the spring, male smallmouth bass often are guarding a nest and have a small home range during this period (Savitz et al. 1993) and foraging activity is presumably reduced. Of the adult smallmouth bass we tagged at the study site, all appeared to move over a relatively large area during the day and did not appear to be nest guarding. Spawning activity occurs in the spring and our tracking may have been conducted after spawning season was over. Also, adult smallmouth bass collected at the study site were collected with gill nets, which selects for more active fish and probably not for nest guarding males.

#### *Relative abundance and diet of piscivorous fishes at the SR 520 bridge site*

We found no evidence that northern pikeminnow were congregated at the SR 520 bridge in comparison to four other nearby sites. Northern pikeminnow have been shown to congregate around dams (Beamesderfer and Reiman 1991) and at the outlets of hatchery facilities (Collis et al. 1995); however, this is likely due to prey availability and not the structure itself. The use of overwater structures by northern pikeminnow in lakes has not been well documented. Acoustic tracking of northern pikeminnow at SR 520 bridge indicated they occasionally use overwater structures; however, they most frequently used a small pier near shore instead of the SR 520 bridge. Exactly why they preferred this small structure is unclear.

The diet composition of northern pikeminnow at the SR 520 bridge site consisted of juvenile salmonids, river lamprey, threespine stickleback, longfin smelt, and crayfish. They did not appear to be feeding on juvenile salmonids to a larger degree than at other sites. Northern pikeminnow are considered opportunity predators that will eat a wide variety of food including plant material (Tabor et al. 1993; Shively et al. 1996) and dead fish (Petersen et al. 1994) and will quickly switch to other prey items as it becomes abundant (Collis et al. 1995; Shively et al. 1996). The diet composition of northern pikeminnow at the SR 520 bridge is probably a reflection of prey abundance and availability. There was no evidence to support the hypothesis that juvenile salmonids are more vulnerable to northern pikeminnow predation due to the bridge structure. Similarly, Ward et al. (1994) found no difference in the frequency of occurrence of juvenile salmonids in northern pikeminnow diets between developed and undeveloped areas of the lower Willamette River.

Juvenile salmonids made up a substantial portion of the diet of northern pikeminnow at all of our five sites in the central-west part of the lake. All of the identifiable salmonids were Chinook salmon. Previous studies of northern pikeminnow in Lake Washington have found Chinook salmon is a rare prey item in their diet (Olney 1975; Brocksmith 1999; Beauchamp et al. 2007a). The other studies usually had small sample sizes in June and their sampling was spread out over the entire lake and thus they could have missed this predation event. If predation of Chinook salmon is strongly concentrated in the central-west part of the lake and little sampling occurred in this area, the overall predation levels on juvenile salmonids may be underestimated by these other studies.

One important finding of our diet analysis was the prevalence of river lamprey in the diet of northern pikeminnow. In previous sampling of northern pikeminnow in Lake Washington by Olney (1975), Brocksmith (1999), Beauchamp et al. (2004) and Beauchamp et al. (2007a), river lamprey was not mentioned as an important prey item. Olney (1975) only states that a few Pacific lamprey *Entosphenus tridentatus* were consumed and does not mention river lamprey. Brocksmith (1999) found lamprey in 3 of 124 gut samples but does not mention which species was present. Beauchamp et al. (2004) and Beauchamp et al. (2007a) did not mention lamprey; instead they found northern pikeminnow preyed on longfin smelt, threespine stickleback, salmonids, yellow perch, and sculpin. These other studies conducted sampling throughout the year and across the entire lake. In our study, we intensively sampled one area of the lake over a short time period. River lamprey may congregate in this area to prey on juvenile salmonids and are in turn preyed on by northern pikeminnow. Because river lamprey was only observed in northern pikeminnow, river lamprey may be particularly vulnerable to piscivorous fishes at night. Northern pikeminnow appear to be able to forage under lower light conditions than the other species (Petersen and Gadomski 1994).

The ecology and abundance of river lamprey in Lake Washington is poorly understood. Typically, river lamprey are anadromous, spending about 5 years in freshwater as ammocoetes and then migrating to estuarine and marine environments to feed on fish and then return to freshwater as adults to spawn and die (McPhail 2007). In Lake Washington, they appear to be able to complete their life history in freshwater. Other landlocked populations have been documented in British Columbia lakes (McPhail 2007). Currently river lamprey is listed as a

support columns; and, 5) decrease the overall number of support columns. Two options (Options A and L) would raise portions of the bridge higher than current elevations. It is unclear how the third design option (Option K) would affect bridge height in the study site area.

Based on our acoustic tracking studies and other studies of migrating Chinook salmon (Kemp 2005; Tabor et al. 2006; Celedonia et al. 2008b; R. Tabor, USFWS, unpublished data), actively migrating Chinook salmon smolts attempt to avoid passing beneath overwater structures. Upon encountering structures such as docks and piers, fish generally move into deeper water and either pass beneath the structure or swim around the perimeter of the structure. Once beyond the structure, fish generally move back into shallower water. Some factors that appear to influence behaviors are structure width, height of structure above the water surface, light conditions beneath the structure, degree of contrast at the light/shadow edge, type and size of adjacent structures, and macrophyte distribution. These are anecdotal observations, however, and more rigorous study is needed to better understand how size, shape, and other parameters of overwater structures influence salmonid behavior. Elevating the bridge above the surface of the water may allow more ambient light beneath the bridge and may thus diminish any influence the bridge shadow has on migrating Chinook salmon. However, a wider bridge may counteract this. It is uncertain how these two factors (bridge width and height of bridge above the surface) would interact to influence behaviors of actively migrating Chinook salmon behaviors.

Given the complexity and uncertainty of factors influencing holding Chinook salmon's use of the bridge, we cannot infer with much certainty the influence of the new bridge design on holding Chinook salmon. Specific features that may influence attraction of Chinook salmon smolts to the current bridge during the day may include one or more of the following: 1) shading under and near the bridge; 2) structural complexity provided by the bridge (i.e., the bridge columns); and, 3) the presence of macrophytes near and/or under the bridge. Elevating the new bridge may diminish the bridge shadow's darkness and the degree of contrast at the light-dark edge, and may thus diminish the attractiveness of shadow as cover as well as allow more dense growth of macrophytes beneath the bridge. The greater width of the new bridge may, however, offset these effects as a wider bridge would allow less ambient light underneath thereby darkening the shadow. Tagged Chinook salmon smolts usually selected for the bridge edge. Thus, a wider bridge would have no influence on these fish. However, we did observe occasional selection for a small area directly beneath the bridge where the bridge was elevated above the surface of the water. A wider bridge that is elevated throughout the study area may thus increase under-bridge area used by Chinook salmon. Fewer and more widely spaced bridge columns may diminish any role the columns serve in providing cover to holding Chinook salmon smolts. The new bridge alignment moves the new bridge slightly north of the current location which will change the proportion of water column depths spanned. For example, the current bridge spans a large proportion of 4-6 m deep water relative to other depths. The proposed bridge alignment will diminish this proportion and will increase the proportion spanning 6-8 m depth. When Chinook salmon were near the bridge, depths of 6-8 m had the highest selection ratios in 2007 and in the later 2008 releases. The proposed bridge would increase the availability of near bridge habitat at these depths. Although it is difficult at best to predict how these changes in bridge design and alignment will interact to influence holding Chinook salmon during the day, we believe that patterns in holding Chinook salmon habitat use near and under the bridge will most likely either be similar to those observed at the current bridge or that selection





U.S. Fish and Wildlife Service

# Movement and Habitat Use of Chinook Salmon Smolts in the Lake Washington Ship Canal

## 2007-2008 Acoustic Tracking Studies

May 2011 By Mark T. Celedonia, Zhuozhuo Li, Scott T. Sanders, Roger A. Tabor, Steve Damm, Daniel W. Lantz and Benjamin E. Price

U.S. Fish & Wildlife Service  
Washington Fish & Wildlife Office  
Lacey, Washington



Seattle  
Public  
Utilities



Funded by Seattle Public Utilities (City of Seattle),  
U.S. Army Corps of Engineers, and King Conservation  
District

LWSC Chinook Salmon Acoustic Tracking, 2007-2008  
FINAL REPORT

May 2011

More than fifty percent of the tagged fish also used south Lake Union, often for more than 24 hours.

In general, tagged Chinook salmon in the LWSC distributed broadly throughout areas with bottom depths  $\geq 4$  m, although shallower areas were used on occasion. Seasonal and inter-annual shifts in spatial distribution appeared to be related to diel period, water temperature, and water clarity. Overwater structures may have also influenced spatial distribution in some cases. We found little evidence of strong shoreline orientation in the LWSC, although extensive shoreline development throughout the LWSC may have obscured the natural tendencies of the fish. This contrasts with findings in Lake Washington where fish remain relatively close to shore in areas with bottom depths of 1-6 m during the day. Lower abundance of some Chinook salmon predator species in the LWSC may contribute to the shift in horizontal spatial distribution of Chinook salmon here.

Tagged Chinook salmon smolts often used the edges of overwater and in-water structures where water depth was greater than 6 m. This was observed primarily at the University Bridge and South Lake Union sites. In general, Chinook salmon milled throughout a zone that started at the structure edge and extended outward 20 m. These findings were similar to those observed in studies at the State Route (SR) 520 bridge and a nearby overwater condo in Lake Washington (Celedonia et al. 2008a; Celedonia et al. 2009). It is possible juvenile Chinook salmon use structure edges to be near cover. This behavior has important management implications in that use of these areas puts Chinook salmon in close contact with known smallmouth bass *Micropterus dolomieu* habitat. However, the extent to which these behaviors result in increased predation requires further study. Nonetheless, resource managers and policy makers should consider this in the design, modification, and permitting of over- and in-water structures in the LWSC where bottom depths are 6 m and deeper.

At the University Bridge site, fish migration behavior was strongly influenced by the University Bridge. Many tagged fish responded by milling along the eastern edge of the bridge and in nearby areas prior to passing beneath the bridge. Similar behaviors were observed at the SR 520 bridge (Celedonia et al. 2008a; Celedonia et al. 2009). Few if any fish responded to the presence of the I-5 bridge, presumably because it is much higher than the University Bridge and has no in-water structure. The milling behaviors at the University Bridge put fish in prolonged contact with edges of in-water structures that were frequented by smallmouth bass (Tabor et al. 2010). This may increase predation on Chinook salmon smolts. In one cases, data showed predation upon a tagged Chinook salmon in this area.

At night, tagged Chinook salmon frequented areas with artificial lighting and spent prolonged periods in these areas. Similar observations were made along the SR 520 bridge (Celedonia et al. 2009). Relatively dim light levels (1.6-2.0 lx) attracted tagged Chinook salmon. Other studies suggest that predation rates by piscivorous fishes may be higher in lighted areas even if predators on the whole do not select for these areas. Any potentially negative consequences to Chinook salmon might be minimized by reducing the intensity of light reaching the water surface.

*Influence of artificial lights on nighttime movement and habitat use*

We observed influences of artificial lighting on nighttime movement and habitat use of tagged Chinook salmon at three study sites: University Bridge, South Lake Union, and the Ballard Locks. This study was not intended to provide a thorough evaluation of artificial lighting. However, upon observing in our tracking data indicators that artificial lighting may have influenced tagged Chinook salmon habitat use, we conducted follow-up site visits to provide at least a minimal level of verification. We identified sources of artificial lighting and/or measured light levels near the water surface. These light surveys were not intended to be rigorous: we did not attempt to locate and measure every source of artificial light. Light intensity levels were measured at the water surface with an Extech Instruments light meter to the nearest 0.1 lx.

At the Ballard Locks, areas of the site that were intensively used by tagged Chinook salmon at night were often associated with artificial light (Figures 44 and 45). These included areas at the large lock approach/entrance along the north pier wall, the area immediately to the north of this pier wall, at the small lock approach/entrance along the north pier wall, as well as two other localized areas (Figure 44). Light levels in these areas were generally greater than 10 lx, although one point was measured as low as 0.3 lx (Figure 45). Ambient light levels measured at 11 points throughout the site were generally 0.0 lx (7 points), and was as high as 0.2 lx (3 points). Interestingly, some areas with elevated light levels were not associated with greater use by tagged Chinook salmon. For example, light levels along a line running parallel to and 15 m from the small lock pier wall were generally 3-10 lx (Figure 45). However, we did not observe any elevated use by tagged Chinook salmon in this area. This may have been due to the proximity of this area to higher light levels closer to the pier wall.

At the South Lake Union site, we observed several instances of tagged Chinook salmon spending prolonged periods near known artificial lights at night (Figure 46). Light levels were measured at only two known sources, and were 2.3-6.0 lx about 1 m above the surface of the water. Ambient light levels measured along the shoreline were 0.5-0.7 lx. Artificial light sources were on structures in areas where the water was relatively deep (> 6 m). There were numerous other areas near overwater structures in deep water where some tagged Chinook salmon spent prolonged periods at night. It is uncertain if there was artificial lighting in these areas. A more rigorous light survey is needed to verify all artificial lights sources and the light level at these sources.



FIGURE 44. Areas of moderate to high intensity use by tagged Chinook salmon at night at the Ballard Locks, June-July, 2007 (left) and 2008 (right). Areas of higher use that were associated with artificial lighting are outlined in black. See Figure 45 for light level measurements in these areas.



FIGURE 45. Light level readings (lx) in selected areas of the Ballard Locks study site. Selected areas used more intensively by tagged Chinook salmon are outlined in black. See Figure 38 for distribution of tagged Chinook salmon usage intensity. Ambient light level was generally 0.0 lx, although in some areas was as high as 0.2 lx.

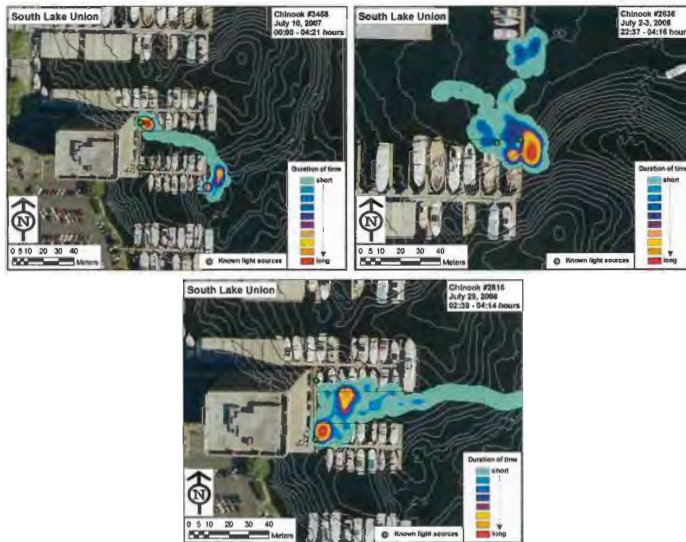


FIGURE 46. Three examples of tagged Chinook salmon use of artificially lit areas at night at the South Lake Union site: Chinook #3458 (upper left), #2636 (upper right), and #2816 (bottom). Sources of known artificial light are shown. Other sources of artificial light may have also been present. Light levels at the two sources in the upper left and bottom images measured about 1 m above the water surface were 6.0 lx (north source) and 2.3 lx (south source). Ambient levels measured along the shoreline were 0.5-0.7 lx. Light levels at the sources in the upper right image were not measured.

At the University Bridge site, there was a notable response of tagged Chinook salmon to artificial lighting on the I-5 bridge deck and the light/shadow edge this lighting created in the water (Figures 47, 48, and 49). Light levels were 1.6-2.0 lx (measured at 3 points) within 1 m of the edge on the light side, and were 0.2-0.5 lx (measured at 6 points) in the shadow area between the lines. Many fish milled along the light/shadow edge on the eastern side of the I-5 bridge and milled between this edge and the University Bridge. These areas were highlighted on both spatial frequency distribution maps (suggesting that many fish spent time milling in this area) and density plots (suggesting that many fish spent prolonged periods here relative to other parts of the site) (Figure 47). Movement pathways of many fish also showed extensive north-south

milling along this edge (e.g., Figure 49). Many of these fish also milled in the area between the edge and the University Bridge, often interspersing periods of milling along the light/shadow edge with periods milling between the bridges. There was a marked reduction in activity in the shadow zone beneath and adjacent to the I-5 bridge. This was evident on both density plots and spatial distribution maps (Figure 47). Tracks of tagged fish suggested that many fish either did not enter the shadow area or moved quickly through without spending much time. Movement pathways of some fish suggested that this light/shadow edge influenced their movement. For example, when Chinook salmon #3168 encountered the western light/shadow edge from the east, it twice changed its pathway and moved away from the edge before crossing the edge on its third encounter (Figure 49).

Also at the University Bridge site, we observed areas of high tagged fish use in the mid-channel area adjacent to the University Bridge support structures (Figure 47). These areas were associated with artificial lighting beneath the bridge attached to the support structures (Figures 47 and 50), presumably as a boating navigational aid. We did not measure light levels here.

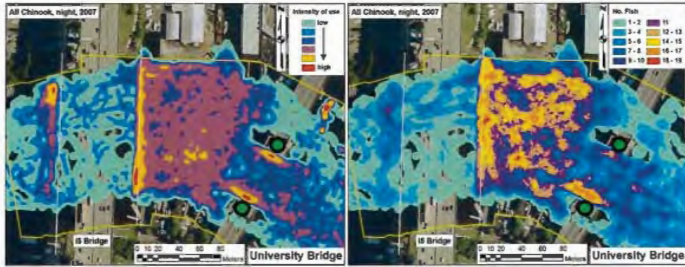


FIGURE 47. Distribution of tagged Chinook salmon at night at the University Bridge study site, June-July, 2007. Density plot (left) shows intensity of fish use for all tracked fish (weighted by time), and spatial frequency distribution (right) shows number of fish tracked by area. The white lines parallel to the I-5 bridge show the location of the light/shadow edge created by artificial lighting on the I-5 bridge deck (see Figure 48). Light levels were 1.6-2.0 lx (measured at 3 points) within 1 m of this line on the light side, and were 0.2-0.5 lx (measured at 6 points) in the shadow area between the lines. Green circles show approximate locations of lights beneath the University Bridge (see Figure 50).



FIGURE 48. Artificial lighting on the I-5 bridge deck spanning the Lake Washington Ship Canal (looking north).

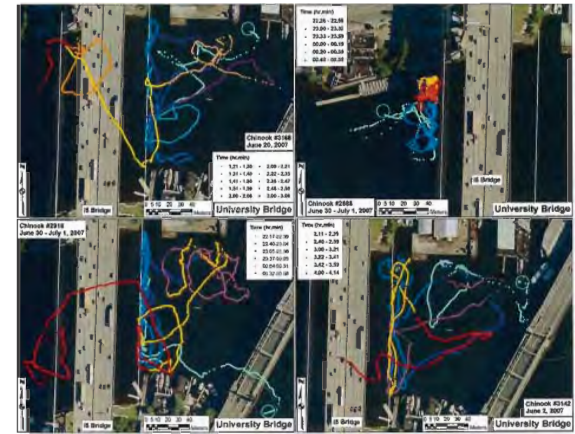


FIGURE 49. Four examples of tagged Chinook salmon behavior near the light/shadow edge created by artificial lighting on the I-5 bridge deck: Chinook #3168 (upper left), #2688 (upper right), #2918 (bottom left), and #3142 (bottom right). The white lines parallel to the I-5 bridge indicate the light/shadow edge created by artificial lighting on the I-5 bridge deck. Light levels were 1.6-2.0 lx (measured at 3 points) within 1 m of this line on the light side, and were 0.2-0.5 lx (measured at 6 points) in the shadow area between the lines. The color scale indicates the time sequence of each track. The blue circle shows the starting point of the fish in each image.

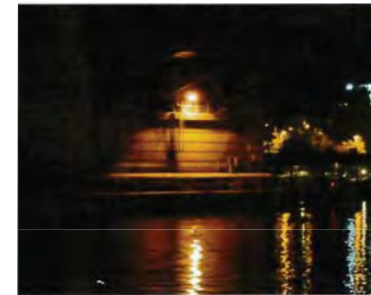


FIGURE 50. Artificial lighting under the University Bridge. Lighting is directed down onto the water surface. Light on the north bridge support structure is pictured. Light on the south support structure is similar. These lights correspond with green circles in Figure 47.

Submission #2  
Subject: Sundial Bridge - CDFG - GGSA

- ✓ Ecosystem Restoration Program Conservation Strategy for Restoration of the Sacramento-San Joaquin Delta, Sacramento Valley and San Joaquin Valley Regions, CDFW, USFWS and NMFS, May 2014  
<https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=87585>
- ✓ Potential Effects of Artificial Light from the Sundial Bridge on Juvenile Chinook Salmon Migratory Behavior and Predation by Predatory Fishes in the Sacramento River, Redding, Shasta County By Andrew Jensen, August 6, 2012  
URL = none at this time
- ✓ State wildlife officials say Sundial Bridge lighting may be hurting salmon, by Damon Arthur, Feb 21, 2013  
Record Searchlight [redding.com](http://www.redding.com)  
URL = <http://www.redding.com/news/state-wildlife-officials-say-sundial-bridge-may>
- ✓ Lights on the river kill salmon, by John McManus, May 5, 2013 The Record Searchlight Redding Ca. [redding.com](http://www.redding.com)  
URL = <http://www.redding.com/opinion/john-mcmanus-lights-on-the-river-kill-salmon>
- ✓ Golden Gate Salmon Association, Golden Gate Salmon Rebuilding Plan, Project B.6 Eliminate or Reduce Lighting at In-River Structures, Dec 2013  
URL = [http://www.ggsalmon.org/salmonplan/GGSA\\_Salmon\\_Plan.pdf](http://www.ggsalmon.org/salmonplan/GGSA_Salmon_Plan.pdf)

## Ecosystem Restoration Program

# Conservation Strategy for Restoration

of the

### Sacramento-San Joaquin Delta, Sacramento Valley and San Joaquin Valley Regions



May 2014



Additionally, assessment of the impacts from light sources along the Sacramento River which lead to increased predation on juvenile salmonids is also needed. A notable example is the Sundial Bridge in Redding, which uses numerous floodlights that illuminate the Sacramento River all night, year round. Approximately 80 percent of the winter-run Chinook salmon population in the state spawn upstream of the bridge and the out-migrating juveniles must pass through the lighted portion of the river below the bridge and face predators. Studies in Washington State have found lighted portions of streams have significantly higher predation rates on juvenile fish. Downstream of the Sundial Bridge, there are several other light sources ranging from highway bridges to lighted water intake structures. These should all be evaluated and recommendations should be developed to fix identified problems.

Conservation actions will include coordination of protection, enhancement, and restoration of occupied and historic Central Valley salmon habitats with other federal, state, and regional programs. These efforts will include implementation of measures in the restoration plan for the AFRP, the Central Valley Salmon and Steelhead Recovery Plan and applicable CDFW management measures; appropriate operation of hatcheries such that natural populations are not threatened; management of fish passage to reduce predation on juveniles and increase their survival; improved export flows to improve conditions for upstream migration of adults; and operation of physical barriers consistent with achieving recovery goals.

**Steelhead.** Steelhead (*O. mykiss*) depend on essentially all habitats of the Sacramento River system: the main channel for migrating between the ocean and upstream spawning and rearing areas and the tributaries for spawning and rearing. The construction of low elevation dams on major tributaries of the Sacramento River has denied steelhead access to most of their historical spawning and rearing habitats in upstream areas. See full write-up in Delta species section.

Conservation actions will include coordination of protection, enhancement, and restoration of occupied and historic Central Valley steelhead habitats with other federal, state, and regional programs; implementation of measures in the restoration plan for the AFRP, the Central Valley Salmon and Steelhead Recovery Plan and applicable CDFW management measures; and the minimization of flow fluctuations to reduce or avoid stranding of juveniles.

**Green and White Sturgeon.** Sturgeons are native anadromous fish that inhabit both salt water and freshwater and tolerate a wide range of salinity concentrations. Spawning occurs in larger rivers upstream of the Delta. White sturgeon rear in the Sacramento-San Joaquin estuary and spawn in the Sacramento and San Joaquin rivers and their major tributaries. Green sturgeon (*Acipenser medirostris*) are an at-risk species native to the Sacramento River, yet little is known about the habitat needs of this species and its response to restoration. The ERP funded research to conduct telemetric, physiological, reproductive, and genetic studies to provide State and Federal agencies such as the ERP Implementing Agencies with information on the size of the population and its critical habitat within the Sacramento-San Joaquin watershed. This



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*EDMUND G. BROWN, Jr., Governor*  
*CHARLTON H. BONHAM, Director*

Potential Effects of Artificial Light from the Sundial Bridge on Juvenile Chinook Salmon Migratory Behavior and Predation by Predatory Fishes in the Sacramento River, Redding, Shasta County

By:  
Andrew Jensen, M.S.  
Staff Environmental Scientist

August 6, 2012

This white paper is being prepared in response to the concern within the Department regarding the artificial night lighting on the Sundial Bridge (Bridge), and the potential effects the lighting may have on juvenile Chinook salmon (*Oncorhynchus tshawytscha*) migration and rates of predation. The purpose of this white paper is to provide a brief overview of the key aspects of the Bridge, outline some of the potential effects artificial night lighting may have on biological organisms (with an emphasis on salmonids), highlight some of the research that has been performed to assess impacts of artificial light, provide some avoidance and minimization measures, highlight the need for future research, and to provide a starting point for future discussions between the resource agencies and the City of Redding.

The Bridge, designed by renowned Spanish architect Santiago Calatrava, is a cantilever spar cable-stayed bridge for bicycle and pedestrian access that spans the Sacramento River in Redding, Shasta County, California. The Bridge is suspended by steel cables from a single 217-foot tall pylon and spans more than 700 feet across the river without touching the water, which was a design criterion to help protect the salmon spawning areas in the vicinity of the Bridge. The Bridge is 23 feet wide and weighs more than three million pounds (Saflex 2009). The construction on the Bridge began in 1999 was completed in 2004, officially opening on July 4, 2004.

Calatrava's design called for a pedestrian walkway of nonskid glass that at night would be illuminated from underneath by 210 lights, creating an ethereal effect (Via 2004). At night, the laminated glass deck is illuminated from underneath with 1/3 of the lights pointing downstream, 1/3 facing upstream, and the remaining 1/3 facing up towards the Bridge deck (Saflex 2009). The result is that from dusk to dawn the Bridge and the Sacramento River in the vicinity of the Bridge are illuminated (Attachment 1). While the Bridge is undoubtedly an architectural masterpiece, a local icon, a major tourist attraction, and has been designed to be environmentally sensitive in many ways, the night time lighting of the Bridge and Sacramento River may be causing detrimental effects to salmon populations that spawn and rear upstream and in the vicinity of the Bridge.

Natural light plays a fundamental role in the biology of organisms. It is important to consider whether artificial illumination outside of the normal circadian cycle affects organisms (Rondorf et al. 2010). Artificial light has the potential to disrupt the biology of many species (Royal Commission 2009). Rich and Longcore (2006) concluded that artificial night lighting may alter the spatial distribution, diel movements, demography, and overwintering success of some freshwater organisms. Light is one of the most potent agents interacting with our biological systems. Biological responses to light include phototropism and stimulation of hormone production, including the fine tuning of cyclical changes. The intensity, spectral quality, duration and periodicity of exposure to light affect the biochemistry, physiology, and behavior of organisms. Wherever artificial light floods into the natural world there is a potential for some aspect of life and its biological rhythms such as migration, reproduction, and feeding, to be affected (Royal Commission 2009). Artificial lighting that is present on over-water structures may disorient migrating juvenile salmonids, compromise their ability to avoid nocturnal predators, and affect the photosynthesis of aquatic vegetation (Rondorf et al. 2010).

The issue of potential biological impacts from artificial lighting of the Bridge was acknowledged and addressed during the environmental review and approval process (City of Redding 2000). Pursuant to the California Environmental Quality Act (CEQA) and the CEQA Guidelines, mitigation measures were identified and included in the *Mitigation Monitoring Program for the Pedestrian Bridge at Turtle Bay, Redding, California, Addendum to the Mitigated Negative Declaration (Use Permit 43-97, SCH 1995023013)*. Specifically, *Biological Resources BR-9 – Fisheries Impacts Due to Lighting of Surface Waters*, states that "Artificial flood lighting along surface waters is known to attract fry and juvenile salmonids, and other predator fish species." Mitigation measure *BR-9m*, states "No direct lighting onto the river shall occur at either approach or from the bridge." The City of Redding Community Services Department is responsible for monitoring and implementing the above mitigation measure.

Due to the complex nature of light in water, fish have evolved well-developed and highly specialized eyes (Rondorf et al. 2010). The *Oncorhynchus spp.* eye contains a large number of rods and cones, showing that it is adapted for vision in both bright and dim light (Brett and Ali 1958). When light levels change abruptly, the eye has to adapt quickly in order to distinguish objects in the background (Dowling 1967). When the introduced light is bright, the eye will not respond to a dim light, which it may have detected under lower light conditions (Simenstad et al. 1999), making it difficult for juvenile salmon to visually detect predators in the areas beyond the brightly lit area.

Scientific research on the effects of artificial lighting on salmonid populations has been limited, thus the overall impacts of such lighting is poorly understood. However, the studies that have been conducted to address this issue, have illustrated results which indicate that increased light intensity appears to slow or stop out-migrating salmon fry, and increase feeding patterns, making them more vulnerable to predation (McDonald 1960; Patten 1971; Ginetz and Larkin 1976; Tabor et al. 2004). Salmonid fry presumably reduce their vulnerability to predators by emigrating at night and selecting areas of the river channel with the fastest current velocities (McDonald 1960). Juvenile salmonids feed primarily on drifting invertebrates during sunrise and dusk, but do not feed during complete darkness (Brett and Groot 1963; Fraser et al. 1997). Therefore the presence of artificial lighting and illumination of the water may facilitate juvenile salmonid feeding, which in turn may increase their vulnerability to predation at night (Rondorf et al. 2010). Ginetz and Larkin (1976) found that predation of sockeye salmon (*Oncorhynchus nerka*) fry by rainbow trout increased as light intensity increased in the artificial streams they used during their research. According to Skykeepers (2008), research shows that artificial light on newly hatched salmon causes vision problems and reduced survival rates. In addition, nighttime lighting of the Bridge presents a possible predator trap for juvenile salmonids migrating downstream from spawning and rearing areas above the Bridge. Celedonia et al. (2011) found that at night, Chinook salmon were attracted to areas where street lamps on a bridge cast light into the water, increasing their risk to predation, and that any negative consequences to Chinook salmon might be minimized by reducing the intensity of light reaching the water surface. Tabor et al. (2004) found that in the Cedar River in Washington, predation of migrating sockeye salmon fry increased as a result of



artificial nighttime lighting, and that the lighting may be one of the factors in the overall decline of the Cedar River sockeye salmon population. With no predators present, the sockeye fry migrated through the river at a faster rate under complete darkness (0.001 Lux) than in the other two light intensities assessed (1.08 and 5.4 Lux).

On June 14, 2012, I performed light measurements at several locations under and around the Bridge, as well as in an adjacent parking lot, using an EXTECH Light Meter (Model LT300). All measurements were taken in Lux, an International System of Units unit of illuminance and luminous emittance. One Lux is equal to one lumen per square meter (Wikipedia 2012). In addition, I took light measurements under the Cypress Road Bridge as a comparison of a bridge spanning the river that has artificial lighting associated with it. The Cypress Road Bridge is located a couple of miles downstream of the Sundial Bridge. Skies were clear and there was no moon visible during the collection of light intensities.

For reference, a moonless clear night sky would result in surface illumination levels of 0.002 lux, a full moon on a clear night would result in 0.27 lux, family living room lights result in 50 lux, and a dark overcast day would be 100 lux (Wikipedia 2012).

Below are the results I obtained:

- Location #1: Located directly under the Sundial Bridge on the south side of the Bridge, taken at the edge of water of the Sacramento River.
  - Time: 10:12 P.M.
  - Result: 25.55 lux
- Location #2: Located approximately 100-feet downstream of the Sundial Bridge on the south side of the Sacramento River, at the water's edge.
  - Time: 10:22 P.M.
  - Result: 1.34 lux
- Location #3: Located approximately 400-feet downstream of the Sundial Bridge on the south side of the Sacramento River. Minimal artificial lighting present, although a minor amount filtering through the trees from the Turtle Bay Museum.
  - Time: 10:31 P.M.
  - Result: 0.01 lux
- Location #4: Located in the Sundial Bridge Parking Lot, in close proximity to a street light, however, not directly beneath it.
  - Time: 10:38 P.M.
  - Result: 6.95 lux
- Location #5: Located in the Turtle Bay Parking Lot directly under a street lamp.
  - Time: 10:45 P.M.
  - Result: 19.56 lux
- Location #6: Located under the Cypress Road Bridge, approximately 2 miles downstream of the Sundial Bridge, taken near the water's edge on the west side of the river. The Cypress Bridge has some artificial lighting shining down into the river; however the lighting appeared much less intense than the Sundial Bridge lighting.
  - Time: 10:55 P.M.
  - Result at downstream side of bridge: 3.47 lux
  - Result at upstream side of bridge: 7.14 lux

In the Sacramento River and tributaries such as Clear Creek, studies have been conducted to assess the seasonal, spatial and diel distribution patterns of juvenile Chinook salmon, M. Brown, U.S. Fish and Wildlife Service (personal communication April 16, 2012; Gaines and Martin 2002). The U.S. Fish and Wildlife Service has been assessing the diurnal timing of juvenile Chinook out-migration in Clear Creek, with 14 trials/studies conducted about every other week from December 2011 through June 2012, and have found that 80% of the fish caught in the rotary-screw trap (RST) entered the RST in a five hour block of time from 1800 to 2300. During this same time period, sunset times ranged from 1645 on December 1, 2011 to 2034 on June 30, 2012 (Calendar-365). The peak of the migration took place from 2000 to 2100. Similar results were observed in two trials that took place in May and June 2011, M. Brown (personal communication April 16, 2012; July 5, 2012). On the Mainstem Sacramento River, Gaines and Martin (2002) found that relative abundance of Chinook salmon fry and pre-smolt/smolt (all runs combined) captured by RST's below Red Bluff Diversion Dam was significantly greater during nocturnal periods. They found that the same results held true for all sizes of rainbow trout (*Oncorhynchus mykiss*) combined, a potential predator species of the juvenile Chinook. Based on these studies, it appears most juvenile Chinook are out-migrating under the cover of darkness, thus artificial lighting could delay or inhibit out-migration and increase predation. McDonald (1960) was able to completely stop the nightly movement of sockeye salmon fry with artificial lighting kept on all night at levels of 30 lux. Tabor et al. (2004) found that if sockeye salmon fry encountered lighted areas, many held their position in low-velocity water, and the migration was delayed. They also found that the fry resumed their migration shortly after the lights were turned off.

Tabor et al. assessed several sources of artificial lighting, including laboratory experiments that included artificial streams, experimental field trials consisting of constructed artificial lighting, and existing sites, such as the Renton Library and the I-405 bridge. Both the library and the bridge span the entire width of the Cedar River, and both structures have several sources of artificial light that illuminate the river, similar to the current conditions of the Sundial Bridge. In addition, sampling was conducted in 1998 and again in 2001 after artificial lights had been shielded and light intensities along the river had been substantially reduced from 9.7-21.5 lux (1998) to 0.14-0.32 lux (2001). Overall, the results from Tabor et al. (2004) suggest that reductions in light intensity can be beneficial for emigrating juvenile salmonids and that the impact of lighting should be considered for any future or existing projects.

Chinook salmon populations in the main-stem Sacramento River have fluctuated greatly in the last decade. Table 1 provides a summary of Chinook salmon run sizes in the main-stem Sacramento River from 2000 through 2011. Currently, three separate Chinook runs migrate to, spawn, and reside as juveniles in the Redding area, both above and below the Bridge. The three runs (known by their timing as they pass San Francisco) are late-fall, winter and fall-run. Winter-Run Chinook salmon are currently only found in the Sacramento River near Redding, and the majority of the population spawns above the Bridge. Winter-Run are currently federally and state listed as Endangered, which makes them the intense focus of fisheries and water agencies, at both a state and federal level, since their juvenile and adult numbers determine harvest regulations for both sport and commercial fishers, as well as guiding agricultural and urban water use transfer limitations, D. Killam (personal communication June 29, 2012). Chinook salmon in this area typically rear for up to a year near the location where they emerged from their redd. They then migrate to the ocean, and return to the same area as adults in 2 to 5 years (typically in 3 years). Understanding this "life history" is important because if the lights from the bridge were impacting juvenile salmon survival, the effects would typically not be apparent until 3 years after juvenile downstream migration occurs, once the juveniles return to the Redding area as adults to spawn. An example of this is if the Bridge lights were first turned on in mid-2004 then the juveniles from 2003 would not have been impacted and would have returned in 2006. The juveniles from 2004 however could have been impacted, but they would have returned in 2007. For purposes of this discussion, populations of adult Chinook salmon from mid-2007 to the present day could have reduced numbers as a result of lighting impacts at the Sundial Bridge.

Table 1. Adult populations of Chinook salmon runs in the main-stem Sacramento River for years 2000 to 2011, (from Princeton to Keswick Dam). Grey area indicates populations whose juveniles could not have been impacted by Sundial Bridge lighting.

Year	Total Main-stem Sac River Population			% Spawning above Sundial Brg.		
	Late-fall	Winter	Fall-Run	Late-fall	Winter	Fall-Run
2000	8702	1,350	96,688	0%	6%	6%
2001	19276	8,224	75,168	26%	35%	7%
2002	36004	7,441	65,690	27%	49%	9%
2003	5532	8,218	89,229	58%	66%	6%
2004	8884	7,869	43,604	84%	16%	10%
2005	10603	15,839	57,012	47%	52%	27%
2006	10175	17,290	55,468	35%	35%	14%
2007	15340	2,541	17,061	57%	52%	20%
2008	3979	2,830	24,743	48%	51%	1%
2009	3424	4,537	5,827	73%	16%	25%
2010	4365	1,596	16,372	72%	48%	16%
2011	3725	824	11,592	73%	6%	34%

As shown in Table 1 above, in 2004, when the Bridge was completed the population was 7,869. In 2005 and 2006 the population topped out at 15,839 and 17,290, respectively. In 2007, three years after the Bridge was completed and night lighting first occurred in this section of river, which is the typical return interval for Chinook

salmon (2004 Year Class), the population had declined to 2,541 fish. In 2008 and 2009, the years in which the 2005 and 2006 year class fish would be expected to return, the populations were 2,830 and 4,537, respectively.

The causes of the population declines since 2007 can be many, and no one cause is likely solely responsible for the declines. However, with the correlation of timing between the completion of the Bridge and the corresponding declines in returning adults, and the fact that research has demonstrated artificial light has a detrimental effect on emigrating juvenile salmonids, this issue warrants further discussion to find possible solutions to avoid and minimize future impacts. Such measures may include changing the position of specific lights to face up rather than out and down towards the river, install shields on some of the lights, turn off some of the lights if not needed, change the type of light used, etc. In addition, it may be deemed necessary to conduct some site specific studies in the vicinity of the Bridge, to help determine the level of biological response occurring due to the nighttime illumination from the Bridge.

In summary, Department staff will propose to meet with other resource agencies such as NOAA Fisheries and the U.S. Fish and Wildlife Service to discuss these issues, determine an appropriate course of action, and outline potential minimization measures that could be implemented to reduce potential impacts from the artificial lighting of the Bridge. Additional meetings should then be conducted with the City of Redding to agree on an appropriate approach. As stated above, The City of Redding is responsible for implementation of the *Mitigation Monitoring Program – Pedestrian Bridge at Turtle Bay*, specifically mitigation measure *BR-9 – Fisheries Impacts Due to Lighting of Surface Waters*. Tabor et al. (2004) states that when attempting to reduce artificial light, efforts should be made to keep levels below 0.1 lux as a prudent management goal. The recommendations of The Royal Commission (2009) regarding artificial lighting, state that artificial light should only be used at times when the benefits are needed, and that lighting standards should require the provision of light at an intensity no greater than the minimum necessary to deliver the intended benefits. In addition, the light should be directed at only those areas which are intended to be illuminated. Therefore, taking this type of approach, we should be able to develop some criteria for lighting that would provide the necessary level of safety for pedestrians using the bridge during the nighttime hours, lighting of the Bridge for its incredible architecture, while providing a necessary level of protection for migrating juvenile Chinook salmon, as well as the overall aquatic ecosystem in the vicinity of the Bridge.

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Attachment 1 – Photos of Sundial Bridge



Photo 1. Sundial Bridge under construction.



Photo 2. Sundial Bridge information sign showing hours of operation.



Photo 3. View of the Sundial Bridge from downstream.



Photo 4 – Sundial Bridge lit up at dusk, with lights pointing down towards the Sacramento River, in a downstream direction.



Photo 5. Nighttime lighting of the Sundial Bridge, resulting in illumination of the Sacramento River across its entire width.



Photo 6. Nighttime lighting of the Sundial Bridge with significant illumination of the Sacramento River.



Photo 7. View of the Sundial Bridge under-deck lights, with one facing down towards the river and one facing up towards the bridge deck.



Photo 8. Looking down into the Sacramento River from the Sundial Bridge at 7:12 P.M., into approximately 5-8 feet of water, with a dead adult Chinook salmon visible on the bottom. It was completely dark outside when the photo was taken, thus the illumination of the river bottom is solely from the lights on the bridge.

# State wildlife officials say Sundial Bridge lighting may be hurting salmon

**BY:** Damon Arthur

**POSTED:** 10:00 PM, Feb 21, 2013

**TAG:** [local \(/topic/local\)](#) | [sacramento river \(/topic/sacramento+river\)](#) | [kurt starman \(/topic/kurt+starman\)](#)

Redding's Sundial Bridge may be bringing about the demise of endangered winter-run Chinook salmon.

Since the bridge opened to walkers and bicycle riders in 2004, the number of winter-run Chinook salmon returning to spawn in the Sacramento River has plummeted from over 15,000 fish in 2005 to 824 in 2011.

The lights under the pedestrian bridge may be one of the reasons why the number of salmon is declining, according to the state Department of Fish and Wildlife, which is studying the effects of the bridge lights.

"Intense levels of artificial light slow or stop juvenile migration of salmon" on their annual trek to the Pacific Ocean, said Andrew Jensen, a DFW staff environmental scientist.

And when the young fish stop in the water under the lights, larger fish, such as rainbow trout, are there to eat them, Jensen said. Other bridges over the Sacramento River in Redding also may have lighting underneath that is disrupting fish migration, he said.

The DFW and the city of Redding have been working together to test different light levels under the Sundial Bridge, he said. Light levels under the bridge deck this week were less than half of what they were before the testing began.

Redding City Manager Kurt Starman said the city is interested in working with the DFW on finding out whether the lights are hurting fish. But whether the lights were harming young salmon was still a "supposition" and further studies were needed, he said.

"I'm not aware of any conclusions or facts to support that," Starman said of the DFW's concerns.

Years before the bridge was built, environmental impact reports noted that light from the bridge shining on the water would hurt fish.

John Oldham, the city's environmental compliance officer, said because of the lighting concern, lamps under the bridge were pointed up to avoid light shining directly on the water.

Some of the lights may have inadvertently been pushed down or slipped down over the years, Oldham said.

There were 240 lights installed under the bridge and they were aimed into the air, said Bob Morrison Jr., the engineer who supervised construction on the bridge.

"There are no lights that shine down on the water," Morrison said. He said the fish may be seeing the light that is pointing into the air.

In an August 2012 report Jensen wrote on the bridge lighting. From dusk to dawn, one third of the lights were pointed up, another third were pointed upstream and another third were pointed downstream, the report says.

The light is apparently reflecting off the translucent panels on the bridge deck and back toward the water, Jensen said.

That light could be influencing how the young salmon migrate to the ocean. About 60 percent of the winter-run salmon, listed as an endangered species under California and federal law, spawn upstream of the Sundial Bridge.

After the salmon eggs hatch in the river and the young salmon swim to the ocean they are preyed upon by larger fish, Jensen said. He said the juvenile salmon migrate at night. But when they encounter bright light on the water it stops them at the light. The light also attracts bugs the young salmon like to feed on, Jensen said. But again, when the juveniles stop to feed on the bugs, the bigger fish can prey on them, he said.

Jensen said he found other scientific studies that back up the DFW's claim that the lights could be hurting young salmon.

In June, the DFW took nighttime measurements of the lighting under the bridge at the water's edge and found it at 25.55 lux, a measurement of illumination per square meter. One hundred feet downstream, the light was 1.34 lux. Light levels near a lamp in the Sundial Bridge parking lot measured 6.95 lux, according to Jensen's report.

City officials have turned down the light under the bridge and it's currently about 11 lux, he said. To help the fish, the lighting level on the water may need to be reduced a level ranging from 1.5 to 3 lux, he said.

Turning down or turning off some of the lights may not be the only solution, Jensen said. The city could place shields over the lights or use shade cloth, or even a different type of light, he said.

Jensen said the DFW is interested in working with the city to solve the problem because of the Sundial Bridge's popularity and because the lighting is part of the bridge's appeal.

## Lights on the river kill salmon

By John McManus

Staff Reports

Sunday, May 5, 2013

This may not sound intuitive, but many brightly lit bridges, docks and marinas along the Sacramento River are causing the deaths of untold numbers of young salmon. Some of these structures, like bridges, have to be lit so drivers can see the roadway, but there's no need to light up the water below. Reducing the lights' brightness, or redirecting them so they don't light up the water, is all that's needed.

Here's the problem. Baby salmon get eaten by most fish bigger than they are. Survival is tough. The baby salmon have pretty good eyesight, but their eyes work in either day or night mode, not both at the same time. They eat during the day and when they travel, they do it at night to minimize detection. When they swim under lit bridges at night, their eyes shift from night to daytime mode. So does their behavior. They slow down and start thinking about food. This is when they become very vulnerable to bigger fish lurking in the shadows.

Scientists have been able to bring migrating baby salmon to a stop by turning on the lights. Officials knew this would be a problem with Redding's Sundial Bridge. When Redding got a permit to build the bridge, one of the conditions said, "No direct lighting onto the river shall occur at either approach or from the bridge." Somehow this got overlooked when the bridge was built. Some lights underneath the bridge were pointed down and lit the river. Recently the city of Redding has been responsive to the problem and has taken steps to fix it, which salmon advocates very much appreciate. But the problem persists at other bridges, marinas, docks and water-intake structures up and down the river.

Among the baby salmon being gobbled up due to lights on the water are some on the federal endangered species list, including winter-run salmon. This creates a big problem for fishing communities on the coast and elsewhere that are seeing their fishing seasons restricted, at great loss, to avoid contact with winter-run fish. Water diverters in the Delta also face restrictions in an effort to protect the winter run.

Experts have pointed to a possible correlation between a recent steep decline in winter-run salmon and the Sundial Bridge's lights.

Before the effects of the bridge's lights on salmon kicked in, winter-run returns hit a high of over 17,000 in 2006. Once the effect of the lights was felt, winter-run salmon numbers dropped to 2,541 fish. They haven't recovered since. Others have pointed to a steep increase in Delta water diversion as a more likely cause of the winter-run decline, and multiple factors can't be ruled out.

Easy steps can be taken to make bridges and other structures more salmon friendly.

Changing the position of specific lights to face up rather than toward the river, installing shields, turning lights off when they're not needed, and changing the type of light used are a few.

Losing winter run, or any juvenile salmon, due to misdirected lighting is something that should be addressed because the fix is so simple. Those of us downstream who rely on salmon for a living are most appreciative of any steps taken in this direction.

*John McManus is the executive director of the Golden Gate Salmon Association.*



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### ***Project B.6 Eliminate or Reduce Lighting at In-River Structures***

Bright lights shining into the water at night from bridges and other structures in the Sacramento River and its tributaries create a significant predation hazard for salmon fry and smolts. These fish tend to move at night when they can avoid predators. When they encounter bright lights they become disoriented and are easy predator prey.

One of the prominent problem bridges was the Sundial foot bridge which crosses the Sacramento River in Redding. Lowering the very bright lights on the bridge was taken up as a project by the regional office of the California Department of Fish and Wildlife. The City of Redding cooperated and the intensity of the lights has been lowered significantly. They have also been redirected away from the water. The next step will be the installation of lower intensity LED lights which will lower the level more plus save electricity. The City and CDFW are also working to reduce lights on other nearby bridges. This project is near complete and will save thousands of smolts.



*The two pictures on the left show the bridge before the lights were lowered and the picture on the right shows it after they were lowered.*

*Photos by Andrew Jensen, California Dept. of Fish and Wildlife*

[More Detail](#)







## ***Welcome to the Golden Gate Salmon Rebuilding Plan***



Submission #\_\_  
Subject: Columbia River Crossing: Biological Assessment  
CRC Biological Assessment - June 2010 - Section 6 (1 of 2) Page 6-48 and 6-49  
[http://www.columbiarivercrossing.org/FileLibrary/Biological\\_Assessment\\_Opinion/CRC\\_BA\\_12\\_Section\\_6\\_1of2.pdf](http://www.columbiarivercrossing.org/FileLibrary/Biological_Assessment_Opinion/CRC_BA_12_Section_6_1of2.pdf)

**1 6.1.4.1 General Effects of Artificial Lighting on Fish**

2 Artificial light sources associated with overwater structures or construction activities may attract  
3 fish. Because salmon rely on vision for capturing prey, the artificial lights may improve both  
4 prey detection and predator avoidance (Tabor et al. 1998, as cited in Carrasquero 2001). During a  
5 study of the Columbia River at Bonneville Pool, Collis et al. (1995) observed that juvenile  
6 salmon were attracted to work lights directed at the water surface. In Lake Washington, juvenile  
7 Chinook have been observed congregating at night near streetlights on the SR 520 bridge  
8 (Celedonia et al. 2008). Tabor et al. (2004) observed sockeye fry in the Cedar River, noting that  
9 they were significantly more abundant under city street lights than at nearby sites that were not  
10 illuminated. Light levels as low as 0.22 lux (0.020 foot candle) appeared to influence fry  
11 behavior. In one location, turning off the streetlights resulted in a significant decrease in the  
12 number of sockeye fry present.

13 Artificial lights can create sharp boundaries between dark and light areas under water. This, in  
14 turn, may cause juvenile fish to become disoriented or avoid crossing the light-dark interface, as  
15 outlined in detail in Section 6.1.3.1. Williams and Thom (2001) noted that artificial lighting on  
16 docks may change nighttime movement patterns in juvenile salmon. Numerous other studies  
17 (Fields 1966, Prinslow et al. 1979, Weitkamp 1982, Ratte and Salo 1985, Pentec 1997, Taylor  
18 and Willey 1997, and Johnson et al. 1998; as cited in Southard et al. 2007) corroborate these  
19 findings, noting behavioral changes in juvenile salmon in response to artificial lighting.  
20 McDonald (1960, as cited in Tabor et al. 2004) found that sockeye fry will stop swimming  
21 downstream upon encountering artificial lighting, and was able to completely stop nightly  
22 migration of sockeye salmon fry with artificial lighting kept on all night at 30 lux (2.8 foot  
23 candles). A USFWS (1998) literature review noted that sockeye fry moved through experimental  
24 streams more quickly in complete darkness than under bright lights (Tabor et al. 1998). Increased  
25 light appeared to inhibit migration of sockeye fry, with significant effects to migration when  
26 light levels reached 2.0 lumens/ft<sup>2</sup> (2.0 foot candles). A later study (Tabor et al. 2004)  
27 corroborated the finding that fewer sockeye moved through illuminated artificial streams than in  
28 darkness, and those that did move, moved more slowly. In this study, light intensity levels from  
29 1.08 to 5.40 lux (0.1 to 0.5 foot candle) appeared to inhibit migration. The same study noted that  
30 the delay in outmigration in sockeye fry increased their vulnerability to predation.

31 Another USFWS study (Tabor and Piaskowski 2001) observed juvenile Chinook in nearshore  
32 habitat in Lake Washington, noting that individuals became active when light levels reached  
33 0.08 to 0.21 foot candle and were scarce in the study area when light levels were between  
34 2.2 to 6.5 foot candles. A review of the impact of ferry terminals on juvenile migration in Puget  
35 Sound (Simenstad and Nightingale 1999) cites Ali (1958, 1960, and 1962) as stating that light is  
36 tremendously important for numerous life functions of chum, coho, sockeye, and pink salmon,  
37 noting that feeding, minimum prey capture, and schooling are dependent on light levels lower  
38 than 10<sup>-4</sup> foot candles (similar to a clear, moonless night) and that maximum prey capture for  
39 chum and pink fry occurs when the light level is 1.0 foot candle (similar to light levels at dawn  
40 and dusk).

41 Artificial light sources may provide an advantage to predators such as smallmouth bass,  
42 largemouth bass, northern pikeminnow, and salmonids. Rainbow trout predation on sockeye fry  
43 in artificial streams increased with increased lighting at levels of less than 1.1 lux (Ginetz and  
44 Larkin 1976, as cited in Tabor et al. 2004). Northern pikeminnow are attracted to areas where  
45 juvenile salmonids congregate, such as hatchery release sites and dams (Collis et al. 1995;

1 Beamesderfer and Rieman 1991). If light sources attract congregations of juvenile salmonids,  
2 this could cause an increase in predation by northern pikeminnow. Celedonia et al. (2008) found  
3 that smallmouth bass may feed at night in the vicinity of artificial light or under moonlight.  
4 Largemouth bass have been shown to forage efficiently at light levels ranging from low-intensity  
5 daylight to full moonlight, with less foraging at light levels equivalent to a starlit, moonless night  
6 (McMahon and Holanov 1995).

7 Tabor et al. (2004) observed the effect of light intensity on cottid predation of sockeye fry in  
8 artificial streams, noting that cottids consumed 45 percent of the fry under intense illumination  
9 (5.4 lux or 0.50 foot candle), 28 percent under dim light (0.22 lux or 0.020 foot candle), and  
10 5 percent in complete darkness (0 lux or 0 foot candle). The study also observed that fewer fry  
11 emigrated in illuminated streams and did so at a faster rate when predators were present than in  
12 lighted streams where predators were not present, indicating that the presence of predators may  
13 inhibit migration in some individuals. In a field study in the Cedar River, Washington, Tabor et  
14 al. (2004) further noted that the number of shoreline fry and rates of predation by cottids  
15 increased with an increase in light levels. At one site, shielding the lights to levels of  
16 0.1 to 0.32 lux (0.013 to 0.030 foot candle) substantially reduced predation.

17 The literature is not in complete agreement about light levels that are likely to impede migration  
18 or increase predation on juvenile fish. However, data from Tabor et al. (2004) may present a  
19 worst-case scenario. That is, light levels as low as 0.22 lux (0.20 foot candle) may delay  
20 migration or increase predation on juvenile salmonids.

#### 21 **6.1.4.2 Effects of Lighting on Fish in the CRC Action Area**

22 The project will install both temporary and permanent lighting.

#### 23 **Temporary Lighting**

24 Temporary overwater lighting sources will include the cofferdams, barges, work  
25 platforms/bridges, oscillator platforms, and tower cranes. Figure 6-17, Figure 6-18, and Figure  
26 6-19 show the locations and sequencing of temporary structures requiring artificial lighting in the  
27 work area. Temporary lighting will not be uniform over all of the in-water construction years.  
28 During the Columbia River in-water construction period, temporary lighting will be limited to  
29 the first three pier complexes during the first year, expand to all six in the second, and taper off  
30 to three or fewer during the last 2 years (Figure 6-17). In North Portland Harbor, temporary  
31 lighting will be distributed more or less evenly over the first 2 years of the in-water construction  
32 periods with illumination-producing structures concentrated in the last in-water construction year  
33 (Figure 6-18). Temporary lighting will be distributed evenly across the Columbia River in-water  
34 demolition period (Figure 6-19).

35 The barges and temporary in-water structures will cast light at the water surface during  
36 construction and demolition in the Columbia River and North Portland Harbor. At this stage in  
37 the project design, the intensity of light likely to be cast on the water surface is not known.  
38 However, to the extent practicable, the project will implement conservation measures that  
39 minimize the effects of lighting on fish. Measures may include using directional lighting with  
40 shielded luminaires to control glare and to direct light onto work areas instead of surface waters.

October 9, 2014

Dana Mahaffey, Associate Planner  
City of Sacramento Community Development Department  
300 Richards Blvd, Third Floor  
Sacramento CA 95811  
[DMahaffey@cityofsacramento.org](mailto:DMahaffey@cityofsacramento.org)

**RE: I Street Bridge Replacement Project (SAC201401517)**

Ms. Mahaffey,

The Sacramento Metropolitan Air Quality Management District (The District) thanks the City of Sacramento for the opportunity to comment on the proposed project to replace the I Street Bridge with a multi-modal facility. The District is required by law to "represent the citizens of the Sacramento district in influencing the decisions of other public and private agencies whose actions may have an adverse impact on air quality within the Sacramento district."<sup>1</sup> We offer our comments in that spirit.

Construction Emissions

Construction of the project may result in significant emissions of criteria pollutants and precursors of primary concern. These emissions should be discussed, quantified, and disclosed in the manner described in Chapter 3 of the District's "CEQA Guide to Air Quality Assessment."<sup>2</sup> Should the project exceed District thresholds, we recommend that construction mitigation be adopted as part of the mitigation monitoring and reporting plan (Attachment).

With respect to greenhouse gas emissions generated from the construction of the project, these emissions should be discussed, quantified, and disclosed in the manner described in Chapter 6 of the District's "CEQA Guide to Air Quality Assessment." Per the guidance, the District recommends that GHG emissions be minimized during the construction phase utilizing the District's "Guidance for Construction GHG Emissions Reductions."<sup>3</sup>

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<sup>1</sup> California Health and Safety Code §40961

<sup>2</sup> <http://www.airquality.org/ceqa/ceqaguideupdate.shtml>

<sup>3</sup> <http://www.airquality.org/ceqa/ceqaguideupdate/Ch6ConstructionMitMeasures.pdf>

Consistency with existing Air Quality Management Plan

A portion of the project is located within the Railyards Specific Plan, which has construction mitigation and an operational air quality mitigation plan. All activity within the Railyards Specific Plan must be consistent with this mitigation, including paying the per acre fee on all land disturbed and the emission reduction requirements outlined in the mitigation monitoring and reporting plan.

Greenhouse Gas Emissions

Operation of the project may result in an increase in Greenhouse Gas emissions. These emissions should be discussed, quantified, and disclosed in the manner described in Chapter 6 of the District's "CEQA Guide to Air Quality Assessment." The proponents should also discuss the project's consistency with existing Greenhouse Gas reduction plans, such as the Metropolitan Transportation Plan/Sustainable Communities Strategy, the California Air Resources Board Scoping Plan and the City of Sacramento Climate Action Plan.

General comments

To summarize, the District requests that the City consider construction and operational emissions, and ensure compliance with the Railyards Specific Plan mitigation monitoring and reporting plan.

The SMAQMD thanks the City of Sacramento for the opportunity to comment on this project. If you have additional questions or require further assistance, please contact me at [pphilley@airquality.org](mailto:pphilley@airquality.org) or (916) 874-4882.

Sincerely,



Paul Philley, AICP  
Associate Air Quality Planner/Analyst  
Sacramento Metropolitan Air Quality Management District  
777 12<sup>th</sup> Street, 3<sup>rd</sup> Floor  
Sacramento, CA 95814

Attachment: Construction Mitigation

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### Basic Construction Emission Control Practices

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## **BASIC CONSTRUCTION EMISSION CONTROL PRACTICES**

The following practices are considered feasible for controlling fugitive dust from a construction site. Control of fugitive dust is required by District Rule 403 and enforced by District staff.

- **Water all exposed surfaces two times daily. Exposed surfaces include, but are not limited to soil piles, graded areas, unpaved parking areas, staging areas, and access roads.**
- **Cover or maintain at least two feet of free board space on haul trucks transporting soil, sand, or other loose material on the site. Any haul trucks that would be traveling along freeways or major roadways should be covered.**
- **Use wet power vacuum street sweepers to remove any visible trackout mud or dirt onto adjacent public roads at least once a day. Use of dry power sweeping is prohibited.**
- **Limit vehicle speeds on unpaved roads to 15 miles per hour (mph).**
- **All roadways, driveways, sidewalks, parking lots to be paved should be completed as soon as possible. In addition, building pads should be laid as soon as possible after grading unless seeding or soil binders are used.**

The following practices describe exhaust emission control from diesel powered fleets working at a construction site. California regulations limit idling from both on-road and off-road diesel powered equipment. The California Air Resources Board enforces the idling limitations.

- **Minimize idling time either by shutting equipment off when not in use or reducing the time of idling to 5 minutes [required by California Code of Regulations, Title 13, sections 2449(d)(3) and 2485]. Provide clear signage that posts this requirement for workers at the entrances to the site.**

Although not required by local or state regulation, many construction companies have equipment inspection and maintenance programs to ensure work and fuel efficiencies.

- **Maintain all construction equipment in proper working condition according to manufacturer's specifications. The equipment must be checked by a certified mechanic and determine to be running in proper condition before it is operated.**

**Lead agencies may add these emission control practices as Conditions of Approval (COA) or include in a Mitigation Monitoring and Reporting Program (MMRP).**

**ENHANCED EXHAUST CONTROL PRACTICES**

1. The project representative shall submit to the lead agency and District a comprehensive inventory of all off-road construction equipment, equal to or greater than 50 horsepower, that will be used an aggregate of 40 or more hours during any portion of the construction project.
  - The inventory shall include the horsepower rating, engine model year, and projected hours of use for each piece of equipment.
  - The project representative shall provide the anticipated construction timeline including start date, and name and phone number of the project manager and on-site foreman.
  - This information shall be submitted at least 4 business days prior to the use of subject heavy-duty off-road equipment.
  - The District's [Equipment List](#) Form can be used to submit this information.
  - The inventory shall be updated and submitted monthly throughout the duration of the project, except that an inventory shall not be required for any 30-day period in which no construction activity occurs.
2. The project representative shall provide a plan for approval by the lead agency and District demonstrating that the heavy-duty off-road vehicles (50 horsepower or more) to be used in the construction project, including owned, leased, and subcontractor vehicles, will achieve a project wide fleet-average 20% NO<sub>x</sub> reduction and 45% particulate reduction compared to the most recent California Air Resources Board (ARB) fleet average.
  - This plan shall be submitted in conjunction with the equipment inventory.
  - Acceptable options for reducing emissions may include use of late model engines, low-emission diesel products, alternative fuels, engine retrofit technology, after-treatment products, and/or other options as they become available.
  - The District's [Construction Mitigation Calculator](#) can be used to identify an equipment fleet that achieves this reduction.
3. The project representative shall ensure that emissions from all off-road diesel powered equipment used on the project site do not exceed 40% opacity for more than three minutes in any one hour.
  - Any equipment found to exceed 40 percent opacity (or Ringelmann 2.0) shall be repaired immediately.

Enhanced Exhaust Control Practices

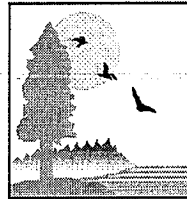
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- **Non-compliant equipment will be documented and a summary provided to the lead agency and District monthly.**
  - **A visual survey of all in-operation equipment shall be made at least weekly.**
  - **A monthly summary of the visual survey results shall be submitted throughout the duration of the project, except that the monthly summary shall not be required for any 30-day period in which no construction activity occurs. The monthly summary shall include the quantity and type of vehicles surveyed as well as the dates of each survey.**
- 4. The District and/or other officials may conduct periodic site inspections to determine compliance. Nothing in this mitigation shall supercede other District, state or federal rules or regulations.**



**CALIFORNIA STATE LANDS COMMISSION**

100 Howe Avenue, Suite 100-South  
Sacramento, CA 95825-8202



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**Contact Phone: (916) 574-1890**  
**Contact FAX: (916) 574-1885**

October 16, 2014

File Ref: SCH # 2014092069

Dana Mahaffey  
City of Sacramento  
300 Richards Blvd., 3<sup>rd</sup> Floor  
Sacramento, CA 95811

**Subject: Notice of Preparation (NOP) for an Environmental Impact Report (EIR)  
for the I Street Bridge Replacement Project, Sacramento and Yolo  
County**

Dear Ms. Mahaffey:

The California State Lands Commission (CSLC) staff has reviewed the subject NOP for an EIR for the I Street Bridge Replacement Project (Project), which is being prepared by the city of Sacramento (City). The City, as a California public agency proposing to carry out the Project, is the lead agency under the California Environmental Quality Act (CEQA) (Pub. Resources Code, § 21000 et seq.). The CSLC is a trustee agency for projects that could directly or indirectly affect sovereign lands and their accompanying Public Trust resources or uses. Additionally, because the Project involves work on sovereign lands, the CSLC will act as a responsible agency. CSLC staff requests that City consult with us on preparation of the Draft EIR as required by CEQA section 21153, subdivision (a), and the State CEQA Guidelines section 15086, subdivisions (a)(1) and (a)(2).

**CSLC Jurisdiction and Public Trust Lands**

The CSLC has jurisdiction and management authority over all ungranted tidelands, submerged lands, and the beds of navigable lakes and waterways. The CSLC also has certain residual and review authority for tidelands and submerged lands legislatively granted in trust to local jurisdictions (Pub. Resources Code, §§ 6301, 6306). All tidelands and submerged lands, granted or ungranted, as well as navigable lakes and waterways, are subject to the protections of the Common Law Public Trust.

As general background, the State of California acquired sovereign ownership of all tidelands and submerged lands and beds of navigable lakes and waterways upon its admission to the United States in 1850. The State holds these lands for the benefit of

all people of the State for statewide Public Trust purposes, which include but are not limited to waterborne commerce, navigation, fisheries, water-related recreation, habitat preservation, and open space. On navigable non-tidal waterways, including lakes, the State holds fee ownership of the bed of the waterway landward to the ordinary low water mark and a Public Trust easement landward to the ordinary high water mark, except where the boundary has been fixed by agreement or a court. Such boundaries may not be readily apparent from present day site inspections.

After reviewing the information contained in the NOP, CSLC staff has determined the Project will be located along areas of the natural bed of the Sacramento River on State-owned sovereign land under the jurisdiction of the CSLC. Therefore, a lease from the CSLC will be required for the City to implement the Project on sovereign lands; please contact Wendy Hall (see contact information below) for further information about the extent of the CSLC's sovereign ownership and leasing requirements.

These comments are made without prejudice to any future assertion of State ownership or public rights, should circumstances change, or should additional information become available. This letter is not intended, nor should it be construed as a waiver or limitation of any right, title, or interest of the State of California in any lands under its jurisdiction.

### **Project Description**

The City is proposing a new I Street Bridge to be constructed just north of the existing I Street Bridge, to fulfill improved access for waterfront uses and circulation between the cities of Sacramento and West Sacramento. The Project area is located in both the city of Sacramento and the city of West Sacramento, and the new bridge will cross the Sacramento River between the Sacramento Railyards and the West Sacramento Washington planned developments.

In 2011, the cities completed the Sacramento River Crossings Alternatives Study, which identified the purpose and need for new bridge crossings. The study concluded that a North Market crossing was needed to replace the I Street Bridge. The I Street Bridge is 100 years old, the lanes are too narrow to serve buses, there are no bicycle lanes, and sidewalks are too narrow to meet accessibility standards. The Project is expected to meet the objectives and needs of both cities as follows:

- Improve mobility for motorists, bicyclists and pedestrians;
- Promote economic development; and
- Provide improved access to the Sacramento River waterfront.

From the Project Description, CSLC staff understands that the Project would include the following components:

- A new bridge connecting C Street in West Sacramento to Railyards Boulevard in Sacramento for vehicle, bicycle, and pedestrian crossing;
- A moveable center span to allow passage of watercraft;
- New signalized intersections at Jibboom Street and Bercut Drive connecting at Railyards Boulevard, and the extension of C Street from the intersection of 3<sup>rd</sup> Street to the proposed bridge;

- Continuance of the existing I Street Bridge for railroad use only, with discontinuance of vehicle and pedestrian access; and
- Demolition of existing roadway approach structures for the I Street Bridge for Jibboom Street, I Street, and J Street in Sacramento, and C Street in West Sacramento.

### Environmental Review

CSLC staff requests that the city consider the following comments when preparing the Draft EIR.

#### General Comments

1. Project Description: A thorough and complete Project Description should be included in the Draft EIR in order to facilitate meaningful environmental review of potential impacts, mitigation measures, and alternatives. In particular, provide a thorough description with illustrations of all proposed work below the mean high tide line, including:
  - Construction of bridge support structures, dewatering and containment structures, dredging operations, water quality BMPs, construction methodology, and topographic construction plans drawn to scale;
  - A visual simulation of the new bridge as viewed from southbound Interstate 5 just north of the bridge location;
  - A description of interrupted recreation access to the Sacramento River and adjacent bike trails;
  - A description of any levee construction work and potential disruption of utility services and easement access;
  - A description of impacts to watercraft navigation and commerce during bridge construction;
  - A restoration plan to mitigate impacts for aquatic and terrestrial habitats and species; and
  - A construction schedule with description of proposed construction equipment, exterior lighting, and locations of staging areas.

Thorough descriptions will facilitate CSLC staff's determination of the extent and locations of its leasing jurisdiction, make for a more robust analysis of the work that may be performed, and minimize the potential for subsequent environmental analysis to be required.

#### Biological Resources

2. The Draft EIR should disclose and analyze all potentially significant effects on sensitive species and habitats in and around the Project area, including special-status wildlife, fish, and plants, and if appropriate, identify feasible mitigation

measures to reduce those impacts. The City should conduct queries of the California Department of Fish and Wildlife's (CDFW) California Natural Diversity Database (CNDDDB) and U.S. Fish and Wildlife Service's (USFWS) Special Status Species Database to identify any special-status plant or wildlife species that may occur in the Project area. The Draft EIR should also include a discussion of consultation with the CDFW, USFWS, and National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS), including any recommended mitigation measures and potentially required permits identified by these agencies. In particular, provide a thorough description of all construction activities with potential to:

- Cause entrapment of fish species through in-channel construction area dewatering and containment activities;
- Adversely affect riverbank vegetation;
- Import or contribute to the spread of non-native invasive species (see below); and/or
- Impede fish passage.

One of the major stressors in California waterways is introduced species. Therefore, the Draft EIR should consider the Project's potential to encourage the establishment or proliferation of aquatic invasive species (AIS) such as the quagga mussel, or other nonindigenous, invasive species including aquatic and terrestrial plants. For example, construction boats and barges brought in from long stays at distant projects may transport new species to the Project area via hull biofouling, wherein marine and aquatic organisms attach to and accumulate on the hull and other submerged parts of a vessel. If the analysis in the Draft EIR finds potentially significant AIS impacts, possible mitigation could include contracting vessels and barges from nearby, or requiring contractors to perform a certain degree of hull-cleaning. The CDFW's Invasive Species Program could assist with this analysis as well as with the development of appropriate mitigation (information at [www.dfg.ca.gov/invasives/](http://www.dfg.ca.gov/invasives/)).

In addition, in light of the recent decline of native pelagic organisms and in order to protect at-risk fish species, the Draft EIR should examine if any elements of the Project (e.g., changes in bankside vegetative cover) would favor non-native fisheries within the Sacramento River and its tributaries.

3. Construction/Pile Driving Noise: The Draft EIR should also evaluate potential adverse noise and vibration impacts on fish and birds from construction, restoration activities in the water and on the levees, and for land-side supporting structures. In particular, pile driving activities are known to cause barotrauma to fish when underwater sound pressure level thresholds are exceeded. Mitigation measures could include species-specific work windows, use of vibratory rather than impact hammers, or deployment of noise curtains, as may be recommended by CDFW, USFWS, and NMFS. Again, staff recommends early consultation with these agencies to minimize the impacts of the Project on sensitive species.

### Climate Change

4. Greenhouse Gases: A greenhouse gas (GHG) emissions analysis consistent with the California Global Warming Solutions Act (Assembly Bill [AB] 32) and required by the State CEQA Guidelines should be included in the Draft EIR. This analysis should identify a threshold for significance for GHG emissions, calculate the level of GHGs that will be emitted as a result of construction of all parts of the Project, determine the significance of the impacts of those emissions, and, if impacts are significant, identify mitigation measures that would reduce them to the extent feasible. For the proposed Project, a myriad of diesel fueled equipment and vehicles are likely required for bridge construction and demolition of existing structures. A comprehensive inventory of all GHG emission source equipment should be developed with estimated levels of produced emissions. Early consultation with the Sacramento Metropolitan Air Quality Management District is recommended for development of a GHG threshold of significance and incorporation of mitigation measures to reduce emissions.

Sea Level Rise: The Draft EIR should discuss the Project as it relates to climate change and sea level rise. This discussion should include both the potential effects of an incremental increase in the ordinary low and high water marks resulting from rising seas as well as a discussion of potential seasonal river flow changes resulting from changes in Sierra snowmelt patterns. If applicable, the Draft EIR should disclose what design elements will be included for the in-channel support structures to ensure they will not impede flows or reduce in-channel capacity for flood control under this future scenario.

### Cultural Resources

5. Submerged Resources: The Draft EIR should evaluate potential impacts to submerged cultural resources in the Project area. The CSLC maintains a shipwrecks database that can assist with this analysis. CSLC staff requests that the City contact Assistant Chief Counsel Pam Griggs (see contact information below) to obtain shipwrecks data from the database and CSLC records for the Project site. The database includes known and potential vessels located on the State's tide and submerged lands; however, the locations of many shipwrecks remain unknown. Please note that any submerged archaeological site or submerged historic resource that has remained in State waters for more than 50 years is presumed to be significant. Because of this possibility, please add a mitigation measure requiring that in the event cultural resources are discovered during any construction activities, Project personnel shall halt all activities in the immediate area and notify a qualified archaeologist to determine the appropriate course of action.

Title to Resources: The Draft EIR should also mention that the title to all abandoned shipwrecks and archaeological sites on or in the tide and submerged lands of California is vested in the State and under the jurisdiction of the CSLC. CSLC staff requests that the city consult with Assistant Chief Counsel Pam Griggs (see contact information below), should these resources on State lands be discovered during construction of the proposed Project.

## Hydrology and Water Quality

6. Hydrology and Flood Protection: Construction of bridge support structures within the active channel will result in a new alteration to channel flows and sedimentation processes. The Draft EIR should provide an analysis of how in-channel support structures are designed to minimize these impacts and any impacts that have potential to occur. Bridge support structures also have potential to reduce channel volume flood control capacity and cause additional stress on levee systems. The City should consider a bridge design with minimum structural volume necessary for support structures within the levees to achieve Project objectives. Early consultation with Sacramento Area Flood Control Association is recommended for bridge design and mitigation measures to reduce impacts on channel volume flood control capacity and levee systems.
7. Mercury/Methylmercury: The Project study area includes the Sacramento River. For those portions of the project involving in-water work, CSLC staff requests that the Draft EIR include sediment quality testing and avoidance and minimization measures prior to dredging to reduce potential release of mercury and other toxins into the aquatic environment.

On April 22, 2010, the Central Valley Regional Water Quality Control Board (CVRWQCB) identified the CSLC as both a State agency that manages open water areas in the Sacramento-San Joaquin Delta Estuary and a nonpoint source discharger of methylmercury (Resolution No. R5-2010-0043), because subsurface lands under the CSLC's jurisdiction are impacted by mercury from legacy mining activities dating back to California's Gold Rush. Pursuant to a CVRWQCB Total Maximum Daily Load (TMDL), the CVRWQCB is requiring the CSLC to fund studies to identify potential methylmercury control methods in the Delta and to participate in an Exposure Reduction Program. The goal of the studies is to evaluate existing control methods and evaluate options to reduce methylmercury in open waters under jurisdiction of the CSLC. Any action taken that may result in mercury or methylmercury suspension within the Sacramento-San Joaquin Delta Estuary may affect the CSLC's efforts to comply with the CVRWQCB TMDL.

## Aesthetics

8. Aesthetics: The new bridge will have a substantial new visual presence within the river channel and to adjacent Sacramento and West Sacramento land uses. In particular, southbound Interstate 5 just south of the American River confluence provides a significant gateway view to downtown Sacramento, the Sacramento River, and West Sacramento, where the new bridge will have a prominent visual presence. As such, the architectural style of the bridge is critically important and should attempt to serve as a future landmark of City identity. Architectural elements, such as visual design, color, scale, orientation, and glare will need to be carefully selected to minimize scenic impacts. The City should prepare a visual simulation of the new bridge from sensitive scenic locations where viewsheds will be impacted, such as the adjacent Interstate 5, to select a location of least visual impact.

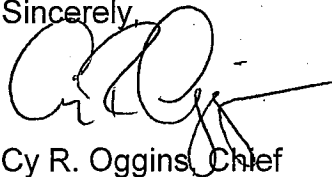
Mandatory Findings of Significance

9. Cumulative Impacts: The Draft EIR should consider whether the combined impacts of other current and future projects in the Project vicinity have potential to result in cumulatively considerable impacts on Sacramento River public trust resources, such as recreation public access, watercraft navigation, waterfront uses, natural resources, public commerce, open space, restoration activities, etc. Other projects in the vicinity could include the new downtown arena, Sacramento Railyards projects, and other current and probable future projects in West Sacramento.

Thank you for the opportunity to comment on the NOP for the Project. As a trustee and responsible agency, the CSLC requests that you consult with us on this Project and keep us advised of changes to the Project description and all other important developments. Please send additional information on the Project to the CSLC staff listed below as the EIR is being prepared.

Please refer questions concerning environmental review to Jason Ramos, Senior Environmental Scientist, at (916) 574-1814 or via e-mail at [jason.ramos@slc.ca.gov](mailto:jason.ramos@slc.ca.gov). For questions concerning archaeological or cultural resources under CSLC jurisdiction, please contact Assistant Chief Counsel Pam Griggs at (916) 574-1854 or via email at [Pamela.Griggs@slc.ca.gov](mailto:Pamela.Griggs@slc.ca.gov). For questions concerning CSLC leasing jurisdiction, please contact Wendy Hall, Public Land Management Specialist, at (916) 574-0994, or via email at [wendy.hall@slc.ca.gov](mailto:wendy.hall@slc.ca.gov).

Sincerely,



Cy R. Oggins, Chief  
Division of Environmental Planning  
and Management

cc: Office of Planning and Research  
LMD, W. Hall  
DEPM, J. Ramos  
Legal, P. Griggs

**From:** [Jesse Gothan](#)  
**To:** [Dana Mahaffey](#); [Bromund, Claire](#); [Rob Himes](#); [Zach Siviglia](#); [Ciara Zanze \(czanze@aimconsultingco.com\)](#); [Gladys Cornell](#)  
**Cc:** [Luken, Mike](#)  
**Subject:** FW: Comments on I Street Bridge Replacement Project Scoping Meeting  
**Date:** Friday, October 17, 2014 9:01:33 AM

---

This NOP comment just arrived. -Jesse

**From:** timcastleman@gmail.com [mailto:timcastleman@gmail.com] **On Behalf Of** Practical Cycle Tim  
**Sent:** Friday, October 17, 2014 8:54 AM  
**To:** Steve Hansen; Jim Brown; James E. Houpt; Jesse Gothan  
**Subject:** Comments on I Street Bridge Replacement Project Scoping Meeting

I attended the October 9 event for a short time and was pleased to see the plan includes a bike trail to go under the new roadway to retain the continuous bike path to and from Old Sacramento.

It is important that bikes are not forced to a stop to cross the new roadway.

In view of the vision for a connected "Loop" defined in the 2003 Riverfront Master Plan, planning MUST include the connection through Old Sacramento to Tower Bridge. I was disappointed to see that the City still has NO PLAN for improvements to the bike trail through Old Sacramento.

This vital segment of the [Sacramento River Parkway](#) on the waterfront between the Tower bridge and the I Street railroad bridge would connect Sacramento and the Bay Area via the [Great California Delta Trail](#). This "gap" also blocks riders from connecting to the [American River Parkway](#) and denies access to the Historic Riverfront Area for those with disabilities.

To ensure these problems are addressed we are asking the City of Sacramento to include improvements to the bike path from the Tower bridge to the I street railroad bridge, including a safe railroad crossing at J Street, a widened and leveled path, with a smooth surface and room for all users, as part of the Old Sacramento Infrastructure (Riverfront Boardwalk) project and the I Street Bridge Replacement project.

Please use this email as my public comment instead of the brief note on the postcard I returned.

Thank you,

Tim Castleman  
Practical Cycle





**Central Valley Regional Water Quality Control Board**

17 October 2014

Dana Mahaffey  
City of Sacramento  
300 Richards Blvd, 3<sup>rd</sup> Floor  
Sacramento, CA 95811

CERTIFIED MAIL  
7014 1200 0000 7154 3045

**COMMENTS TO NOTICE OF PREPARATION FOR THE DRAFT ENVIRONMENTAL IMPACT REPORT, I STREET BRIDGE REPLACEMENT PROJECT: A NEW BRIDGE OVER THE SACRAMENTO RIVER PROJECT, SCH NO. 2014092069, SACRAMENTO & YOLO COUNTIES**

Pursuant to the State Clearinghouse's 22 September 2014 request, the Central Valley Regional Water Quality Control Board (Central Valley Water Board) has reviewed the *Notice of Preparation for the Draft Environmental Impact Report* for the I Street Bridge Replacement Project: A New Bridge over the Sacramento River Project, located in Sacramento & Yolo Counties.

Our agency is delegated with the responsibility of protecting the quality of surface and groundwaters of the state; therefore our comments will address concerns surrounding those issues.

**Construction Storm Water General Permit**

Dischargers whose project disturb one or more acres of soil or where projects disturb less than one acre but are part of a larger common plan of development that in total disturbs one or more acres, are required to obtain coverage under the General Permit for Storm Water Discharges Associated with Construction Activities (Construction General Permit), Construction General Permit Order No. 2009-009-DWQ. Construction activity subject to this permit includes clearing, grading, grubbing, disturbances to the ground, such as stockpiling, or excavation, but does not include regular maintenance activities performed to restore the original line, grade, or capacity of the facility. The Construction General Permit requires the development and implementation of a Storm Water Pollution Prevention Plan (SWPPP).

For more information on the Construction General Permit, visit the State Water Resources Control Board website at:  
[http://www.waterboards.ca.gov/water\\_issues/programs/stormwater/constpermits.shtml](http://www.waterboards.ca.gov/water_issues/programs/stormwater/constpermits.shtml).

### **Clean Water Act Section 401 Permit – Water Quality Certification**

If an USACOE permit (e.g., Non-Reporting Nationwide Permit, Nationwide Permit, Letter of Permission, Individual Permit, Regional General Permit, Programmatic General Permit), or any other federal permit (e.g., Section 9 from the United States Coast Guard), is required for this project due to the disturbance of waters of the United States (such as streams and wetlands), then a Water Quality Certification must be obtained from the Central Valley Water Board prior to initiation of project activities. There are no waivers for 401 Water Quality Certifications.

### **Waste Discharge Requirements**

If USACOE determines that only non-jurisdictional waters of the State (i.e., "non-federal" waters of the State) are present in the proposed project area, the proposed project will require a Waste Discharge Requirement (WDR) permit to be issued by Central Valley Water Board. Under the California Porter-Cologne Water Quality Control Act, discharges to all waters of the State, including all wetlands and other waters of the State including, but not limited to, isolated wetlands, are subject to State regulation.

For more information on the Water Quality Certification and WDR processes, visit the Central Valley Water Board website at:

[http://www.waterboards.ca.gov/centralvalley/help/business\\_help/permit2.shtml](http://www.waterboards.ca.gov/centralvalley/help/business_help/permit2.shtml).

### **Regulatory Compliance for Commercially Irrigated Agriculture**

If the property will be used for commercial irrigated agricultural, the discharger will be required to obtain regulatory coverage under the Irrigated Lands Regulatory Program.

There are two options to comply:

1. **Obtain Coverage Under a Coalition Group.** Join the local Coalition Group that supports land owners with the implementation of the Irrigated Lands Regulatory Program. The Coalition Group conducts water quality monitoring and reporting to the Central Valley Water Board on behalf of its growers. The Coalition Groups charge an annual membership fee, which varies by Coalition Group. To find the Coalition Group in your area, visit the Central Valley Water Board's website at: [http://www.waterboards.ca.gov/centralvalley/water\\_issues/irrigated\\_lands/app\\_approval/index.shtml](http://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/app_approval/index.shtml); or contact water board staff at (916) 464-4611 or via email at [IrrLands@waterboards.ca.gov](mailto:IrrLands@waterboards.ca.gov).
2. **Obtain Coverage Under the General Waste Discharge Requirements for Individual Growers, General Order R5-2013-0100.** Dischargers not participating in a third-party group (Coalition) are regulated individually. Depending on the specific site conditions, growers may be required to monitor runoff from their property, install monitoring wells, and submit a notice of intent, farm plan, and other action plans regarding their actions to comply with their General Order. Yearly costs would include State administrative fees (for example, annual fees for farm sizes from 10-100 acres are currently \$1,084 + \$6.70/Acre); the cost to prepare annual monitoring reports; and water quality monitoring costs. To enroll as an Individual Discharger under the Irrigated Lands Regulatory

Program, call the Central Valley Water Board phone line at (916) 464-4611 or e-mail board staff at [IrrLands@waterboards.ca.gov](mailto:IrrLands@waterboards.ca.gov).

**Low or Limited Threat General NPDES Permit**

If the proposed project includes construction dewatering and it is necessary to discharge the groundwater to waters of the United States, the proposed project will require coverage under a National Pollutant Discharge Elimination System (NPDES) permit. Dewatering discharges are typically considered a low or limited threat to water quality and may be covered under the General Order for *Dewatering and Other Low Threat Discharges to Surface Waters* (Low Threat General Order) or the General Order for *Limited Threat Discharges of Treated/Untreated Groundwater from Cleanup Sites, Wastewater from Superchlorination Projects, and Other Limited Threat Wastewaters to Surface Water* (Limited Threat General Order). A complete application must be submitted to the Central Valley Water Board to obtain coverage under these General NPDES permits.

For more information regarding the Low Threat General Order and the application process, visit the Central Valley Water Board website at:  
[http://www.waterboards.ca.gov/centralvalley/board\\_decisions/adopted\\_orders/general\\_orders/r5-2013-0074.pdf](http://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/general_orders/r5-2013-0074.pdf)

For more information regarding the Limited Threat General Order and the application process, visit the Central Valley Water Board website at:  
[http://www.waterboards.ca.gov/centralvalley/board\\_decisions/adopted\\_orders/general\\_orders/r5-2013-0073.pdf](http://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/general_orders/r5-2013-0073.pdf)

If you have questions regarding these comments, please contact me at (916) 464-4684 or [tcleak@waterboards.ca.gov](mailto:tcleak@waterboards.ca.gov).



Trevor Cleak  
Environmental Scientist

cc: State Clearinghouse Unit, Governor's Office of Planning and Research, Sacramento



October 21, 2014

Dana Mahaffey, Associate Planner  
City of Sacramento Community Development Department  
300 Richards Blvd., Third Floor, Sacramento, CA 95811  
DMahaffey@cityofsacramento.org

Subject: Notice of Preparation of an Environmental Impact Report for the I Street Bridge Replacement Project

Dear Ms. Mahaffey,

The Sacramento Municipal Utility District (SMUD) appreciates the opportunity to provide comments on the Notice of Preparation (NOP) of an Environmental Impact Report for the I Street Bridge Replacement Project. SMUD is the primary energy provider for Sacramento County and the proposed project location. SMUD's vision is to empower our customers with solutions and options that increase energy efficiency, protect the environment, reduce global warming, and lower the cost to serve our region. As a Responsible Agency, SMUD aims to ensure that the proposed project limits the potential for significant environmental effects on SMUD facilities, employees, and customers.

It is our desire that the I Street Bridge Replacement Project will acknowledge any project impacts related to the following:

- Overhead and or underground transmission and distribution line easements
- Electrical load needs/ requirements
- Energy Efficiency
- Utility line routing
- Climate Change

SMUD would like to be involved in discussing these issues as early as possible. We aim to be partners in the efficient and sustainable delivery of the proposed project. Please ensure that the information included in this response is conveyed to the project planners and the appropriate project proponents.

Environmental leadership is a core value of SMUD and we look forward to collaborating with you on this project. Again, we appreciate the opportunity to provide input on the NOP. If you have any questions regarding this letter, please contact Rob Ferrera, SMUD Environmental Specialist at (916) 732-6676.

Sincerely,

A handwritten signature in black ink, appearing to read 'Rob Ferrera', with a long horizontal line extending to the right.

Rob Ferrera  
Environmental Specialist  
Environmental Management  
Legislative & Regulatory Affairs  
Sacramento Municipal Utility District

Cc: Pat Durham  
Beth Tincher  
Steve Johns  
Joseph Schofield



10/21/2014

VIA EMAIL

Dana Mahaffey, Associate Planner  
City of Sacramento Community Development Department  
300 Richards Blvd., Third Floor  
Sacramento, CA 95811

**RE: Notice of Preparation of an Environmental Impact Report for the proposed I Street Bridge Replacement Project**

Dear Ms. Mahaffey:

WALKSacramento has reviewed the Notice of Preparation of an Environmental Impact Report for the I Street Bridge Replacement Project. We offer the following comments on the scope of the EIR.

Walking provides many benefits to individuals and the public, among which are improved physical health and mobility. Walking, instead of driving, between Sacramento and West Sacramento can help people attain the minimum-recommended physical activity of thirty minutes of moderate exercise per day, and it can reduce the demand for vehicle crossings on the proposed bridge replacement and the existing and new roadways connecting to the bridge.

In order to fully evaluate the impacts of the proposed bridge replacement on pedestrians, the EIR should consider changes to pedestrian mobility and safety that occur due to construction and operation of the bridge. Mobility evaluation could include pedestrian travel time between the 3<sup>rd</sup> Street/C Street intersection in West Sacramento and the 2<sup>nd</sup> Street/I Street intersection in Sacramento. Because the bridge landing point on the Sacramento side changes considerably with the new bridge, travel times to several destinations could also be calculated to evaluate overall mobility. Safety of pedestrians on sidewalks should be considered if there is mixing of pedestrians and bicyclists. Pedestrian safety should also be considered in respect to changes to new or additional intersection and road crossings required to complete walking trips. Wider roadways with longer crossing times, greater crossing distances and less frequent crossing opportunities can put pedestrians at greater risk to vehicle collisions.

WALKSacramento is working to support increased physical activity such as walking and bicycling in local neighborhoods as well as helping to create community environments that support walking and bicycling. The benefits include improved physical fitness, less motor vehicle traffic congestion, better air quality, and a stronger sense of cohesion and safety in local neighborhoods.

Thank you for your consideration of these comments and recommendations. If you have questions or need additional information, please contact me at (916) 446-9255 or [cholm@walksacramento.org](mailto:cholm@walksacramento.org).

Sincerely,

Chris Holm  
Project Analyst



October 21, 2014

Ms. Dana Mahaffey, Associate Planner  
City of Sacramento  
Community Development Department  
300 Richards Boulevard 3<sup>rd</sup> Floor  
Sacramento, CA 95811

**Re: RESPONSE TO NOTICE OF PREPARATION OF AN ENVIRONMENTAL  
IMPACT REPORT FOR THE I-STREET BRIDGE REPLACEMENT PROJECT:  
A NEW BRIDGE OVER THE SACRAMENTO RIVER (IDENTIFIED BY THE  
U.S. COAST GUARD AS THE "C STREET BRIDGE") SCH # 2014092069**

Dear Ms. Mahaffey:

Thank you for the Notice of Preparation ("NOP") of an Environmental Impact Report ("EIR") for the I-Street Bridge Replacement Project: a new bridge over the Sacramento River (identified by the U.S. Coast Guard as the "C-Street Bridge") ("Project").

The proposed project, as described in the NOP, has the potential to impact the West Sacramento Project – West Sacramento's flood risk reduction plans to achieve the state-mandated 200-year level of flood protection. These potential impacts include, but are not necessarily limited to: geology & soils; hydrology & water quality; and recreation. As your Project moves forward, we request the project design and EIR consider both the impacts to the existing levee and the future flood risk reduction improvements. More specifically, we request your Project incorporate levee improvements, or be compatible with the future levee improvements.

Thank you for the opportunity to review and comment on the NOP. We appreciate the Project's purpose and beneficial impact it will have for both cities. If you have any questions about our comments, please contact me at (916) 617-4850 or via e-mail at [gregf@CityofWestSacramento.org](mailto:gregf@CityofWestSacramento.org).

Sincerely,

A handwritten signature in black ink, appearing to read "A. Fabun", is written over a light blue background.

Greg Fabun  
Flood Protection Manager

cc: Mike Luken, Transportation Manager, City of West Sacramento  
Denix Anbiah, Director of Public Works, City of West Sacramento





October 21, 2014

Dana Mahaffey, Associate Planner  
City of Sacramento, Community Development Department  
Environmental Planning Services  
300 Richards Boulevard, Third Floor  
Sacramento, CA 95811-0218  
[DMahaffey@cityofsacramento.org](mailto:DMahaffey@cityofsacramento.org)

Subject: Notice of Preparation (NOP) of an Environmental Impact Report (EIR) for the I Street Bridge Replacement Project

Dear Ms. Mahaffey:

Thank you for the opportunity to comment on the subject NOP. We greatly appreciate that the Cities of Sacramento and West Sacramento are planning to build a new low-level, neighborhood friendly bridge across the Sacramento River. The new bridge will help address the critical lack of convenient and safe crossings of the river for bicyclists and allow many more people to use bicycles for trips to jobs, shopping, entertainment, or the Sacramento Valley Station. We believe the bicycle facilities on the bridge should be designed for the large proportion of the population (~60%) that is interested in bicycling but concerned about interacting with high speeds or volumes of vehicle traffic (Mekuria et al. 2012).

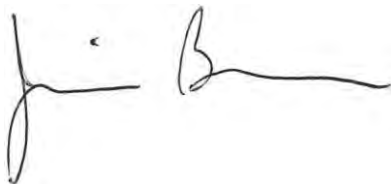
To assist the City of Sacramento in achieving the goals of its Climate Action Plan, every project should make it possible for its residents, employees, and visitors to safely and conveniently take more trips by bicycle. The proposed project will cause a significant adverse effect on the environment if it will not adequately provide access by bicycle for the majority of our population. Therefore the project must be designed and constructed to be friendly for bicyclists of all ages and abilities:

- Either the bridge must be designed for not more than 30 mph vehicle traffic or, if vehicle speed limit is intended to be greater, vehicle lanes must be separated from bicycle lanes (e.g. with buffers that are painted and delineated with flexible bollards)
- Vehicle parking should not be placed alongside the bicycle lanes to prevent the hazard of car doors being opened in front of bicyclists (if vehicle parking is designed on the bridge and/or its approaches, ensure the combined width of parking lane and bicycle lane is at least 14 ft)
- Traffic control devices should be installed at the intersections of the bridge with Jibboom Street in Sacramento and at 2<sup>nd</sup> St in West Sacramento to ensure vehicle speeds do not exceed 30 mph
- Convenient connections between the bicycle lanes across the bridge and the river front bicycle paths must be provided on both sides of the river.

SABA works to ensure that bicycling is safe, convenient, and desirable for everyday transportation. Bicycling is the healthiest, cleanest, cheapest, quietest, most energy efficient, and least congesting form of transportation.

Thank you for considering our comments.

Sincerely,

A handwritten signature in black ink, appearing to read "Jim Brown". The signature is written in a cursive style with a large, looped initial "J" and a long horizontal stroke extending to the right.

Jim Brown  
Executive Director

CC: Paul Philley, SMAQMD ([pphilley@airquality.org](mailto:pphilley@airquality.org))  
Ed Cox, City of Sacramento Alternative Modes Coordinator ([ecox@cityofsacramento.org](mailto:ecox@cityofsacramento.org))

## Species Lists



# United States Department of the Interior



## FISH AND WILDLIFE SERVICE

Sacramento Fish and Wildlife Office

FEDERAL BUILDING, 2800 COTTAGE WAY, ROOM W-2605

SACRAMENTO, CA 95825

PHONE: (916)414-6600 FAX: (916)414-6713

Consultation Code: 08ESMF00-2015-SLI-0340

April 17, 2015

Event Code: 08ESMF00-2015-E-01724

Project Name: I Street Bridge Replacement

Subject: List of threatened and endangered species that may occur in your proposed project location, and/or may be affected by your proposed project

### To Whom It May Concern:

The enclosed species list identifies threatened, endangered, proposed and candidate species, as well as proposed and final designated critical habitat, under the jurisdiction of the U.S. Fish and Wildlife Service (Service) that may occur within the boundary of your proposed project and/or may be affected by your proposed project. The species list fulfills the requirements of the Service under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 *et seq.*).

Please follow the link below to see if your proposed project has the potential to affect other species or their habitats under the jurisdiction of the National Marine Fisheries Service:

[http://www.nwr.noaa.gov/protected\\_species/species\\_list/species\\_lists.html](http://www.nwr.noaa.gov/protected_species/species_list/species_lists.html)

New information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. Please feel free to contact us if you need more current information or assistance regarding the potential impacts to federally proposed, listed, and candidate species and federally designated and proposed critical habitat. Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. This verification can be completed formally or informally as desired. The Service recommends that verification be completed by visiting the ECOS-IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested through the ECOS-IPaC system by completing the same process used to receive the enclosed list.

The purpose of the Act is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Under sections 7(a)(1) and 7(a)(2)

of the Act and its implementing regulations (50 CFR 402 *et seq.*), Federal agencies are required to utilize their authorities to carry out programs for the conservation of threatened and endangered species and to determine whether projects may affect threatened and endangered species and/or designated critical habitat.

A Biological Assessment is required for construction projects (or other undertakings having similar physical impacts) that are major Federal actions significantly affecting the quality of the human environment as defined in the National Environmental Policy Act (42 U.S.C. 4332(2) (c)). For projects other than major construction activities, the Service suggests that a biological evaluation similar to a Biological Assessment be prepared to determine whether the project may affect listed or proposed species and/or designated or proposed critical habitat. Recommended contents of a Biological Assessment are described at 50 CFR 402.12.

If a Federal agency determines, based on the Biological Assessment or biological evaluation, that listed species and/or designated critical habitat may be affected by the proposed project, the agency is required to consult with the Service pursuant to 50 CFR 402. In addition, the Service recommends that candidate species, proposed species and proposed critical habitat be addressed within the consultation. More information on the regulations and procedures for section 7 consultation, including the role of permit or license applicants, can be found in the "Endangered Species Consultation Handbook" at:

<http://www.fws.gov/endangered/esa-library/pdf/TOC-GLOS.PDF>

Please be aware that bald and golden eagles are protected under the Bald and Golden Eagle Protection Act (16 U.S.C. 668 *et seq.*), and projects affecting these species may require development of an eagle conservation plan ([http://www.fws.gov/windenergy/eagle\\_guidance.html](http://www.fws.gov/windenergy/eagle_guidance.html)). Additionally, wind energy projects should follow the wind energy guidelines (<http://www.fws.gov/windenergy/>) for minimizing impacts to migratory birds and bats.

Guidance for minimizing impacts to migratory birds for projects including communications towers (e.g., cellular, digital television, radio, and emergency broadcast) can be found at: <http://www.fws.gov/migratorybirds/CurrentBirdIssues/Hazards/towers/towers.htm>; <http://www.towerkill.com>; and <http://www.fws.gov/migratorybirds/CurrentBirdIssues/Hazards/towers/comtow.html>.

We appreciate your concern for threatened and endangered species. The Service encourages Federal agencies to include conservation of threatened and endangered species into their project planning to further the purposes of the Act. Please include the Consultation Tracking Number in the header of this letter with any request for consultation or correspondence about your project that you submit to our office.

The table below outlines lead FWS field offices by county and land ownership/project type. Please refer to this table when you are ready to coordinate (including requests for section 7 consultation) with the field office corresponding to your project, and send any documentation regarding your project to that corresponding office. Therefore, the lead FWS field office may not be the office listed above in the letterhead. Please visit our office's website (<http://www.fws.gov/sacramento>) to view a map of office jurisdictions.

### Lead FWS offices by County and Ownership/Program

<b>County</b>	<b>Ownership/Program</b>	<b>Species</b>	<b>Office Lead*</b>
<b>Alameda</b>	Tidal wetlands/marsh adjacent to Bays	Salt marsh species, delta smelt	BDFWO
<b>Alameda</b>	All ownerships but tidal/estuarine	All	SFWO
<b>Alpine</b>	Humboldt Toiyabe National Forest	All	RFWO
<b>Alpine</b>	Lake Tahoe Basin Management Unit	All	RFWO
<b>Alpine</b>	Stanislaus National Forest	All	SFWO
<b>Alpine</b>	El Dorado National Forest	All	SFWO
<b>Colusa</b>	Mendocino National Forest	All	AFWO
<b>Colusa</b>	Other	All	By jurisdiction (see map)
<b>Contra Costa</b>	Legal Delta (Excluding ECCHCP)	All	BDFWO
<b>Contra Costa</b>	Antioch Dunes NWR	All	BDFWO
<b>Contra Costa</b>	Tidal wetlands/marsh adjacent to Bays	Salt marsh species, delta smelt	BDFWO
<b>Contra Costa</b>	All ownerships but tidal/estuarine	All	SFWO

<b>El Dorado</b>	El Dorado National Forest	All	SFWO
<b>El Dorado</b>	LakeTahoe Basin Management Unit		RFWO
<b>Glenn</b>	Mendocino National Forest	All	AFWO
<b>Glenn</b>	Other	All	By jurisdiction (see map)
<b>Lake</b>	Mendocino National Forest	All	AFWO
<b>Lake</b>	Other	All	By jurisdiction (see map)
<b>Lassen</b>	Modoc National Forest	All	KFWO
<b>Lassen</b>	Lassen National Forest	All	SFWO
<b>Lassen</b>	Toiyabe National Forest	All	RFWO
<b>Lassen</b>	BLM Surprise and Eagle Lake Resource Areas	All	RFWO
<b>Lassen</b>	BLM Alturas Resource Area	All	KFWO
<b>Lassen</b>	Lassen Volcanic National Park	All (includes Eagle Lake trout on all ownerships)	SFWO
<b>Lassen</b>	All other ownerships	All	By jurisdiction (see map)

<b>Marin</b>	Tidal wetlands/marsh adjacent to Bays	Salt marsh species, delta smelt	BDFWO
<b>Marin</b>	All ownerships but tidal/estuarine	All	SFWO
<b>Mendocino</b>	Russian River watershed	All	SFWO
<b>Mendocino</b>	All except Russian River watershed	All	AFWO
<b>Napa</b>	All ownerships but tidal/estuarine	All	SFWO
<b>Napa</b>	Tidal wetlands/marsh adjacent to San Pablo Bay	Salt marsh species, delta smelt	BDFWO
<b>Nevada</b>	Humboldt Toiyabe National Forest	All	RFWO
<b>Nevada</b>	All other ownerships	All	By jurisdiction (See map)
<b>Placer</b>	Lake Tahoe Basin Management Unit	All	RFWO
<b>Placer</b>	All other ownerships	All	SFWO
<b>Sacramento</b>	Legal Delta	Delta Smelt	BDFWO
<b>Sacramento</b>	Other	All	By jurisdiction (see map)
<b>San Francisco</b>	Tidal wetlands/marsh adjacent to San Francisco Bay	Salt marsh species, delta smelt	BDFWO



<b>San Francisco</b>	All ownerships but tidal/estuarine	All	SFWO
<b>San Mateo</b>	Tidal wetlands/marsh adjacent to San Francisco Bay	Salt marsh species, delta smelt	BDFWO
<b>San Mateo</b>	All ownerships but tidal/estuarine	All	SFWO
<b>San Joaquin</b>	Legal Delta excluding San Joaquin HCP	All	BDFWO
<b>San Joaquin</b>	Other	All	SFWO
<b>Santa Clara</b>	Tidal wetlands/marsh adjacent to San Francisco Bay	Salt marsh species, delta smelt	BDFWO
<b>Santa Clara</b>	All ownerships but tidal/estuarine	All	SFWO
<b>Shasta</b>	Shasta Trinity National Forest except Hat Creek Ranger District (administered by Lassen National Forest)	All	YFWO
<b>Shasta</b>	Hat Creek Ranger District	All	SFWO
<b>Shasta</b>	Bureau of Reclamation (Central Valley Project)	All	BDFWO
<b>Shasta</b>	Whiskeytown National Recreation Area	All	YFWO
<b>Shasta</b>	BLM Alturas Resource Area	All	KFWO

<b>Shasta</b>	Caltrans	By jurisdiction	SFWO/AFWO
<b>Shasta</b>	Ahjumawi Lava Springs State Park	Shasta crayfish	SFWO
<b>Shasta</b>	All other ownerships	All	By jurisdiction (see map)
<b>Shasta</b>	Natural Resource Damage Assessment, all lands	All	SFWO/BDFWO
<b>Sierra</b>	Humboldt Toiyabe National Forest	All	RFWO
<b>Sierra</b>	All other ownerships	All	SFWO
<b>Solano</b>	Suisun Marsh	All	BDFWO
<b>Solano</b>	Tidal wetlands/marsh adjacent to San Pablo Bay	Salt marsh species, delta smelt	BDFWO
<b>Solano</b>	All ownerships but tidal/estuarine	All	SFWO
<b>Solano</b>	Other	All	By jurisdiction (see map)
<b>Sonoma</b>	Tidal wetlands/marsh adjacent to San Pablo Bay	Salt marsh species, delta smelt	BDFWO
<b>Sonoma</b>	All ownerships but tidal/estuarine	All	SFWO
<b>Tehama</b>	Mendocino National Forest	All	AFWO
	Shasta Trinity National Forest		

<b>Tehama</b>	except Hat Creek Ranger District (administered by Lassen National Forest)	All	YFWO
<b>Tehama</b>	All other ownerships	All	By jurisdiction (see map)
<b>Yolo</b>	Yolo Bypass	All	BDFWO
<b>Yolo</b>	Other	All	By jurisdiction (see map)
<b>All</b>	FERC-ESA	All	By jurisdiction (see map)
<b>All</b>	FERC-ESA	Shasta crayfish	SFWO
<b>All</b>	FERC-Relicensing (non-ESA)	All	BDFWO
<b>*Office Leads:</b>			
<b>AFWO=Arcata Fish and Wildlife Office</b>			
<b>BDFWO=Bay Delta Fish and Wildlife Office</b>			
<b>KFWO=Klamath Falls Fish and Wildlife Office</b>			
<b>RFWO=Reno Fish and Wildlife Office</b>			
<b>YFWO=Yreka Fish and Wildlife Office</b>			

Attachment



United States Department of Interior  
Fish and Wildlife Service

Project name: I Street Bridge Replacement

## Official Species List

### Provided by:

Sacramento Fish and Wildlife Office  
FEDERAL BUILDING  
2800 COTTAGE WAY, ROOM W-2605  
SACRAMENTO, CA 95825  
(916) 414-6600

### Non-participating U.S. Fish and Wildlife Service office(s):

The following office(s) have jurisdictions that overlap your project area, but do not provide automatically generated Species list documents. Please contact them directly to request a Species list document. Do this by visiting their website, if it is provided below. If a website is not provided, contact the office(s) by mail or phone.

San Francisco Bay-Delta Fish and Wildlife  
650 CAPITOL MALL  
SUITE 8-300  
SACRAMENTO, CA 95814  
(916) 930-5603

**Consultation Code:** 08ESMF00-2015-SLI-0340

**Event Code:** 08ESMF00-2015-E-01724

**Project Type:** Bridge Construction / Maintenance

**Project Name:** I Street Bridge Replacement

**Project Description:** Construct a new public crossing of the Sacramento River north of the Union Pacific Railroad-owned I Street Bridge and south of Richards Boulevard.

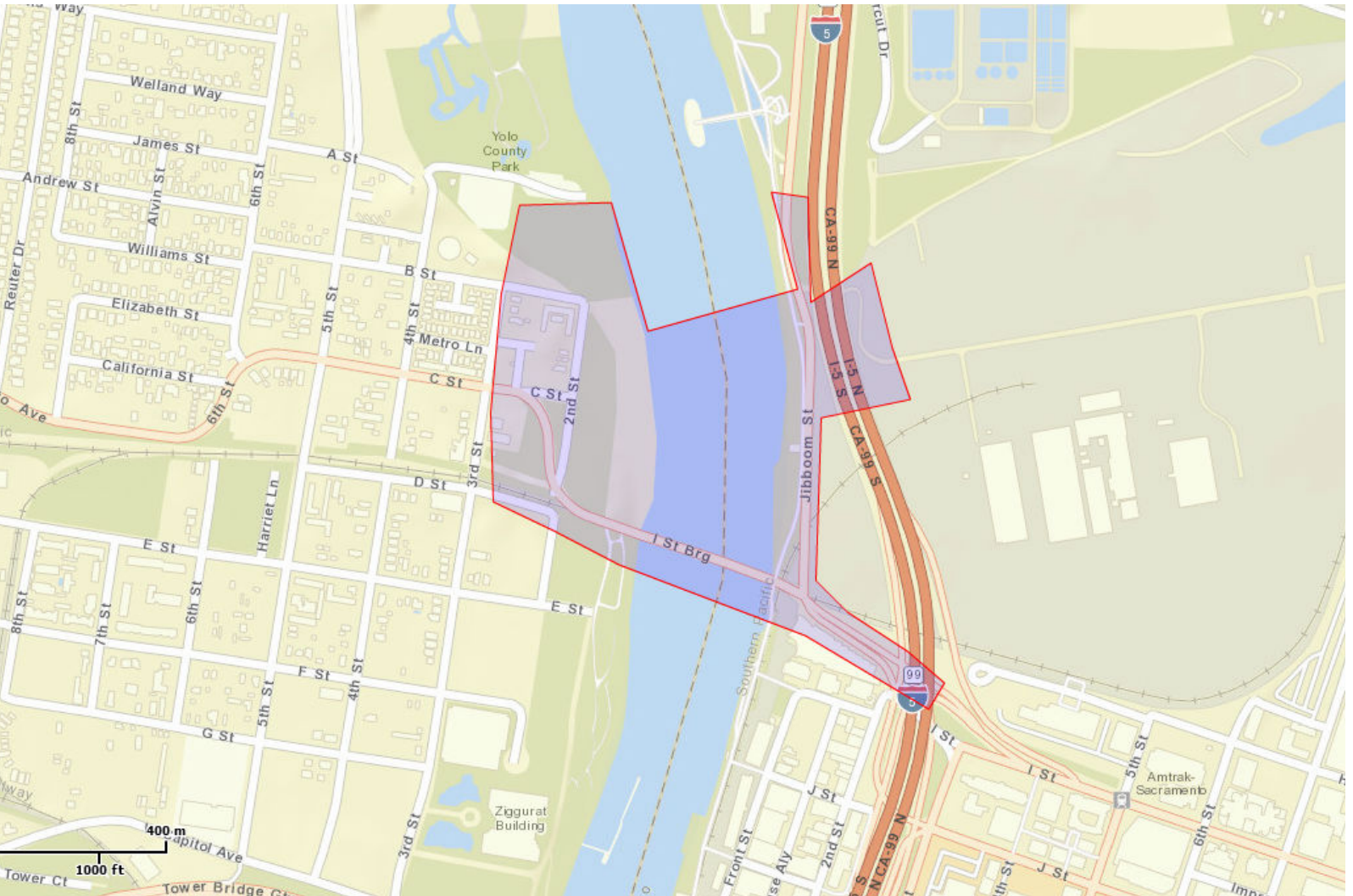
**Please Note:** The FWS office may have modified the Project Name and/or Project Description, so it may be different from what was submitted in your previous request. If the Consultation Code matches, the FWS considers this to be the same project. Contact the office in the 'Provided by' section of your previous Official Species list if you have any questions or concerns.



United States Department of Interior  
Fish and Wildlife Service

Project name: I Street Bridge Replacement

### Project Location Map:



**Project Coordinates:** MULTIPOLYGON (((-121.5027735 38.5843329, -121.5047883 38.5852705, -121.5078353 38.5861763, -121.5098974 38.5869831, -121.5099403 38.5881236, -121.5097687 38.5896331, -121.5094683 38.5907719, -121.5079662 38.5908071, -121.5073654 38.5891635, -121.5049192 38.5897002, -121.5053484 38.5909396, -121.5047476 38.5908725, -121.5047047 38.5895308, -121.5037176 38.5900339, -121.5033743 38.5889605, -121.5030739 38.5882896, -121.504533 38.5880548, -121.5046188 38.585975, -121.5041038 38.5855725, -121.5031168 38.5850693, -121.502516 38.5846667, -121.5027735 38.5843329)))



United States Department of Interior  
Fish and Wildlife Service

Project name: I Street Bridge Replacement

**Project Counties:** Sacramento, CA | Yolo, CA



United States Department of Interior  
Fish and Wildlife Service

Project name: I Street Bridge Replacement

## Endangered Species Act Species List

There are a total of 8 threatened or endangered species on your species list. Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species. Critical habitats listed under the **Has Critical Habitat** column may or may not lie within your project area. See the **Critical habitats within your project area** section further below for critical habitat that lies within your project. Please contact the designated FWS office if you have questions.

Amphibians	Status	Has Critical Habitat	Condition(s)
California Tiger Salamander ( <i>Ambystoma californiense</i> ) Population: U.S.A. (CA - Sonoma County)	Endangered	Final designated	
California red-legged frog ( <i>Rana draytonii</i> ) Population: Entire	Threatened	Final designated	
<b>Crustaceans</b>			
Vernal Pool fairy shrimp ( <i>Branchinecta lynchi</i> ) Population: Entire	Threatened	Final designated	
Vernal Pool tadpole shrimp ( <i>Lepidurus packardii</i> ) Population: Entire	Endangered	Final designated	
<b>Fishes</b>			
Delta smelt ( <i>Hypomesus transpacificus</i> ) Population: Entire	Threatened	Final designated	
steelhead ( <i>Oncorhynchus (=salmo)</i> )	Threatened	Final designated	



United States Department of Interior  
Fish and Wildlife Service

Project name: I Street Bridge Replacement

<i>mykiss</i> Population: Northern California DPS			
<b>Insects</b>			
Valley Elderberry Longhorn beetle ( <i>Desmocerus californicus dimorphus</i> ) Population: Entire	Threatened	Final designated	
<b>Reptiles</b>			
Giant Garter snake ( <i>Thamnophis gigas</i> ) Population: Entire	Threatened		





United States Department of Interior  
Fish and Wildlife Service

Project name: I Street Bridge Replacement

## **Critical habitats that lie within your project area**

There are no critical habitats within your project area.



# United States Department of the Interior



## FISH AND WILDLIFE SERVICE

Sacramento Fish and Wildlife Office

FEDERAL BUILDING, 2800 COTTAGE WAY, ROOM W-2605

SACRAMENTO, CA 95825

PHONE: (916)414-6600 FAX: (916)414-6713

Consultation Code: 08ESMF00-2015-SLI-0340

January 27, 2016

Event Code: 08ESMF00-2016-E-01499

Project Name: I Street Bridge Replacement -- created on April 17, 2015 11:24

Subject: Updated list of threatened and endangered species that may occur in your proposed project location, and/or may be affected by your proposed project

### To Whom It May Concern:

The enclosed species list identifies threatened, endangered, proposed and candidate species, as well as proposed and final designated critical habitat, under the jurisdiction of the U.S. Fish and Wildlife Service (Service) that may occur within the boundary of your proposed project and/or may be affected by your proposed project. The species list fulfills the requirements of the Service under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 *et seq.*).

Please follow the link below to see if your proposed project has the potential to affect other species or their habitats under the jurisdiction of the National Marine Fisheries Service:

[http://www.nwr.noaa.gov/protected\\_species/species\\_list/species\\_lists.html](http://www.nwr.noaa.gov/protected_species/species_list/species_lists.html)

New information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. Please feel free to contact us if you need more current information or assistance regarding the potential impacts to federally proposed, listed, and candidate species and federally designated and proposed critical habitat. Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. This verification can be completed formally or informally as desired. The Service recommends that verification be completed by visiting the ECOS-IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested through the ECOS-IPaC system by completing the same process used to receive the enclosed list.

The purpose of the Act is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Under sections 7(a)(1) and 7(a)(2)

of the Act and its implementing regulations (50 CFR 402 *et seq.*), Federal agencies are required to utilize their authorities to carry out programs for the conservation of threatened and endangered species and to determine whether projects may affect threatened and endangered species and/or designated critical habitat.

A Biological Assessment is required for construction projects (or other undertakings having similar physical impacts) that are major Federal actions significantly affecting the quality of the human environment as defined in the National Environmental Policy Act (42 U.S.C. 4332(2) (c)). For projects other than major construction activities, the Service suggests that a biological evaluation similar to a Biological Assessment be prepared to determine whether the project may affect listed or proposed species and/or designated or proposed critical habitat. Recommended contents of a Biological Assessment are described at 50 CFR 402.12.

If a Federal agency determines, based on the Biological Assessment or biological evaluation, that listed species and/or designated critical habitat may be affected by the proposed project, the agency is required to consult with the Service pursuant to 50 CFR 402. In addition, the Service recommends that candidate species, proposed species and proposed critical habitat be addressed within the consultation. More information on the regulations and procedures for section 7 consultation, including the role of permit or license applicants, can be found in the "Endangered Species Consultation Handbook" at:

<http://www.fws.gov/endangered/esa-library/pdf/TOC-GLOS.PDF>

Please be aware that bald and golden eagles are protected under the Bald and Golden Eagle Protection Act (16 U.S.C. 668 *et seq.*), and projects affecting these species may require development of an eagle conservation plan ([http://www.fws.gov/windenergy/eagle\\_guidance.html](http://www.fws.gov/windenergy/eagle_guidance.html)). Additionally, wind energy projects should follow the wind energy guidelines (<http://www.fws.gov/windenergy/>) for minimizing impacts to migratory birds and bats.

Guidance for minimizing impacts to migratory birds for projects including communications towers (e.g., cellular, digital television, radio, and emergency broadcast) can be found at: <http://www.fws.gov/migratorybirds/CurrentBirdIssues/Hazards/towers/towers.htm>; <http://www.towerkill.com>; and <http://www.fws.gov/migratorybirds/CurrentBirdIssues/Hazards/towers/comtow.html>.

We appreciate your concern for threatened and endangered species. The Service encourages Federal agencies to include conservation of threatened and endangered species into their project planning to further the purposes of the Act. Please include the Consultation Tracking Number in the header of this letter with any request for consultation or correspondence about your project that you submit to our office.

Attachment



United States Department of Interior  
Fish and Wildlife Service

Project name: I Street Bridge Replacement -- created on April 17, 2015 11:24

## Official Species List

### Provided by:

Sacramento Fish and Wildlife Office  
FEDERAL BUILDING  
2800 COTTAGE WAY, ROOM W-2605  
SACRAMENTO, CA 95825  
(916) 414-6600

**Consultation Code:** 08ESMF00-2015-SLI-0340

**Event Code:** 08ESMF00-2016-E-01499

**Project Type:** BRIDGE CONSTRUCTION / MAINTENANCE

**Project Name:** I Street Bridge Replacement -- created on April 17, 2015 11:24

**Project Description:** Construct a new public crossing of the Sacramento River north of the Union Pacific Railroad-owned I Street Bridge and south of Richards Boulevard.

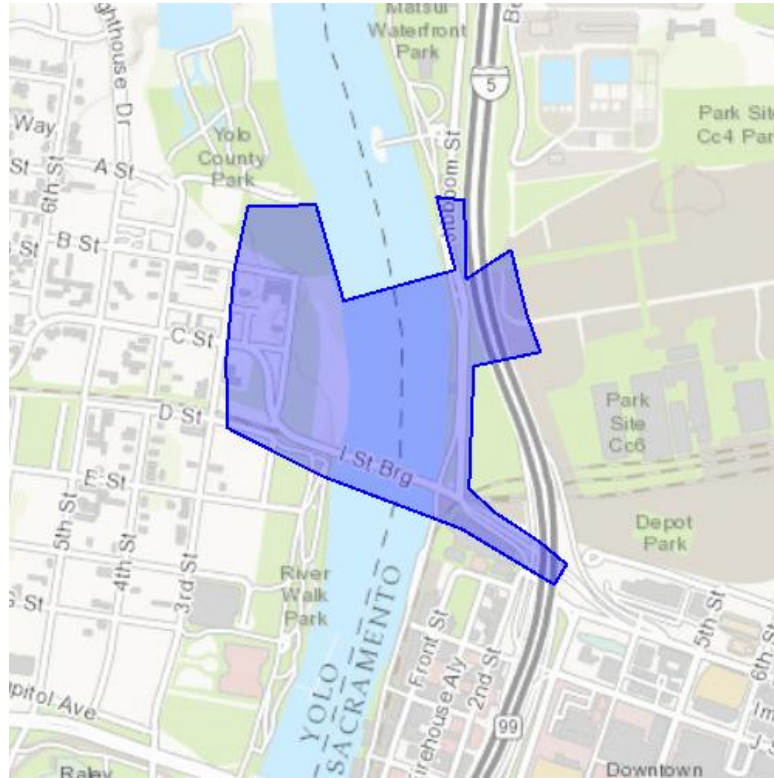
**Please Note:** The FWS office may have modified the Project Name and/or Project Description, so it may be different from what was submitted in your previous request. If the Consultation Code matches, the FWS considers this to be the same project. Contact the office in the 'Provided by' section of your previous Official Species list if you have any questions or concerns.



United States Department of Interior  
Fish and Wildlife Service

Project name: I Street Bridge Replacement -- created on April 17, 2015 11:24

### Project Location Map:



**Project Coordinates:** MULTIPOLYGON (((-121.5027735 38.5843329, -121.5047883 38.5852705, -121.5078353 38.5861763, -121.5098974 38.5869831, -121.5099403 38.5881236, -121.5097687 38.5896331, -121.5094683 38.5907719, -121.5079662 38.5908071, -121.5073654 38.5891635, -121.5049192 38.5897002, -121.5053484 38.5909396, -121.5047476 38.5908725, -121.5047047 38.5895308, -121.5037176 38.5900339, -121.5033743 38.5889605, -121.5030739 38.5882896, -121.504533 38.5880548, -121.5046188 38.585975, -121.5041038 38.5855725, -121.5031168 38.5850693, -121.502516 38.5846667, -121.5027735 38.5843329)))

**Project Counties:** Sacramento, CA | Yolo, CA



## Endangered Species Act Species List

There are a total of 9 threatened or endangered species on your species list. Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species. Critical habitats listed under the **Has Critical Habitat** column may or may not lie within your project area. See the **Critical habitats within your project area** section further below for critical habitat that lies within your project. Please contact the designated FWS office if you have questions.

Amphibians	Status	Has Critical Habitat	Condition(s)
California red-legged frog ( <i>Rana draytonii</i> ) Population: Entire	Threatened	Final designated	
California tiger Salamander ( <i>Ambystoma californiense</i> ) Population: U.S.A. (Central CA DPS)	Threatened	Final designated	
<b>Birds</b>			
Least Bell's vireo ( <i>Vireo bellii pusillus</i> ) Population: Entire	Endangered	Final designated	
<b>Crustaceans</b>			
Vernal Pool fairy shrimp ( <i>Branchinecta lynchi</i> ) Population: Entire	Threatened	Final designated	
Vernal Pool tadpole shrimp ( <i>Lepidurus packardii</i> ) Population: Entire	Endangered	Final designated	
<b>Fishes</b>			



United States Department of Interior  
Fish and Wildlife Service

Project name: I Street Bridge Replacement -- created on April 17, 2015 11:24

Delta smelt ( <i>Hypomesus transpacificus</i> ) Population: Entire	Threatened	Final designated	
steelhead ( <i>Oncorhynchus (=salmo) mykiss</i> ) Population: Northern California DPS	Threatened	Final designated	
<b>Insects</b>			
Valley Elderberry Longhorn beetle ( <i>Desmocerus californicus dimorphus</i> ) Population: Entire	Threatened	Final designated	
<b>Reptiles</b>			
Giant Garter snake ( <i>Thamnophis gigas</i> ) Population: Entire	Threatened		



United States Department of Interior  
Fish and Wildlife Service

Project name: I Street Bridge Replacement -- created on April 17, 2015 11:24

## Critical habitats that lie within your project area

The following critical habitats lie fully or partially within your project area.

Fishes	Critical Habitat Type
Delta smelt ( <i>Hypomesus transpacificus</i> ) Population: Entire	Final designated





# United States Department of the Interior



## FISH AND WILDLIFE SERVICE

Sacramento Fish and Wildlife Office

FEDERAL BUILDING, 2800 COTTAGE WAY, ROOM W-2605

SACRAMENTO, CA 95825

PHONE: (916)414-6600 FAX: (916)414-6713

Consultation Code: 08ESMF00-2017-SLI-0452

December 06, 2016

Event Code: 08ESMF00-2017-E-00836

Project Name: I Street Bridge Replacement

Subject: Updated list of threatened and endangered species that may occur in your proposed project location, and/or may be affected by your proposed project

### To Whom It May Concern:

The enclosed species list identifies threatened, endangered, proposed and candidate species, as well as proposed and final designated critical habitat, under the jurisdiction of the U.S. Fish and Wildlife Service (Service) that may occur within the boundary of your proposed project and/or may be affected by your proposed project. The species list fulfills the requirements of the Service under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 *et seq.*).

Please follow the link below to see if your proposed project has the potential to affect other species or their habitats under the jurisdiction of the National Marine Fisheries Service:

[http://www.nwr.noaa.gov/protected\\_species/species\\_list/species\\_lists.html](http://www.nwr.noaa.gov/protected_species/species_list/species_lists.html)

New information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. Please feel free to contact us if you need more current information or assistance regarding the potential impacts to federally proposed, listed, and candidate species and federally designated and proposed critical habitat. Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. This verification can be completed formally or informally as desired. The Service recommends that verification be completed by visiting the ECOS-IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested through the ECOS-IPaC system by completing the same process used to receive the enclosed list.

The purpose of the Act is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Under sections 7(a)(1) and 7(a)(2)

of the Act and its implementing regulations (50 CFR 402 *et seq.*), Federal agencies are required to utilize their authorities to carry out programs for the conservation of threatened and endangered species and to determine whether projects may affect threatened and endangered species and/or designated critical habitat.

A Biological Assessment is required for construction projects (or other undertakings having similar physical impacts) that are major Federal actions significantly affecting the quality of the human environment as defined in the National Environmental Policy Act (42 U.S.C. 4332(2) (c)). For projects other than major construction activities, the Service suggests that a biological evaluation similar to a Biological Assessment be prepared to determine whether the project may affect listed or proposed species and/or designated or proposed critical habitat. Recommended contents of a Biological Assessment are described at 50 CFR 402.12.

If a Federal agency determines, based on the Biological Assessment or biological evaluation, that listed species and/or designated critical habitat may be affected by the proposed project, the agency is required to consult with the Service pursuant to 50 CFR 402. In addition, the Service recommends that candidate species, proposed species and proposed critical habitat be addressed within the consultation. More information on the regulations and procedures for section 7 consultation, including the role of permit or license applicants, can be found in the "Endangered Species Consultation Handbook" at:

<http://www.fws.gov/endangered/esa-library/pdf/TOC-GLOS.PDF>

Please be aware that bald and golden eagles are protected under the Bald and Golden Eagle Protection Act (16 U.S.C. 668 *et seq.*), and projects affecting these species may require development of an eagle conservation plan ([http://www.fws.gov/windenergy/eagle\\_guidance.html](http://www.fws.gov/windenergy/eagle_guidance.html)). Additionally, wind energy projects should follow the wind energy guidelines (<http://www.fws.gov/windenergy/>) for minimizing impacts to migratory birds and bats.

Guidance for minimizing impacts to migratory birds for projects including communications towers (e.g., cellular, digital television, radio, and emergency broadcast) can be found at: <http://www.fws.gov/migratorybirds/CurrentBirdIssues/Hazards/towers/towers.htm>; <http://www.towerkill.com>; and <http://www.fws.gov/migratorybirds/CurrentBirdIssues/Hazards/towers/comtow.html>.

We appreciate your concern for threatened and endangered species. The Service encourages Federal agencies to include conservation of threatened and endangered species into their project planning to further the purposes of the Act. Please include the Consultation Tracking Number in the header of this letter with any request for consultation or correspondence about your project that you submit to our office.

Attachment



United States Department of Interior  
Fish and Wildlife Service

Project name: I Street Bridge Replacement

## Official Species List

### Provided by:

Sacramento Fish and Wildlife Office  
FEDERAL BUILDING  
2800 COTTAGE WAY, ROOM W-2605  
SACRAMENTO, CA 95825  
(916) 414-6600

### Expect additional Species list documents from the following office(s):

San Francisco Bay-Delta Fish and Wildlife  
650 CAPITOL MALL  
SUITE 8-300  
SACRAMENTO, CA 95814  
(916) 930-5603  
[http://kim\\_squires@fws.gov](mailto:kim_squires@fws.gov)

**Consultation Code:** 08ESMF00-2017-SLI-0452

**Event Code:** 08ESMF00-2017-E-00836

**Project Type:** BRIDGE CONSTRUCTION / MAINTENANCE

**Project Name:** I Street Bridge Replacement

**Project Description:** Construct a new public crossing of the Sacramento River north of the Union Pacific Railroad-owned I Street Bridge and south of Richards Boulevard.

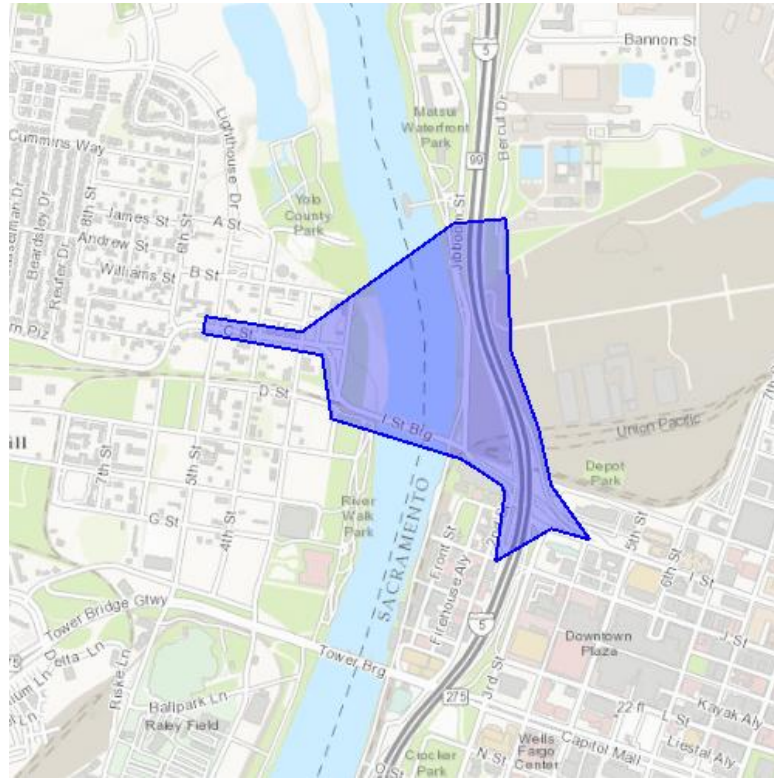
**Please Note:** The FWS office may have modified the Project Name and/or Project Description, so it may be different from what was submitted in your previous request. If the Consultation Code matches, the FWS considers this to be the same project. Contact the office in the 'Provided by' section of your previous Official Species list if you have any questions or concerns.



United States Department of Interior  
Fish and Wildlife Service

Project name: I Street Bridge Replacement

**Project Location Map:**



**Project Coordinates:** MULTIPOLYGON (((-121.50386171345434 38.58301907037809, -121.50355677133562 38.584723918026924, -121.50365326256579 38.58489686422338, -121.50493081334031 38.58557329362821, -121.50906402104778 38.5865398212973, -121.5093462250166 38.58812256485836, -121.51316500101463 38.588665866523, -121.51305221245535 38.589087138091074, -121.51000165942715 38.588710033671774, -121.50517118653293 38.591411669912404, -121.50353402906273 38.591500513436955, -121.50337353110986 38.58824087817738, -121.50248334285739 38.586300858470246, -121.50206563405716 38.584909217561744, -121.50086601846203 38.58357171765275, -121.50206105028106 38.58381649187633, -121.50386171345434 38.58301907037809)))

**Project Counties:** Sacramento, CA | Yolo, CA



United States Department of Interior  
Fish and Wildlife Service

Project name: I Street Bridge Replacement

## Endangered Species Act Species List

There are a total of 9 threatened or endangered species on your species list. Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species. Critical habitats listed under the **Has Critical Habitat** column may or may not lie within your project area. See the **Critical habitats within your project area** section further below for critical habitat that lies within your project. Please contact the designated FWS office if you have questions.

Amphibians	Status	Has Critical Habitat	Condition(s)
California red-legged frog ( <i>Rana draytonii</i> ) Population: Wherever found	Threatened	Final designated	
California tiger Salamander ( <i>Ambystoma californiense</i> ) Population: U.S.A. (Central CA DPS)	Threatened	Final designated	
<b>Birds</b>			
Least Bell's vireo ( <i>Vireo bellii pusillus</i> ) Population: Wherever found	Endangered	Final designated	
<b>Crustaceans</b>			
Vernal Pool fairy shrimp ( <i>Branchinecta lynchi</i> ) Population: Wherever found	Threatened	Final designated	
Vernal Pool tadpole shrimp ( <i>Lepidurus packardii</i> ) Population: Wherever found	Endangered	Final designated	
<b>Fishes</b>			



United States Department of Interior  
Fish and Wildlife Service

Project name: I Street Bridge Replacement

Delta smelt ( <i>Hypomesus transpacificus</i> ) Population: Wherever found	Threatened	Final designated	
steelhead ( <i>Oncorhynchus (=salmo) mykiss</i> ) Population: Northern California DPS	Threatened		
<b>Insects</b>			
Valley Elderberry Longhorn beetle ( <i>Desmocerus californicus dimorphus</i> ) Population: Wherever found	Threatened	Final designated	
<b>Reptiles</b>			
Giant Garter snake ( <i>Thamnophis gigas</i> ) Population: Wherever found	Threatened		



United States Department of Interior  
Fish and Wildlife Service

Project name: I Street Bridge Replacement

## Critical habitats that lie within your project area

The following critical habitats lie fully or partially within your project area.

Fishes	Critical Habitat Type
Delta smelt ( <i>Hypomesus transpacificus</i> ) Population: Wherever found	Final designated



# United States Department of the Interior



FISH AND WILDLIFE SERVICE  
Sacramento Fish And Wildlife Office  
Federal Building  
2800 Cottage Way, Room W-2605  
Sacramento, CA 95825-1846  
Phone: (916) 414-6600 Fax: (916) 414-6713

In Reply Refer To:

August 09, 2017

Consultation Code: 08ESMF00-2017-SLI-0452

Event Code: 08ESMF00-2017-E-07883

Project Name: I Street Bridge Replacement

Subject: Updated list of threatened and endangered species that may occur in your proposed project location, and/or may be affected by your proposed project

To Whom It May Concern:

The enclosed species list identifies threatened, endangered, proposed and candidate species, as well as proposed and final designated critical habitat, under the jurisdiction of the U.S. Fish and Wildlife Service (Service) that may occur within the boundary of your proposed project and/or may be affected by your proposed project. The species list fulfills the requirements of the Service under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 et seq.).

Please follow the link below to see if your proposed project has the potential to affect other species or their habitats under the jurisdiction of the National Marine Fisheries Service:

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New information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. Please feel free to contact us if you need more current information or assistance regarding the potential impacts to federally proposed, listed, and candidate species and federally designated and proposed critical habitat. Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. This verification can be completed formally or informally as desired. The Service recommends that verification be completed by visiting the ECOS-IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested through the ECOS-IPaC system by completing the same process used to receive the enclosed list.

The purpose of the Act is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Under sections 7(a)(1) and 7(a)(2) of the Act and its implementing regulations (50 CFR 402 et seq.), Federal agencies are required to



utilize their authorities to carry out programs for the conservation of threatened and endangered species and to determine whether projects may affect threatened and endangered species and/or designated critical habitat.

A Biological Assessment is required for construction projects (or other undertakings having similar physical impacts) that are major Federal actions significantly affecting the quality of the human environment as defined in the National Environmental Policy Act (42 U.S.C. 4332(2) (c)). For projects other than major construction activities, the Service suggests that a biological evaluation similar to a Biological Assessment be prepared to determine whether the project may affect listed or proposed species and/or designated or proposed critical habitat. Recommended contents of a Biological Assessment are described at 50 CFR 402.12.

If a Federal agency determines, based on the Biological Assessment or biological evaluation, that listed species and/or designated critical habitat may be affected by the proposed project, the agency is required to consult with the Service pursuant to 50 CFR 402. In addition, the Service recommends that candidate species, proposed species and proposed critical habitat be addressed within the consultation. More information on the regulations and procedures for section 7 consultation, including the role of permit or license applicants, can be found in the "Endangered Species Consultation Handbook" at:

<http://www.fws.gov/endangered/esa-library/pdf/TOC-GLOS.PDF>

Please be aware that bald and golden eagles are protected under the Bald and Golden Eagle Protection Act (16 U.S.C. 668 et seq.), and projects affecting these species may require development of an eagle conservation plan ([http://www.fws.gov/windenergy/eagle\\_guidance.html](http://www.fws.gov/windenergy/eagle_guidance.html)). Additionally, wind energy projects should follow the wind energy guidelines (<http://www.fws.gov/windenergy/>) for minimizing impacts to migratory birds and bats.

Guidance for minimizing impacts to migratory birds for projects including communications towers (e.g., cellular, digital television, radio, and emergency broadcast) can be found at: <http://www.fws.gov/migratorybirds/CurrentBirdIssues/Hazards/towers/towers.htm>; <http://www.towerkill.com>; and <http://www.fws.gov/migratorybirds/CurrentBirdIssues/Hazards/towers/comtow.html>.

We appreciate your concern for threatened and endangered species. The Service encourages Federal agencies to include conservation of threatened and endangered species into their project planning to further the purposes of the Act. Please include the Consultation Tracking Number in the header of this letter with any request for consultation or correspondence about your project that you submit to our office.

Attachment(s):

- Official Species List
-

## Official Species List

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

This species list is provided by:

### **Sacramento Fish And Wildlife Office**

Federal Building  
2800 Cottage Way, Room W-2605  
Sacramento, CA 95825-1846  
(916) 414-6600

This project's location is within the jurisdiction of multiple offices. Expect additional species list documents from the following office, and expect that the species and critical habitats in each document reflect only those that fall in the office's jurisdiction:

### **San Francisco Bay-Delta Fish And Wildlife**

650 Capitol Mall  
Suite 8-300  
Sacramento, CA 95814  
(916) 930-5603

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## Project Summary

Consultation Code: 08ESMF00-2017-SLI-0452

Event Code: 08ESMF00-2017-E-07883

Project Name: I Street Bridge Replacement

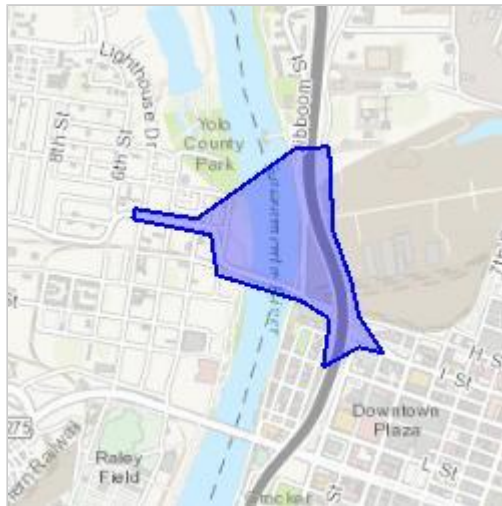
Project Type: BRIDGE CONSTRUCTION / MAINTENANCE

Project Description: Construct a new public crossing of the Sacramento River north of the Union Pacific Railroad-owned I Street Bridge and south of Richards Boulevard.

Project Location:

Approximate location of the project can be viewed in Google Maps:

<https://www.google.com/maps/place/38.58725979190753N121.50605787333976W>



Counties: Sacramento, CA | Yolo, CA

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## Endangered Species Act Species

There is a total of 9 threatened, endangered, or candidate species on this species list. Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species. See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

### Birds

NAME	STATUS
Least Bell's Vireo <i>Vireo bellii pusillus</i> There is a <b>final critical habitat</b> designated for this species. Your location is outside the designated critical habitat. Species profile: <a href="https://ecos.fws.gov/ecp/species/5945">https://ecos.fws.gov/ecp/species/5945</a>	Endangered

### Reptiles

NAME	STATUS
Giant Garter Snake <i>Thamnophis gigas</i> No critical habitat has been designated for this species. Species profile: <a href="https://ecos.fws.gov/ecp/species/4482">https://ecos.fws.gov/ecp/species/4482</a>	Threatened

### Amphibians

NAME	STATUS
California Red-legged Frog <i>Rana draytonii</i> There is a <b>final critical habitat</b> designated for this species. Your location is outside the designated critical habitat. Species profile: <a href="https://ecos.fws.gov/ecp/species/2891">https://ecos.fws.gov/ecp/species/2891</a>	Threatened
California Tiger Salamander <i>Ambystoma californiense</i> Population: U.S.A. (Central CA DPS) There is a <b>final critical habitat</b> designated for this species. Your location is outside the designated critical habitat. Species profile: <a href="https://ecos.fws.gov/ecp/species/2076">https://ecos.fws.gov/ecp/species/2076</a>	Threatened

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## Fishes

NAME	STATUS
Delta Smelt <i>Hypomesus transpacificus</i> There is a <b>final critical habitat</b> designated for this species. Your location overlaps the designated critical habitat. Species profile: <a href="https://ecos.fws.gov/ecp/species/321">https://ecos.fws.gov/ecp/species/321</a>	Threatened
Steelhead <i>Oncorhynchus (=Salmo) mykiss</i> Population: Northern California DPS There is a <b>final critical habitat</b> designated for this species. Your location overlaps the designated critical habitat. Species profile: <a href="https://ecos.fws.gov/ecp/species/1007">https://ecos.fws.gov/ecp/species/1007</a>	Threatened

## Insects

NAME	STATUS
Valley Elderberry Longhorn Beetle <i>Desmocerus californicus dimorphus</i> There is a <b>final critical habitat</b> designated for this species. Your location is outside the designated critical habitat. Species profile: <a href="https://ecos.fws.gov/ecp/species/7850">https://ecos.fws.gov/ecp/species/7850</a>	Threatened

## Crustaceans

NAME	STATUS
Vernal Pool Fairy Shrimp <i>Branchinecta lynchi</i> There is a <b>final critical habitat</b> designated for this species. Your location is outside the designated critical habitat. Species profile: <a href="https://ecos.fws.gov/ecp/species/498">https://ecos.fws.gov/ecp/species/498</a>	Threatened
Vernal Pool Tadpole Shrimp <i>Lepidurus packardii</i> There is a <b>final critical habitat</b> designated for this species. Your location is outside the designated critical habitat. Species profile: <a href="https://ecos.fws.gov/ecp/species/2246">https://ecos.fws.gov/ecp/species/2246</a>	Endangered

## Critical habitats

There is 1 critical habitat wholly or partially within your project area under this office's jurisdiction.

NAME	STATUS
Delta Smelt <i>Hypomesus transpacificus</i> <a href="https://ecos.fws.gov/ecp/species/321#crithab">https://ecos.fws.gov/ecp/species/321#crithab</a>	Final designated

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UNITED STATES DEPARTMENT OF COMMERCE  
National Oceanic and Atmospheric Administration  
NATIONAL MARINE FISHERIES SERVICE  
West Coast Region  
650 Capitol Mall, Suite 5-100  
Sacramento, California 95814-4700

AUG 20 2015

Ms. Sue Bauer  
Chief, Environmental Management, M-1 Branch  
Department of Transportation, District 3  
703 B Street  
Marysville, CA 95901

Re: Endangered Species Act (ESA) Section 7(a)(2) Species List for I Street Bridge Replacement Project

Dear Ms. Bauer:

This is in response to your July 22, 2015, letter requesting technical assistance from NOAA's National Marine Fisheries Service (NMFS) regarding the California Department of Transportation's (Caltrans) proposed project to replace the I Street Bridge over the Sacramento River between the cities of Sacramento and West Sacramento, approximately 1,000 feet north of the existing I Street Bridge, in Sacramento County, California. Waterways within the project area include the mainstem of the Sacramento River upstream of the Sacramento-San Joaquin Delta (Delta) and downstream of its confluence with the American River. Caltrans has requested NMFS to provide the species listed on the Federal List of Endangered and Threatened Wildlife (50 C.F.R. 70.11), or critical habitat designated that may occur within the project area.

Available information indicates that the following listed species and designated critical habitat could occur in the project area, or have the potential to be affected by the project (Table 1):

In addition, a comprehensive collection of species listing information, critical habitat designations, status reviews, distribution maps and Federal Register (FR) Notices for listed salmonids can be found on the NMFS West Coast Region website at:

[http://www.westcoast.fisheries.noaa.gov/protected\\_species/salmon\\_steelhead/salmon\\_and\\_steelhead\\_listings/salmon\\_and\\_steelhead\\_listings.html](http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/salmon_and_steelhead_listings/salmon_and_steelhead_listings.html), and for green sturgeon at:

[http://www.westcoast.fisheries.noaa.gov/protected\\_species/green\\_sturgeon/green\\_sturgeon\\_pg.html](http://www.westcoast.fisheries.noaa.gov/protected_species/green_sturgeon/green_sturgeon_pg.html).

Formal and informal consultation is initiated through a request that must include the following six pieces of information as described in CFR 402.14(c):

- (1) A description of the proposed action to be covered;



(2) A description of the specific area that may be affected by the proposed action;  
 Table 1—FR ESA listings for affected species and their critical habitat designations as applicable in or near the project area.

Species	ESU or DPS	Original Final FR Listing	Current Final Listing Status	Critical Habitat Designated
Chinook salmon ( <i>Oncorhynchus tshawytscha</i> )	Central Valley (CV) spring-run ESU	9/16/1999 64 FR 50394 Threatened	6/28/2005 70 FR 37160 Threatened	9/2/2005 70 FR 52488
Chinook salmon ( <i>O. tshawytscha</i> )	Sacramento River (SR) winter-run ESU	1/4/1994 59 FR 440 Endangered	6/28/2005 70 FR 37160 Endangered	6/16/1993 58 FR 33212
Steelhead ( <i>O. mykiss</i> )	California Central Valley (CCV) DPS	3/19/1998 63 FR 13347 Threatened	1/5/2006 71 FR 834 Threatened	9/2/2005 70 FR 52488
North American (NA) Green sturgeon ( <i>Acipenser medirostris</i> )	Southern DPS	4/7/2006 71 FR 17757 Threatened	4/7/2006 71 FR 17757 Threatened	10/9/2009 74 FR 52300

(3) A description of any listed species or critical habitat that may be affected by the proposed action;

(4) A description of the manner in which the action may affect any listed species or critical habitat, and an analysis of any direct, indirect, or cumulative effects.

- a. Direct Effects: Effects to listed species of designated critical habitat that occur during implementation of the project.
- b. Indirect Effects: Effects to listed species that occur later in time or offsite, but are reasonably certain to occur.
- c. Cumulative Effects: For purposes of the ESA, cumulative effects are defined as the effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within an action area of the Federal action subject to consultation (50 CFR 402.02). Future Federal actions are not included here because they require separate consultation pursuant to Section 7 of the ESA;

(5) Relevant reports, including any environmental impact statements, environmental assessments, biological assessments or other analysis prepared regarding the proposal; and

(6) Any other relevant studies or other information available on the action, the affected listed species, or critical habitat.

**The following is a description of critical habitat for SR winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead in or near the project area:**

Critical habitat includes the stream channels in the designated stream reaches and the lateral extent as defined by the ordinary high-waterline. In areas where the ordinary high-waterline has not been defined, the lateral extent will be defined by the bankfull elevation (defined as the level at which water begins to leave the channel and move into the floodplain; it is reached at a discharge that generally has a recurrence interval of 1 to 2 years on the annual flood series). Critical habitat for SR winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead are defined as specific areas that contain the primary constituent elements (PCE) and physical habitat elements (PHE) essential to the conservation of the species. The following information discusses the inland habitat types used as PCEs for CV spring-run Chinook salmon and CCV steelhead and as PHEs for SR winter-run Chinook salmon that may occur along the Sacramento River mainstem near the project site.

PCEs for CV spring-run salmon and CCV steelhead and PHEs for SR winter-run Chinook salmon in the Sacramento River near the project site

*Freshwater Rearing Habitat*

Freshwater rearing sites are those with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large woody material, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. Both spawning areas and migratory corridors comprise rearing habitat for juveniles, which feed and grow before and during their outmigration. Rearing habitat condition is strongly affected by habitat complexity, food supply, and the presence of predators of juvenile salmonids. The channelized, leveed, and riprapped river reaches and sloughs that are common in the Delta south of the project location have been significantly degraded by the placement of riprap. Freshwater rearing habitats are considered to have a high conservation value and recovery potential even if they are significantly degraded compared to their natural state.

*Freshwater Migration Corridors*

Ideal freshwater migration corridors are free of migratory obstructions, with water quantity and quality conditions that enhance migratory movements. They contain natural cover such as riparian canopy structure, submerged and overhanging large woody objects, aquatic vegetation, large rocks, and boulders, side channels, and undercut banks which augment juvenile and adult mobility, survival, and food supply. These corridors allow the upstream passage of adults, and the downstream emigration of outmigrant juveniles. The Sacramento River is a primary migration corridor for adult and juvenile salmon and steelhead. Freshwater migration corridors are considered to have a high conservation and recovery potential value even if they are significantly degraded compared to their natural state.



### *Estuarine Areas*

Estuarine areas free of migratory obstructions with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh and salt water are included as a PCE. Natural cover such as submerged and overhanging large woody material, aquatic vegetation floodplains and side channels, are essential for juvenile and adult foraging. The project area is located along the Sacramento River mainstem just north of the Delta and may be a critical component of estuarine PCEs. Estuarine areas are considered to have a high conservation value as they provide factors which function to provide predator avoidance and as a transitional zone to the ocean environment. Estuarine areas are considered to have a high conservation and recovery potential value even if they are significantly degraded compared to their natural state.

### **The following is a description of critical habitat for the Southern DPS of NA green sturgeon in or near the project area:**

Critical habitat for Southern DPS green sturgeon includes the stream channels and waterways in and near the Delta to the ordinary high waterline. There are several PCEs present that should be considered at the project location.

### PCEs for the Southern DPS of NA green sturgeon in the Sacramento River near the project site

#### *Food Resources*

Abundant food items within estuarine habitats and substrates for juvenile, subadult, and adult life stages are required for the proper functioning of this PCE for green sturgeon. Prey species for juvenile, subadult, and adult green sturgeon within bays and estuaries primarily consist of benthic invertebrates and fish, including crangonid shrimp, callinassid shrimp, burrowing thalassinidean shrimp, amphipods, isopods, clams, annelid worms, crabs, sand lances, and anchovies. These prey species are critical for the rearing, foraging, growth, and development of juvenile, subadult, and adult green sturgeon within the bays and estuaries.

#### *Water Flow*

Within bays and estuaries adjacent to the Sacramento River (*i.e.*, the Delta and the Suisun, San Pablo, and San Francisco bays), sufficient flow into the bay and estuary to allow adults to successfully orient to the incoming flow and migrate upstream to spawning grounds is required. Sufficient flows are needed to attract adult green sturgeon into the Sacramento River from the bay and to initiate the upstream spawning migration into the upper river.

#### *Water Quality*

Adequate water quality, including temperature, salinity, oxygen content, and other chemical characteristics are necessary for normal behavior, growth, and viability of all life stages. Suitable water temperatures for juvenile green sturgeon should be below 24°C (75°F). At temperatures above 24°C, juvenile green sturgeon exhibit decreased swimming performance and increased cellular stress. Adequate levels of dissolved oxygen (DO) are also required to support

oxygen consumption by juveniles (ranging from 61.8 to 76.1 mg O<sub>2</sub> hr<sup>-1</sup> kg<sup>-1</sup>). Suitable water quality also includes water free of contaminants (*e.g.*, organochlorine pesticides, polyaromatic hydrocarbons (PAHs), or elevated levels of heavy metals) that may disrupt the normal development of juvenile life stages, or the growth, survival, or reproduction of subadult or adult stages.

### *Migratory Corridor*

Safe and unobstructed migratory pathways are necessary for successful and timely passage of adult, sub-adult, and juvenile fish within the region's different estuarine habitats and between the upstream riverine habitat and the marine habitats. Within the waterways comprising the Delta, and bays downstream of the Sacramento River, safe and unobstructed passage is needed for juvenile green sturgeon during the rearing phase of their life cycle. Rearing fish need the ability to freely migrate from the river through the estuarine waterways of the Delta and bays and eventually out into the ocean. Passage within the bays and the Delta is also critical for adults and subadults for feeding and summer holding, as well as to access the Sacramento River for their upstream spawning migrations and to make their outmigration back into the ocean. Within bays and estuaries outside of the Delta and the areas comprised by Suisun, San Pablo, and San Francisco bays, safe and unobstructed passage is necessary for adult and subadult green sturgeon to access feeding areas, holding areas, and thermal refugia, and to ensure passage back out into the ocean.

### *Water Depth*

A diversity of depths is necessary for shelter, foraging, and migration of juvenile, subadult, and adult life stages. Adults and subadults within the estuary primarily occupy waters over shallow depths of less than 10 meters, either swimming near the surface or foraging along the bottom. In a study of juvenile green sturgeon in the Delta, relatively large numbers of juveniles were captured primarily in shallow waters from 3 to 8 feet deep, indicating juveniles may require shallower depths for rearing and foraging. Thus, a diversity of depths is important to support different life stages and habitat uses for green sturgeon within estuarine areas.

### *Sediment Quality*

Sediment quality (*i.e.*, chemical characteristics) is necessary for normal behavior, growth, and viability of all life stages. This includes sediments free of contaminants (*e.g.*, elevated levels of selenium, PAHs, and organochlorine pesticides) that can cause negative effects on all life stages of green sturgeon.

### **Essential Fish Habitat (EFH)**

The proposed project site is within the region identified as EFH for Pacific salmon in Amendment 14 of the Pacific Salmon FMP. EFH is defined as those waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purposes of interpreting the definition of EFH, "waters" includes aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used

by fish where appropriate; "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities; "necessary" means habitat required to support a sustainable fishery and a healthy ecosystem; and, "spawning, breeding, feeding, or growth to maturity" covers all habitat types used by a species throughout its life cycle. In order to protect EFH, federal agencies are required to consult with NMFS on activities that may adversely affect EFH, and NMFS must provide EFH conservation recommendations to those agencies (section 305(b)(4)(A)).

Fall-run Chinook salmon have the potential to be present near the project location and are managed under the Pacific Coast Salmon Fisheries Management Plan (FMP). Habitat areas of particular concern (HAPCs), as designated under this FMP, include (1) complex channels and floodplain habitats, (2) thermal refugia, (3) spawning habitat, (4) estuaries, and (5) marine and estuarine submerged aquatic vegetation. Caltrans should identify and discuss HAPCs present, if any, along the Sacramento River mainstem near the project location.

### **ESA Section 7(a)(1) Conservation Recommendations**

Section 7(a)(1) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C 1531 *et seq.*), directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of threatened and endangered species. Conservation recommendations are discretionary agency activities intended to minimize or avoid adverse effects of a proposed project on listed species or critical habitat, to help implement recovery plans, or to develop information.

Bridge replacement projects have a high potential to further degrade habitat for anadromous fish and reduce their recovery potential. We recommend a pre-consultation meeting to discuss methods to minimize and avoid impacts of this project, including project timing. Some examples include:

- (1) Re-vegetate onsite at a 3:1 ratio immediately following the completion of the proposed project for any area consisting of removed or disturbed vegetation with native riparian species in efforts to facilitate the development of shaded riverine aquatic (SRA) habitat. A detailed re-vegetation plan should be provided and should include a list of species and designs depicting the proposed location for each species and their density. The vegetation plan should also include proposed irrigation and vegetation monitoring schedules which will likely be needed for several years;
- (2) Develop a monitoring plan to evaluate the success of the re-vegetation efforts which would indicate the overall performance of the planted vegetation at each site and include guidelines for replacing vegetation that fail to establish.
- (3) Purchase rearing habitat credits at a 3:1 ratio for the placement of rock slope protection (RSP), if used, within the action area at a NMFS approved anadromous fish conservation bank;

- (4) Implement best management practices, including Storm Water Pollution Prevention Program and Water Pollution Control Program, to minimize effects to federally listed fish and their designated critical habitat;
  - (5) Use a soil-rock mixture to facilitate re-vegetation of the proposed project area. A ratio of rock to soil (70:30) is recommended. We suggest a soil-rock mixture on top of the rock revetment to allow native riparian vegetation to be planted to ensure SRA habitat is replaced;
  - (6) Caltrans should use a vibratory hammer whenever possible to avoid acoustic impacts to ESA-listed fish when pile driving. If an impact hammer is necessary, a bubble curtain or other sound attenuation method should be used to reduce impacts;
  - (7) Construction should occur when vulnerable life stages of listed anadromous fish would be least likely to occur in the project area;
  - (8) To address potential fish migration concerns upstream and downstream of the RSP placement points, see NMFS Guidelines for Salmonid Passage at Stream Crossings at [http://www.westcoast.fisheries.noaa.gov/publications/hydropower/fish\\_passage\\_at\\_stream\\_crossings\\_guidance.pdf](http://www.westcoast.fisheries.noaa.gov/publications/hydropower/fish_passage_at_stream_crossings_guidance.pdf);
  - (9) Minimize bridge demolition impacts by removing the existing superstructure piece by piece and disposing of it in an environmentally conscious way off-site. This includes protecting the river below the bridge by routing any flow around the construction area;
  - (10) Stabilize and restore the affected project footprint area by applying appropriate soil stabilization and re-vegetation techniques. This may include the implementation of riparian plantings and locally native grass and/or forb seeds to reduce and offset construction impacts. Seeded areas should be covered with broadcast straw and/or seeded erosion control blankets;
  - (11) Caltrans should continue to work cooperatively with other State and Federal agencies, private landowners, governments, and local watershed groups to identify opportunities for cooperative analysis and funding to support salmonid and sturgeon habitat restoration projects within the Sacramento River watershed;
  - (12) Caltrans and other local, State, and Federal agencies should provide training for Caltrans environmental and engineering staff that will assist in avoiding or minimizing the impacts of transportation projects on ESA-listed salmonids, NA green sturgeon and their designated critical habitats; and
  - (13) Caltrans should purchase salmonid habitat restoration credits at a NFMS-approved anadromous fish conservation bank at a 3:1 ratio for the footprint of the project area. The purchase of credits is consistent with 7(a)(1) because it will result in the restoration and long-term preservation of valuable habitat attributes that will improve the survival and recovery of the species.
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This response is provided as technical assistance with Caltrans. This response is not intended to take the place of formal comments or consultation as required under the ESA, and does not provide incidental take authorization pursuant to section 7(b)(4) and section 7(o)(2) of the ESA.

Please contact Dylan Van Dyne at (916) 930-3625, or via e-mail at [Dylan.VanDyne@noaa.gov](mailto:Dylan.VanDyne@noaa.gov) if you have any questions or require additional information.

Sincerely,

A handwritten signature in black ink, appearing to read 'M. Rea', with a long horizontal flourish extending to the right.

*for* Maria C. Rea  
Assistant Regional Administrator,  
California Central Valley Area Office

Cc: Chron File: ARN 151422-WCR2015-SA00159

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## United States Department of the Interior



FISH AND WILDLIFE SERVICE  
San Francisco Bay-Delta Fish And Wildlife  
650 Capitol Mall  
Suite 8-300  
Sacramento, CA 95814  
Phone: (916) 930-5603 Fax: (916) 930-5654  
[http://kim\\_squires@fws.gov](http://kim_squires@fws.gov)

In Reply Refer To:

August 09, 2017

Consultation Code: 08FBBDT00-2017-SLI-0041

Event Code: 08FBBDT00-2017-E-00496

Project Name: I Street Bridge Replacement

Subject: Updated list of threatened and endangered species that may occur in your proposed project location, and/or may be affected by your proposed project

To Whom It May Concern:

The enclosed species list identifies threatened, endangered, proposed and candidate species, as well as proposed and final designated critical habitat, that may occur within the boundary of your proposed project and/or may be affected by your proposed project. The species list fulfills the requirements of the U.S. Fish and Wildlife Service (Service) under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 et seq.).

New information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. Please feel free to contact us if you need more current information or assistance regarding the potential impacts to federally proposed, listed, and candidate species and federally designated and proposed critical habitat. Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. This verification can be completed formally or informally as desired. The Service recommends that verification be completed by visiting the ECOS-IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested through the ECOS-IPaC system by completing the same process used to receive the enclosed list.

The purpose of the Act is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Under sections 7(a)(1) and 7(a)(2) of the Act and its implementing regulations (50 CFR 402 et seq.), Federal agencies are required to utilize their authorities to carry out programs for the conservation of threatened and endangered species and to determine whether projects may affect threatened and endangered species and/or designated critical habitat.

A Biological Assessment is required for construction projects (or other undertakings having

similar physical impacts) that are major Federal actions significantly affecting the quality of the human environment as defined in the National Environmental Policy Act (42 U.S.C. 4332(2)(c)). For projects other than major construction activities, the Service suggests that a biological evaluation similar to a Biological Assessment be prepared to determine whether the project may affect listed or proposed species and/or designated or proposed critical habitat. Recommended contents of a Biological Assessment are described at 50 CFR 402.12.

If a Federal agency determines, based on the Biological Assessment or biological evaluation, that listed species and/or designated critical habitat may be affected by the proposed project, the agency is required to consult with the Service pursuant to 50 CFR 402. In addition, the Service recommends that candidate species, proposed species and proposed critical habitat be addressed within the consultation. More information on the regulations and procedures for section 7 consultation, including the role of permit or license applicants, can be found in the "Endangered Species Consultation Handbook" at:

<http://www.fws.gov/endangered/esa-library/pdf/TOC-GLOS.PDF>

Please be aware that bald and golden eagles are protected under the Bald and Golden Eagle Protection Act (16 U.S.C. 668 et seq.), and projects affecting these species may require development of an eagle conservation plan ([http://www.fws.gov/windenergy/eagle\\_guidance.html](http://www.fws.gov/windenergy/eagle_guidance.html)). Additionally, wind energy projects should follow the wind energy guidelines (<http://www.fws.gov/windenergy/>) for minimizing impacts to migratory birds and bats.

Guidance for minimizing impacts to migratory birds for projects including communications towers (e.g., cellular, digital television, radio, and emergency broadcast) can be found at: <http://www.fws.gov/migratorybirds/CurrentBirdIssues/Hazards/towers/towers.htm>; <http://www.towerkill.com>; and <http://www.fws.gov/migratorybirds/CurrentBirdIssues/Hazards/towers/comtow.html>.

We appreciate your concern for threatened and endangered species. The Service encourages Federal agencies to include conservation of threatened and endangered species into their project planning to further the purposes of the Act. Please include the Consultation Tracking Number in the header of this letter with any request for consultation or correspondence about your project that you submit to our office.

Attachment(s):

- Official Species List

## Official Species List

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

This species list is provided by:

### **San Francisco Bay-Delta Fish And Wildlife**

650 Capitol Mall

Suite 8-300

Sacramento, CA 95814

(916) 930-5603

This project's location is within the jurisdiction of multiple offices. Expect additional species list documents from the following office, and expect that the species and critical habitats in each document reflect only those that fall in the office's jurisdiction:

### **Sacramento Fish And Wildlife Office**

Federal Building

2800 Cottage Way, Room W-2605

Sacramento, CA 95825-1846

(916) 414-6600

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## Project Summary

Consultation Code: 08FBDT00-2017-SLI-0041

Event Code: 08FBDT00-2017-E-00496

Project Name: I Street Bridge Replacement

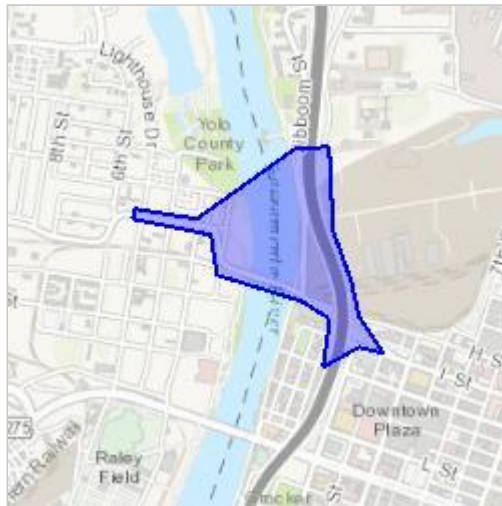
Project Type: BRIDGE CONSTRUCTION / MAINTENANCE

Project Description: Construct a new public crossing of the Sacramento River north of the Union Pacific Railroad-owned I Street Bridge and south of Richards Boulevard.

Project Location:

Approximate location of the project can be viewed in Google Maps:

<https://www.google.com/maps/place/38.58725979190753N121.50605787333976W>



Counties: Sacramento, CA | Yolo, CA

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## Endangered Species Act Species

There is a total of 9 threatened, endangered, or candidate species on this species list. Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species. See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

### Birds

NAME	STATUS
Least Bell's Vireo <i>Vireo bellii pusillus</i> There is a <b>final critical habitat</b> designated for this species. Your location is outside the designated critical habitat. Species profile: <a href="https://ecos.fws.gov/ecp/species/5945">https://ecos.fws.gov/ecp/species/5945</a>	Endangered

### Reptiles

NAME	STATUS
Giant Garter Snake <i>Thamnophis gigas</i> No critical habitat has been designated for this species. Species profile: <a href="https://ecos.fws.gov/ecp/species/4482">https://ecos.fws.gov/ecp/species/4482</a>	Threatened

### Amphibians

NAME	STATUS
California Red-legged Frog <i>Rana draytonii</i> There is a <b>final critical habitat</b> designated for this species. Your location is outside the designated critical habitat. Species profile: <a href="https://ecos.fws.gov/ecp/species/2891">https://ecos.fws.gov/ecp/species/2891</a>	Threatened
California Tiger Salamander <i>Ambystoma californiense</i> Population: U.S.A. (Central CA DPS) There is a <b>final critical habitat</b> designated for this species. Your location is outside the designated critical habitat. Species profile: <a href="https://ecos.fws.gov/ecp/species/2076">https://ecos.fws.gov/ecp/species/2076</a>	Threatened

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## Fishes

NAME	STATUS
Delta Smelt <i>Hypomesus transpacificus</i> There is a <b>final critical habitat</b> designated for this species. Your location overlaps the designated critical habitat. Species profile: <a href="https://ecos.fws.gov/ecp/species/321">https://ecos.fws.gov/ecp/species/321</a>	Threatened
Steelhead <i>Oncorhynchus (=Salmo) mykiss</i> Population: Northern California DPS There is a <b>final critical habitat</b> designated for this species. Your location overlaps the designated critical habitat. Species profile: <a href="https://ecos.fws.gov/ecp/species/1007">https://ecos.fws.gov/ecp/species/1007</a>	Threatened

## Insects

NAME	STATUS
Valley Elderberry Longhorn Beetle <i>Desmocerus californicus dimorphus</i> There is a <b>final critical habitat</b> designated for this species. Your location is outside the designated critical habitat. Species profile: <a href="https://ecos.fws.gov/ecp/species/7850">https://ecos.fws.gov/ecp/species/7850</a>	Threatened

## Crustaceans

NAME	STATUS
Vernal Pool Fairy Shrimp <i>Branchinecta lynchi</i> There is a <b>final critical habitat</b> designated for this species. Your location is outside the designated critical habitat. Species profile: <a href="https://ecos.fws.gov/ecp/species/498">https://ecos.fws.gov/ecp/species/498</a>	Threatened
Vernal Pool Tadpole Shrimp <i>Lepidurus packardii</i> There is a <b>final critical habitat</b> designated for this species. Your location is outside the designated critical habitat. Species profile: <a href="https://ecos.fws.gov/ecp/species/2246">https://ecos.fws.gov/ecp/species/2246</a>	Endangered

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## Critical habitats

There are 8 critical habitats wholly or partially within your project area under this office's jurisdiction.

NAME	STATUS
<p>Chinook Salmon <i>Oncorhynchus</i> (=Salmo) <i>tshawytscha</i>            Population: Central Valley spring-run ESU            For information on why this critical habitat appears for your project, even though Chinook Salmon is not on the list of potentially affected species at this location, contact the local field office.  <a href="https://ecos.fws.gov/ecp/species/8091#crithab">https://ecos.fws.gov/ecp/species/8091#crithab</a></p>	Final designated
<p>Chinook Salmon <i>Oncorhynchus</i> (=Salmo) <i>tshawytscha</i>            Population: California Coastal ESU            For information on why this critical habitat appears for your project, even though Chinook Salmon is not on the list of potentially affected species at this location, contact the local field office.  <a href="https://ecos.fws.gov/ecp/species/8091#crithab">https://ecos.fws.gov/ecp/species/8091#crithab</a></p>	Final designated
<p>Delta Smelt <i>Hypomesus transpacificus</i>  <a href="https://ecos.fws.gov/ecp/species/321#crithab">https://ecos.fws.gov/ecp/species/321#crithab</a></p>	Final designated
<p>Steelhead <i>Oncorhynchus</i> (=Salmo) <i>mykiss</i>            Population: Northern California DPS  <a href="https://ecos.fws.gov/ecp/species/1007#crithab">https://ecos.fws.gov/ecp/species/1007#crithab</a></p>	Final designated
<p>Steelhead <i>Oncorhynchus</i> (=Salmo) <i>mykiss</i>            Population: South-Central California Coast DPS  <a href="https://ecos.fws.gov/ecp/species/1007#crithab">https://ecos.fws.gov/ecp/species/1007#crithab</a></p>	Final designated
<p>Steelhead <i>Oncorhynchus</i> (=Salmo) <i>mykiss</i>            Population: Central California Coast DPS  <a href="https://ecos.fws.gov/ecp/species/1007#crithab">https://ecos.fws.gov/ecp/species/1007#crithab</a></p>	Final designated
<p>Steelhead <i>Oncorhynchus</i> (=Salmo) <i>mykiss</i>            Population: California Central Valley DPS  <a href="https://ecos.fws.gov/ecp/species/1007#crithab">https://ecos.fws.gov/ecp/species/1007#crithab</a></p>	Final designated
<p>Steelhead <i>Oncorhynchus</i> (=Salmo) <i>mykiss</i>            Population: Southern California DPS  <a href="https://ecos.fws.gov/ecp/species/1007#crithab">https://ecos.fws.gov/ecp/species/1007#crithab</a></p>	Final designated

## Osmondson, Jennifer A@DOT

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**From:** Osmondson, Jennifer A@DOT  
**Sent:** Wednesday, June 08, 2016 1:44 PM  
**To:** 'nmfsswcrca.specieslist@noaa.gov'  
**Subject:** NMFS Species List

### NMFS Species List

Federal Agency: Federal Highway Administration – California Division  
Federal Agency Address: 650 Capitol Mall, Suite 4-100, Sacramento, CA 95814-4708  
Non-Federal Agency Representative: California Department of Transportation  
Non-Federal Agency Representative Address: 703 B Street, Marysville, CA 95901  
Project Name: I Street Bridge Replacement Project (BRLS-5002(164))  
Point-of-Contact: Jennifer Osmondson, Jennifer\_Osmondson@dot.ca.gov, (530) 740-4807

Quad Name **Sacramento West**

### ESA Anadromous Fish

Central Valley Spring-run Chinook Salmon ESU (T) **X**  
Sacramento River Winter-run Chinook Salmon ESU (E) **X**  
California Central Valley Steelhead DPS (T) **X**  
sDPS Green Sturgeon (T) **X**

### ESA Anadromous Fish Critical Habitat

Central Valley Spring-run Chinook Salmon Critical Habitat **X**  
Sacramento River Winter-run Chinook Salmon Critical Habitat **X**  
California Central Valley Steelhead Critical Habitat **X**  
sDPS Green Sturgeon Critical Habitat **X**

### Essential Fish Habitat

Chinook Salmon EFH **X**  
Groundfish EFH **X**

Quad Name **Sacramento East**

### ESA Anadromous Fish

Central Valley Spring-run Chinook Salmon ESU (T) **X**  
Sacramento River Winter-run Chinook Salmon ESU (E) **X**  
California Central Valley Steelhead DPS (T) **X**  
sDPS Green Sturgeon (T) **X**

### ESA Anadromous Fish Critical Habitat

Central Valley Spring-run Chinook Salmon Critical Habitat **X**  
California Central Valley Steelhead Critical Habitat **X**  
sDPS Green Sturgeon Critical Habitat **X**

**Essential Fish Habitat**

Chinook Salmon EFH **X**  
Groundfish EFH **X**

**Jennifer Osmondson** | Biologist  
California Department of Transportation  
703 B Street, Marysville, CA 95901  
Phone: (530) 740-4807

**From:** Osmondson, Jennifer A@DOT  
**To:** ["nmfswcrca.specieslist@noaa.gov"](mailto:nmfswcrca.specieslist@noaa.gov)  
**Subject:** FHWA-Caltrans - I Street Bridge Replacement Project  
**Date:** Thursday, February 02, 2017 9:16:00 AM

---

### **NMFS Species List**

Federal Agency: Federal Highway Administration – California Division  
Federal Agency Address: 650 Capitol Mall, Suite 4-100, Sacramento, CA 95814-4708  
Non-Federal Agency Representative: California Department of Transportation  
Non-Federal Agency Representative Address: 703 B Street, Marysville, CA 95901  
Project Name: I Street Bridge Replacement Project (BRLS-5002(164))  
Point-of-Contact: Jennifer Osmondson, [Jennifer\\_Osmondson@dot.ca.gov](mailto:Jennifer_Osmondson@dot.ca.gov), (530) 740-4807

Quad Name **Sacramento West**

Quad Number **38121-E5**

### **ESA Anadromous Fish**

SONCC Coho ESU (T) -

CCC Coho ESU (E) -

CC Chinook Salmon ESU (T) -

CVSR Chinook Salmon ESU (T) - **X**

SRWR Chinook Salmon ESU (E) - **X**

NC Steelhead DPS (T) -

CCC Steelhead DPS (T) -

SCCC Steelhead DPS (T) -

SC Steelhead DPS (E) -

CCV Steelhead DPS (T) - **X**

Eulachon (T) -

sDPS Green Sturgeon (T) - **X**

### **ESA Anadromous Fish Critical Habitat**

SONCC Coho Critical Habitat -

CCC Coho Critical Habitat -

CC Chinook Salmon Critical Habitat -

CVSR Chinook Salmon Critical Habitat - **X**

SRWR Chinook Salmon Critical Habitat - **X**

NC Steelhead Critical Habitat -

CCC Steelhead Critical Habitat -

SCCC Steelhead Critical Habitat -

SC Steelhead Critical Habitat -

CCV Steelhead Critical Habitat - **X**

Eulachon Critical Habitat -

sDPS Green Sturgeon Critical Habitat - **X**

### **ESA Marine Invertebrates**

Range Black Abalone (E) -

Range White Abalone (E) -

### **ESA Marine Invertebrates Critical Habitat**

Black Abalone Critical Habitat -

### **ESA Sea Turtles**

East Pacific Green Sea Turtle (T) -

Olive Ridley Sea Turtle (T/E) -  
Leatherback Sea Turtle (E) -  
North Pacific Loggerhead Sea Turtle (E) -

**ESA Whales**

Blue Whale (E) -  
Fin Whale (E) -  
Humpback Whale (E) -  
Southern Resident Killer Whale (E) -  
North Pacific Right Whale (E) -  
Sei Whale (E) -  
Sperm Whale (E) -

**ESA Pinnipeds**

Guadalupe Fur Seal (T) -  
Steller Sea Lion Critical Habitat -

**Essential Fish Habitat**

Coho EFH -  
Chinook Salmon EFH - **X**  
Groundfish EFH - **X**  
Coastal Pelagics EFH -  
Highly Migratory Species EFH -

**MMPA Species (See list at left)**

**ESA and MMPA Cetaceans/Pinnipeds**

**See list at left and consult the NMFS Long Beach office  
562-980-4000**

MMPA Cetaceans -  
MMPA Pinnipeds -

Quad Name **Sacramento East**

Quad Number **38121-E4**

**ESA Anadromous Fish**

SONCC Coho ESU (T) -  
CCC Coho ESU (E) -  
CC Chinook Salmon ESU (T) -  
CVSR Chinook Salmon ESU (T) - **X**  
SRWR Chinook Salmon ESU (E) - **X**  
NC Steelhead DPS (T) -  
CCC Steelhead DPS (T) -  
SCCC Steelhead DPS (T) -  
SC Steelhead DPS (E) -  
CCV Steelhead DPS (T) - **X**  
Eulachon (T) -  
sDPS Green Sturgeon (T) - **X**

**ESA Anadromous Fish Critical Habitat**

SONCC Coho Critical Habitat -  
CCC Coho Critical Habitat -



CC Chinook Salmon Critical Habitat -  
CVSR Chinook Salmon Critical Habitat - **X**  
SRWR Chinook Salmon Critical Habitat -  
NC Steelhead Critical Habitat -  
CCC Steelhead Critical Habitat -  
SCCC Steelhead Critical Habitat -  
SC Steelhead Critical Habitat -  
CCV Steelhead Critical Habitat - **X**  
Eulachon Critical Habitat -  
sDPS Green Sturgeon Critical Habitat - **X**

**ESA Marine Invertebrates**

Range Black Abalone (E) -  
Range White Abalone (E) -

**ESA Marine Invertebrates Critical Habitat**

Black Abalone Critical Habitat -

**ESA Sea Turtles**

East Pacific Green Sea Turtle (T) -  
Olive Ridley Sea Turtle (T/E) -  
Leatherback Sea Turtle (E) -  
North Pacific Loggerhead Sea Turtle (E) -

**ESA Whales**

Blue Whale (E) -  
Fin Whale (E) -  
Humpback Whale (E) -  
Southern Resident Killer Whale (E) -  
North Pacific Right Whale (E) -  
Sei Whale (E) -  
Sperm Whale (E) -

**ESA Pinnipeds**

Guadalupe Fur Seal (T) -

Steller Sea Lion Critical Habitat -

**Essential Fish Habitat**

Coho EFH -  
Chinook Salmon EFH - **X**  
Groundfish EFH - **X**  
Coastal Pelagics EFH -  
Highly Migratory Species EFH -

**MMPA Species (See list at left)**

**ESA and MMPA Cetaceans/Pinnipeds**

See list at left and consult the NMFS Long Beach office  
562-980-4000

MMPA Cetaceans -  
MMPA Pinnipeds -

**From:** Russo, Kenneth W@DOT  
**Sent:** Monday, August 14, 2017 7:18 AM  
**To:** 'nmfswcrca.specieslist@noaa.gov' <[nmfswcrca.specieslist@noaa.gov](mailto:nmfswcrca.specieslist@noaa.gov)>  
**Subject:** I Street Bridge updated NMFS list

Quad Name **Sacramento West**  
Quad Number **38121-E5**

**ESA Anadromous Fish**

- SONCC Coho ESU (T) -
- CCC Coho ESU (E) -
- CC Chinook Salmon ESU (T) -
- CVSR Chinook Salmon ESU (T) - **X**
- SRWR Chinook Salmon ESU (E) - **X**
- NC Steelhead DPS (T) -
- CCC Steelhead DPS (T) -
- SCCC Steelhead DPS (T) -
- SC Steelhead DPS (E) -
- CCV Steelhead DPS (T) - **X**
- Eulachon (T) -
- sDPS Green Sturgeon (T) - **X**

**ESA Anadromous Fish Critical Habitat**

- SONCC Coho Critical Habitat -
- CCC Coho Critical Habitat -
- CC Chinook Salmon Critical Habitat -
- CVSR Chinook Salmon Critical Habitat - **X**
- SRWR Chinook Salmon Critical Habitat - **X**
- NC Steelhead Critical Habitat -
- CCC Steelhead Critical Habitat -
- SCCC Steelhead Critical Habitat -
- SC Steelhead Critical Habitat -
- CCV Steelhead Critical Habitat - **X**
- Eulachon Critical Habitat -
- sDPS Green Sturgeon Critical Habitat - **X**

**ESA Marine Invertebrates**

Range Black Abalone (E) -

Range White Abalone (E) -

**ESA Marine Invertebrates Critical Habitat**

Black Abalone Critical Habitat -

**ESA Sea Turtles**

East Pacific Green Sea Turtle (T) -

Olive Ridley Sea Turtle (T/E) -

Leatherback Sea Turtle (E) -

North Pacific Loggerhead Sea Turtle (E) -

**ESA Whales**

Blue Whale (E) -

Fin Whale (E) -

Humpback Whale (E) -

Southern Resident Killer Whale (E) -

North Pacific Right Whale (E) -

Sei Whale (E) -

Sperm Whale (E) -

**ESA Pinnipeds**

Guadalupe Fur Seal (T) -

**Essential Fish Habitat**

Coho EFH -

Chinook Salmon EFH -

**X**

Groundfish EFH -

**X**

Coastal Pelagics EFH -

Highly Migratory Species EFH -

**MMPA Species (See list at left)**

**ESA and MMPA Cetaceans/Pinnipeds**

See list at left and consult Monica DeAngelis

[monica.deangelis@noaa.gov](mailto:monica.deangelis@noaa.gov)

562-980-3232

MMPA Cetaceans -

MMPA Pinnipeds -

Kenneth Russo  
Associate Environmental Planner,  
Natural Science (Biology)  
Caltrans District 3, Marysville, Ca.  
(530) 741-4291

**U.S. Fish and Wildlife Service Biological Opinion**



## United States Department of the Interior



FISH AND WILDLIFE SERVICE  
San Francisco Bay-Delta Fish and Wildlife Office  
650 Capitol Mall, Suite 8-300  
Sacramento, California 95814

In reply refer to:  
08FBDT00-2016-F-0227

Ms. Laura Loeffler, Branch Chief  
North Region Environmental Planning M-1  
California Department of Transportation, District 3  
703 B Street  
Marysville, CA 95901

JUN 15 2017

Subject: Formal Consultation on the I Street Bridge Replacement Project, Sacramento County, California (Fed ID# BRLS-5002 (164))

Dear Ms. Loeffler:

This letter is in response to the California Department of Transportation's (Caltrans) August 4, 2016, request to initiate formal consultation with the U.S. Fish and Wildlife Service (Service) on the I Street Bridge Replacement Project between the cities of Sacramento and West Sacramento, Sacramento and Yolo Counties, California. Caltrans determined that the proposed project may affect and is likely to adversely affect the threatened federally threatened delta smelt (*Hypomesus transpacificus*) and its critical habitat and the valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*). Caltrans' request was received by the Service on August 9, 2016. This response is provided under the authority of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*) (Act).

Fixing America's Surface Transportation Act (FAST Act) was signed into law on December 4, 2015. Providing funding from 2016 to 2020, the FAST Act includes provisions to promote streamlined and accelerated project delivery. Caltrans is approved to participate in the FAST Act project delivery program through the National Environmental Policy Act (NEPA) Assignment Memorandum of Understanding (MOU). The MOU allows Caltrans to assume the Federal Highway Administration's (FHWA) responsibilities under NEPA as well as FHWA's consultation and coordination responsibilities under Federal environmental laws for most highway projects in California. Caltrans is exercising this authority as the Federal nexus for section 7 consultation on this project.

In reviewing this project, the Service has relied upon (1) the biological assessment enclosed with the initiation letter (Caltrans 2016); (2) emails between the Service and Caltrans; and (3) other information available to the Service.

The Service has reviewed the proposed project and its effects to the delta smelt's designated critical habitat. In designating critical habitat for the delta smelt, the Service identified the following Primary Constituent Elements essential to the conservation of the species and how the project may or may not affect each Primary Constituent Element. Primary Constituent Element 1 is physical habitat for spawning. Effects to the spawning substrate are not expected to occur. Primary Constituent Element 2 is suitable water quality for all life stages. During the proposed project water in the action area may be affected through the creation of small sediment plumes (i.e., turbidity) during the pile driving above critical habitat and may be exposed to contaminants. The sediment plumes are temporary in nature and typically dissipate within the same day of activity. The sediment plumes are discountable in relation to the size of the Delta and temporary, and would not be expected to affect the overall water quality of the Delta ecosystem. Primary Constituent Element 3 is river flow. The proposed project will not affect river flow within critical habitat. Primary Constituent Element 4 is salinity for rearing and the project will not affect salinity. Based on the above analysis, the Service has determined that the proposed project is not likely to adversely affect the delta smelt's designated critical habitat.

### **Consultation History**

August 9, 2016	The Service received the Caltrans request for consultation and biological assessment.
November 2016	The Service exchanged emails with Caltrans regarding project effects.
January 10, 2017	The Service received an email from Caltrans regarding changes to the project description.
May 8, 2017	The Service received the Caltrans request for consultation on the geotechnical work to inform the design of the I Street Bridge. Prior communications with Caltrans indicated Caltrans preference for issuing bridge replacement biological opinion prior to geotechnical work even if it results in reinitiation due to changes in project description.
June 5, 2017	The Service received information regarding a project change and confirmation of impacts and proposed compensatory mitigation.

## **BIOLOGICAL OPINION**

### **Description of the Proposed Action**

The City of Sacramento (Applicant), in cooperation with the City of West Sacramento and Caltrans, proposes to construct a new bridge over the Sacramento River to replace the vehicle crossing that is current accommodated by the existing I Street bridge in order to remove a series of functionally obsolete or structurally deficient bridges (i.e. approach structures). The proposed bridge will be located approximately 1,000 feet to the north of the existing bridge connecting C Street in West Sacramento with Railyards Boulevard in Sacramento. The 860-foot-long bridge,

consisting of two vehicle lanes, on-street Class II bike lanes, and sidewalks along both sides will be located north of the existing I Street Bridge. The proposed bridge will be a five-span bridge with an approximately 330-foot-long movable center span. The proposed project will install an abutment on each bank of the river and four piers across the river to support the five-span bridge. From west to east, these support structures are referred to as Abutment 1, Pier 2, Pier 3, Pier 4, Pier 5, and Abutment 6.

Construction is expected to require 30 consecutive months beginning in Spring 2018 and ending in Summer 2020. Construction is expected to require two years of in-water construction limited to the period of May 1 to November 30 during these years. Construction is expected to require excavation, dewatering, grubbing/land clearing, earthmoving, grading, compaction, paving, auguring, pile driving, and demolition activities. Construction is expected to require a variety of heavy equipment including excavators, crawler tractors, scrapers, front end loaders, dump trucks, graders, drill rigs, impact and vibratory pile drivers, compactors, water trucks, air compressors, generators, forklifts, trenchers, pavers, hoe rams, barges, tug boats, cranes, and concrete trucks.

#### New Bridge Construction

The total bridge length will be approximately 860 feet long, consisting of a 270-foot-long approach span from the west connected to a movable 330-foot-span in the center connect to a 200-foot-long approach span from the east. The approach span from the west will cross Abutment 1 and Piers 2 and 3 and the approach span from the east will cross Abutment 6 and Piers 4 and 5. Abutments 1 and 6 will be constructed on the banks of the river, and Piers 2 and 5 will be placed within the river approximately around the existing bank toe of slope.

The abutments will consist of approximately 50 piles per abutment that are driven or cast-in-drill-hole (CIDH) to a depth of approximately 70 feet below original ground elevation. Piers 2 and 5 will consist of 50 driven or CIDH piles per pier that are approximately 70 feet below the original ground elevation. The piles will be either precast concrete or steel and the Applicant will drive these piles using an impact hammer. Piers 3 and 4 will consist of four large diameter cast-in-steel-shell piles per pier. Each pier will be 9 feet in diameter, extending approximately 140 feet below the original ground elevation and will be driven with a vibratory hammer and/or a hydraulic oscillator/rotator system. Installation of these piers will also require driving 8 temporary steel "spud" piles to a depth of 40 feet for anchoring barges used for project activities. It is anticipated that rock slope protection will be installed around the bridge abutments and piers within the water to control erosion.

#### Installation of a Fender Protection System

The Applicant will install a fender protection system around Piers 3 and 4 to protect the piers from errant watercrafts that are navigating along the river. The fender system will consist of 30 driven concrete or wooden piles around each pier. These piles will be driven to a depth of approximately 30 feet below the original ground elevation.



### Temporary Trestles and Cofferdams

The Applicant will install temporary trestles and cofferdams to construct Piers 2, 3, 4, and 5. The Applicant will construct the trestles during the first construction season using temporary piles within the river. The platform atop each trestle will include approximately 80 driven steel piles. The piles will be either 16-inch diameter or 16-inch H piles driven with an impact hammer. Once installed, the temporary trestle piles will remain in the river throughout the duration of construction. The Applicant will remove these piles in the second construction season following completion of construction.

The Applicant will construct temporary cofferdams to dewater the area to allow construction of Piers 2 and 5. The cofferdams will consist of approximately 180 sheet piles driven to a depth of 25 feet below original ground elevation using a vibratory hammer. The Applicant will remove the sheet piles comprising the cofferdams following completion of construction using a vibratory hammer.

### Demolition of Approach Spans to Existing Bridge

Following completion of the connection of Railyards Boulevard and C Street to the proposed bridge, the Applicant will remove the four existing approach structures to the existing bridge. These bridges will be demolished and the foundations would be removed to a depth of 3 feet below original ground elevation. Encroachment permits from Caltrans and Union Pacific Railroad will be needed to complete removal of these bridges. The existing bridge is owned and operated by Union Pacific Railroad and will continue to be used by trains following construction of the new bridge.

### Roadway, Bikeway, and Levee Modifications

The Applicant proposes to improve roadway access along C Street and Railyards Boulevard to the proposed bridge location. The Applicant will purchase property in the area to accommodate these improvements. These improvements include wider lanes and enhancements to bicycle and pedestrian access. The Applicant will also demolish roadways leading to the existing I Street Bridge.

The Applicant will reconstruct the existing Class I Sacramento River Parkway Bikeway along Jibboom Street approximately 500 feet to the north and 300 feet to the south of Railyards Boulevard. The Applicant will construct retaining walls along the path to account for the vertical elevation difference between Jibboom Street and a path underneath the proposed bridge.

The Applicant will improve the existing levee along the West Sacramento side of the river. The existing levee does not meet current standards required by Title 23 of the California Code of Regulations. The Applicant will reconstruct the levee cross-section approximately 300 feet to the north and south of the proposed C Street alignment. The levee improvements will include a slurry cutoff wall extending to a depth of 110 feet below original ground elevation. The Applicant will also construct access roads from the new roadway to the top of the improved levee

section to maintain access to the levee. The proposed grading for the levee will require relocation of an existing water tower located along 2<sup>nd</sup> street. This new levee maintenance road will also serve as a future extension to the Class I River Walk Park bikeway.

### Staging and Storage during Construction

The Applicant will use two staging areas to store materials and equipment during construction, such as pipe materials, precast manholes and drop inlets, steel girders, piles, and rebar, along with construction equipment when not in use. One area will be located south of Railyards Boulevard under Interstate 5 in Sacramento. The other area will be located in West Sacramento west of the landward site of the levee and south of the new bridge location. The Applicant will use the staging areas throughout the duration of construction and return the areas to their pre-project conditions at the completion of the project.

### General Conservation Measures

#### *Measure 1: Install Barrier Fencing between the Construction Area and Sensitive Biological Resources*

The Applicant will install orange construction barrier fencing around sensitive areas as one of the first orders of work and prior to equipment staging. Before construction begins, the Applicant will work with the project engineer and a resource specialist to identify the locations for the barrier fencing and place stakes around sensitive sites to indicate these locations. The protected areas will be designated as environmentally sensitive areas and clearly identified on the construction plans and described in the specifications. To minimize the potential for snakes and other ground-dwelling animals from being caught in the barrier fencing, the fencing will be placed with at least a 1-foot gap between the ground and the bottom of the barrier fencing. The exception to this condition is where barrier fencing overlaps with erosion control fencing and must be secured to prevent sediment runoff. Barrier fencing will be installed before construction activities are initiated, maintained throughout the construction period, and removed after completion of construction.

#### *Measure 2: Conduct Environmental Awareness Training for Construction Employees*

The Applicant will retain a qualified biologist to conduct environmental awareness training for construction crews before project implementation. The awareness training will be provided to all construction personnel and would brief them on the need to avoid effects on sensitive biological resources (e.g., native trees, natural communities of special concern, and special-status species habitats in and adjacent to the construction area). The education program will include a brief review of the special-status species with the potential to occur in Caltrans' biological study area (BSA) (including their life history, habitat requirements, and photographs of the species). The training will identify the portions of the BSA in which the species may occur, as well as their legal status and protection.

The program also will cover the restrictions and guidelines that would be followed by all construction personnel to reduce or avoid effects on these species during project implementation. This will include the steps to be taken if a sensitive species is found within the construction area (i.e., notifying the crew foreman, who would call a qualified biological monitor). In addition, construction employees will be educated about the importance of controlling and preventing the spread of invasive plant infestations. An environmental awareness handout that describes and illustrates sensitive resources to be avoided during project construction and identifies all relevant permit conditions would be provided to each crew member. The crew foreman would be responsible for ensuring that crew members adhere to the guidelines and restrictions. Education programs would be conducted for appropriate new personnel as they are brought on the job during the construction period.

*Measure 3: Conduct Periodic Biological Monitoring*

The Applicant will retain a qualified biological monitor for the project who will visit the site a minimum of once per week to ensure that fencing around environmentally sensitive areas is intact and that activities are being conducted in accordance with the agreed upon project schedule and agency conditions of approval. The monitor will provide the Applicant with a monitoring log for each site visit.

Conservation Measures for the Valley Elderberry Longhorn Beetle

*Measure 4: Avoid and Minimize Impacts on Valley Elderberry Longhorn Beetle*

The following will be implemented prior to and during construction to ensure effects to valley elderberry longhorn beetles are minimized:

- Consistent with Measure 2, contractors will be briefed on the need to avoid damaging the elderberry plants and the possible penalties for not complying with these requirements. Crews also will be educated on the status of the valley elderberry longhorn beetle and the need to protect its habitat.
- All elderberry shrubs that are outside of the permanent project footprint or that can be avoided will be identified on construction drawings, with notes indicating that they are sensitive resources to be avoided.
- Consistent with Measure 1, orange construction barrier fencing will be placed at a minimum of 20 feet from each shrub's dripline or as far out from the dripline as possible. No construction activities will be permitted within the buffer zone other than those activities necessary to erect the fencing. As specified in the Conservation Guidelines for the Valley Elderberry Longhorn Beetle (Guidelines) (Service 1999), signs will be posted every 50 feet (at a minimum) along the perimeter of the buffer area fencing. The signs will contain the following information: This area is habitat of the Valley Elderberry Longhorn Beetle, a threatened species, and must not be disturbed. This species is protected by the Endangered Species Act of 1973, as amended. Violators are subject to

prosecution, fines, and imprisonment. The signs should be clearly readable from a distance of 20 feet and must be maintained for the duration of construction.

- Consistent with Measure 3, buffer area fences around the shrubs will be inspected weekly by a biological monitor during ground-disturbing activities and monthly after ground-disturbing activities until project construction is complete or until the fences are removed, as approved by the biological monitor. The biological monitor will check that the contractor is maintaining the buffer area fences around elderberry shrubs throughout construction. Biological inspection reports would be provided to the Service and the Applicant.

#### *Measure 5: Transplant Elderberry Shrubs That Cannot Be Avoided*

Elderberry shrubs that cannot be avoided would be transplanted to a Service-approved conservation area in accordance with the Guidelines. Transplanting will occur during the plant's dormant phase (approximately November through the first 2 weeks of February, after they have lost their leaves). A qualified biologist that is familiar with elderberry shrub transplantation procedures will supervise the transplanting. The location of the conservation area transplantation site will be approved by the Service before removal of the shrubs.

#### *Measure 6: Compensate for Impacts on Valley Elderberry Longhorn Beetle*

Before construction begins, the project proponent will compensate for direct impacts (including transplanting) on all elderberry stems measuring 1 inch or more at ground level (i.e., habitat for the valley elderberry longhorn beetle) that are located within 20 feet of proposed construction activities. Compensation will include planting replacement elderberry seedlings or cuttings and associated native plantings in a Service-approved conservation area, at a ratio between 1:1 and 8:1 (ratio = new plantings to affected stems), depending on the diameter of the stem at ground level, the presence or absence of exit holes, and whether the shrub is located in riparian habitat (Service 1999).

Mitigation credits for impacts to valley elderberry longhorn beetle habitat would be purchased at a Service-approved mitigation bank. There are three mitigation banks listed on the Service website that sell valley elderberry longhorn beetle credits and have service areas that overlap the project area. These banks are: French Camp Conservation Bank, Laguna Creek Conservation Bank, and River Ranch Conservation Bank. The Applicant would plant 34 elderberry seedlings and 34 associated native plants in a Service-approved conservation area.

#### Conservation Measures for the Delta Smelt

#### *Measure 7: Conduct All In-Water Construction Activities between May 1 and November 30 and during Daylight Hours Only*

The Applicant will conduct all in-water construction work and pile driving (in-water and shore-based within 250 feet of the Sacramento River), installation of cofferdams, removal of temporary

sheet piles, and placement of rock revetment between May 1 and November 30 to avoid or minimize causing disturbance and injury to, or mortality of, special-status fish species in the affected reaches of the Sacramento River. In addition, in-water work will be conducted during daylight hours only to provide fish in the affected reaches of the Sacramento River with an extended quiet period during nighttime hours for feeding and unobstructed passage.

*Measure 8: Implement Measures to Minimize Exceedance of Interim Threshold Sound Levels during Pile Driving*

The Applicant will require the contractor to implement the following measures, developed in coordination with project design engineers, to minimize the exposure of listed fish species to potentially harmful underwater sounds:

- The contractor will vibrate all piles to the maximum depth possible before using an impact hammer.
- No more than 20 piles will be driven per day, and pile driving with an impact hammer will occur on no more than 75 individual days total during construction.
- During impact driving, the contractor will limit the number of strikes per day to the minimum necessary to complete the work and would limit the total number of hammer strikes to 16,000 strikes per day (i.e., 800 hammer strikes per pile, per day) for piles for the bridge piers and temporary trestles, and 20,000 strikes per day (i.e., 1,000 hammer strikes per pile, per day) for the piles for the bridge fender system. The smallest pile driver and minimum force necessary will be used to complete the work.
- During impact driving, the Applicant will require the contractor to use a bubble curtain or similar device to minimize the extent to which the interim peak and cumulative Sound Exposure Level (SEL) thresholds are exceeded.
- No pile driving activity will occur at night, thereby providing fish with an extended quiet period during nighttime hours on days pile driving is being conducted for feeding and unobstructed passage.

*Measure 9: Develop and Implement a Hydroacoustic Monitoring Plan*

The Applicant and/or their construction contractor will develop and implement a hydroacoustic monitoring plan. The monitoring plan will be submitted to the resource agencies (California Department of Fish and Wildlife [CDFW], National Marine Fisheries Service [NMFS], and the Service) for approval at least 60 days before the start of project activities. The plan will include the following requirements:

- The Applicant and/or its construction contractor will monitor underwater noise levels during all impact pile driving activities on land and in water to ensure that peak and

cumulative SELs do not exceed estimated values in Table 4-4 of the biological assessment.

- The monitoring plan will describe the methods and equipment that would be used to document the extent of underwater sounds produced by pile driving, including the number, location, distances, and depths of the hydrophones and associated monitoring equipment. The monitoring plan will include a reporting schedule for daily summaries of the hydroacoustic monitoring results and for more comprehensive reports to be provided to the resource agencies on a monthly basis during the pile driving season. The daily reports will include the number of piles installed per day; the number of strikes per pile; the interval between strikes; the peak sound pressure level (SPL) and accumulated SEL per strike; and the accumulated SEL per day at each monitoring station.
- The Applicant or its contractors will ensure that a qualified fish biologist is on site during impact pile driving to document any occurrences of stressed, injured, or dead fish. If stressed, injured, or dead fish are observed during pile driving, the Applicant and/or its construction contractor will reduce the number of strikes per day to ensure that fish are no longer showing signs of stress, injury, or mortality.

*Measure 10: Protect Water Quality and Prevent Erosion and Sedimentation in Drainages and Wetlands*

The Applicants and/or their construction contractor would comply with all construction site Best Management Practices (BMPs) specified in the Water Quality Assessment Report prepared for the project (ICF 2015) and the final Storm Water Pollution Prevention Plan (SWPPP) that would be developed for the project, as well as any other permit conditions to minimize introduction of construction-related contaminants and mobilization of sediment in the Sacramento River and the riparian forest/shrub wetland. Broadly, these BMPs would address soil stabilization, sediment control, wind erosion control, vehicle tracking control, non-storm water management, and waste management practices. The BMPs will be based on the best conventional and best available technology. Refer to the biological assessment for further details for Measure 10.

*Measure 11: Monitor Turbidity in the Sacramento River*

The Applicant will require the construction contractor to monitor turbidity levels in the Sacramento River during in-water construction activities (e.g., pile driving, extraction of temporary sheet piles used for cofferdams, placement of rock slope protection [RSP])). Turbidity will be measured using standard techniques upstream and downstream of the construction area to determine whether changes in ambient turbidity levels exceed 20%, the threshold derived from the Sacramento and San Joaquin Rivers Basins Plan (Central Valley Regional Water Quality Control Board 2011). If it is determined that turbidity levels exceed the 20% threshold, then the Applicant and/or its contractors would adjust work to ensure that turbidity levels do not exceed the 20% threshold.

*Measure 12: Implement Cofferdam Restrictions*

The following restrictions will be implemented during installation of the cofferdams and cofferdam dewatering:

- The extent of cofferdam footprints will be limited to the minimum necessary to support construction activities.
- Sheet piles used for cofferdams will be installed and removed using a vibratory pile driver.
- Cofferdams will be installed and removed only during the proposed in-water work window (between May 1 and November 30).
- Cofferdams will not be left in place over winter where they could be overtopped by winter/spring flows and when listed species are most likely to be present in the construction area.
- All pumps used during dewatering of cofferdams will be screened according to CDFW and NMFS guidelines for screens. Cofferdam dewatering and fish rescue/relocation from within cofferdams will commence immediately following cofferdam closure.

*Measure 13: Prepare and Implement a Fish Rescue and Relocation Plan*

The Applicant and/or their construction contractor will develop and implement a fish rescue and relocation plan to recover any fish trapped in cofferdams. The fish rescue and relocation plan would be submitted to the resource agencies (CDFW, NMFS, and the Service) for approval at least 60 days before initiating activities to install cofferdams. At a minimum, the plan will include the following:

- A requirement that fish rescue and relocation activities will commence immediately after cofferdam closure and that dewatering has sufficiently lowered water levels inside cofferdams to make it feasible to rescue fish.
- A description of the methods and equipment proposed to collect, transfer, and release all fish trapped within cofferdams. Capture methods may include seining, dip netting, and/or electrofishing as approved by CDFW, NMFS, and the Service. The precise methods and equipment to be used would be developed cooperatively by CDFW, NMFS, the Service, and the Applicant and/or contractor.
- A requirement that only CDFW-, NMFS-, and Service-approved fish biologists will conduct the fish rescue and relocation.

- A requirement that fish biologists will contact CDFW, NMFS, and the Service immediately if any listed species are found dead or injured.
- A requirement that a fish rescue and relocation report be prepared and submitted to CDFW, NMFS, and the Service within 5 business days following completion of the fish relocation. Data will be provided in tabular form and at a minimum will include the species and number rescued and relocated, approximate size of each fish (or alternatively, approximate size range if large number of individuals are encountered), date and time of their capture, and general condition of all live fish (e.g., good–active with no injuries; fair–reduced activity with some superficial injuries; poor–difficulty swimming/orienting with major injuries). For dead fish, additional data will include fork length and description of injuries and/or possible cause of mortality if it can be determined.

*Measure 14: Prevent the Spread or Introduction of Aquatic Invasive Species*

The Applicant or their contractors will implement the following actions to prevent the potential spread or introduction of aquatic invasive species (AIS) associated with the operation of barges and other in-water construction activities. Species of concern related to the operation of barges and other equipment in the lower Sacramento River include invasive mussels (e.g., quagga mussels [*Dreissena bugensis*] and zebra mussels [*Dreissena polymorpha*]) and aquatic plants (e.g., Brazilian waterweed [*Egeria densa*] and hydrilla [*Hydrilla verticillata*]) (California Department of Fish and Game 2008).

The Applicant or their contractors will coordinate with the CDFW's Invasive Species Program to ensure that the appropriate BMPs are implemented to prevent the spread or introduction of AIS. Educate construction supervisors and managers about the importance of controlling and preventing the spread of AIS. Train vessel and equipment operators and maintenance personnel in the recognition and proper prevention, treatment, and disposal of AIS.

To the extent feasible, prior to departure of vessels from their place of origin and before in-water construction equipment is allowed to operate within the waters of the Sacramento River, the Applicant or their contractors will thoroughly inspect and remove and dispose of all dirt, mud, plant matter, and animals from all surfaces that are submerged or may become submerged, or places where water can be held and transferred to the surrounding water.

*Measure 15: Minimize or Avoid Temporary Construction Lighting and Permanent Bridge Lighting from Directly Radiating on Water Surfaces of the Sacramento River*

The Applicant will minimize or avoid the effects of nighttime lighting on special-status fish species by implementing the following actions:

Temporary Construction Lighting

- Avoiding construction activities at night, to the maximum extent practicable.
- Using the minimal amount of lighting necessary to safely and effectively illuminate the



work areas.

- Shielding and focusing lights on work areas and away from the water surface of the Sacramento River, to the maximum extent practicable.

#### Permanent Bridge Lighting

- Minimizing nighttime lighting of the bridge structure for aesthetic purposes.
- Using the minimal amount of lighting necessary to safely and effectively illuminate vehicular, bicycle, and pedestrian areas on the bridge.
- Shielding and focusing lights on vehicular, bicycle, and pedestrian areas and away from the water surface of the Sacramento River, to the maximum extent practicable.

#### *Measure 16: Compensate for Permanent Loss of Shallow Water Habitat for Delta Smelt*

Permanent impacts on shallow water habitat for delta smelt, totaling 0.036 acre, will be mitigated at a 3:1 ratio. The Applicant proposes to compensate for the permanent loss of shallow water habitat through the purchase of 0.108 acre of mitigation credits at a Service-approved mitigation bank, such as the Liberty Island Conservation Bank, to offset the project's impact.

#### **Action Area**

The Action area is defined in 50 CFR § 402.02, as “all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action.” For the proposed project, the Service considers the action area to include the approximately 42-acre BSA described in the biological assessment and portions of the Sacramento River that may be affected by elevated turbidity, sediment deposition, and underwater noise generated by in- and near-water construction activities.

Because pile driving effects are anticipated to extend beyond water quality effects (with BMPs in place), the action area includes areas both upstream and downstream from pile driving activity where pile driving noise may have a physical or behavioral effect on delta smelt. Based on the analysis, in the biological assessment, of sound expected to be generated by pile driving the action area for this project also includes the entire width of the Sacramento River channel 7,400 feet upstream and 7,600 feet downstream of the proposed bridge crossing (i.e., from approximately River Mile 58 to approximately River Mile 61) extending out 2,000 feet beyond the straight line.

#### **Analytical Framework for the Jeopardy Determination**

Section 7(a)(2) of the Act requires that Federal agencies ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of listed species. “Jeopardize the continued existence of” means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and

recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR § 402.02).

The jeopardy analysis in this biological opinion considers the effects of the proposed Federal action, and any cumulative effects, on the rangewide survival and recovery of the listed species. It relies on four components: (1) the Status of the Species, which describes the rangewide condition of the species, the factors responsible for that condition, and its survival and recovery needs; (2) the Environmental Baseline, which analyzes the condition of the species in the action area, the factors responsible for that condition, and the relationship of the action area to the survival and recovery of the species; (3) the Effects of the Action, which determines the direct and indirect impacts of the proposed Federal action and the effects of any interrelated or interdependent activities on the species; and (4) the Cumulative Effects, which evaluates the effects of future, non-Federal activities in the action area on the species.

## **Status of the Species**

### Delta Smelt

#### Legal Status

The Service proposed to list the delta smelt as threatened with proposed critical habitat on October 3, 1991 (Service 1991). The Service listed the delta smelt as threatened on March 5, 1993 (Service 1993), and designated critical habitat for the species on December 19, 1994 (Service 1994). The delta smelt was one of eight fish species addressed in the *Recovery Plan for the Sacramento–San Joaquin Delta Native Fishes* (Service 1996), which is currently under revision. A 5-year status review of the delta smelt was completed on March 31, 2004 (Service 2004). The 2004 review concluded that delta smelt remained a threatened species. A subsequent 5-year status review recommended uplisting delta smelt from threatened to endangered (Service 2010a). A 12-month finding on a petition to reclassify the delta smelt as an endangered species was completed on April 7, 2010 (Service 2010b). After reviewing all available scientific and commercial information, the Service determined that re-classifying the delta smelt from a threatened to an endangered species was warranted but precluded by other higher priority listing actions (Service 2010c). The Service annually reviews the status and uplisting recommendation for delta smelt during its Candidate Notice of Review (CNOR) process. Each year, the CNOR has recommended the uplisting from threatened to endangered. Electronic copies of these documents are available at [http://ecos.fws.gov/docs/five\\_year\\_review/doc3570.pdf](http://ecos.fws.gov/docs/five_year_review/doc3570.pdf) and <http://www.gpo.gov/fdsys/pkg/FR-2013-11-22/pdf/2013-27391.pdf> (Service 2010a; Service 2010b).

#### Description and Life Cycle

The delta smelt is a small fish of the family Osmeridae. It is endemic to the San Francisco Bay-Delta where it primarily occupies open-water habitats in Suisun Bay and marsh and the Sacramento-San Joaquin Delta. The delta smelt is primarily an annual species, meaning that it completes its life cycle in one year which typically occurs from April to the following April,

within a 1-2 month buffer. In captivity delta smelt can survive to spawn at two years of age (Lindberg *et al.* 2013), but this appears to be rare in the wild (Bennett 2005). Very few individuals reach lengths over 3.5 inches (90 millimeters [mm]).

### Population Numbers

Currently, the spawning stock of delta smelt appears to be at its second lowest abundance on record, the lowest having been recorded during WY 2016 (Table 1). The 2016 Fall Mid water Trawl (FMWT) Index was 8, the second lowest value on record. The California Department of Fish and Wildlife's (CDFW) Spring Kodiak Trawl (SKT) monitors the adult spawning stock of delta smelt and serves as an indication for the relative number and distribution of spawners in the system. The Service has calculated an absolute abundance estimate<sup>1</sup> for adult spawners in water year 2017 using January and February SKT data. This absolute abundance estimate is also the second lowest on record (Table 1). The population size of adult delta smelt January-February (2017) was estimated to be between 22,000 and 92,000 fish with a point estimate of 47,786. The January-February (2016) point estimates were the lowest values since 2002 and suggested delta smelt experienced increased mortality during extreme drought conditions occurring during 2013-2015. While 2017 estimates likely represent an increase in recruitment and survival from the prior year, the continued low parental stock of delta smelt relative to historical numbers suggest the population will continue to be vulnerable to stochastic events and operational changes that may occur in response until successive years of increased population growth result in a substantial increase of abundance.

**Table 1. Three indicators of adult delta smelt status for water years 2002-2017. Column 2 is the CDFW Fall Mid water Trawl Index by water year (i.e., the indices for calendar years 2001-2016). Column 3 is the CDFW Spring Kodiak Trawl Index. Column 4 is an estimate of adult delta smelt abundance during January and February that the Service calculates from the Spring Kodiak Trawl Survey.**

Water Year	FMWT Index (unitless)	SKT Index (unitless)	Jan-Feb SKT abundance estimate (thousands of fish)
2002	603	N/A	739.8
2003	139	N/A	634
2004	210	99.7	654.5
2005	74	52.9	477.8
2006	26	18.2	186.8
2007	41	32.5	292
2008	28	24.1	325.3
2009	23	43.8	365.9
2010	17	27.4	169.4
2011	29	18.8	290.8

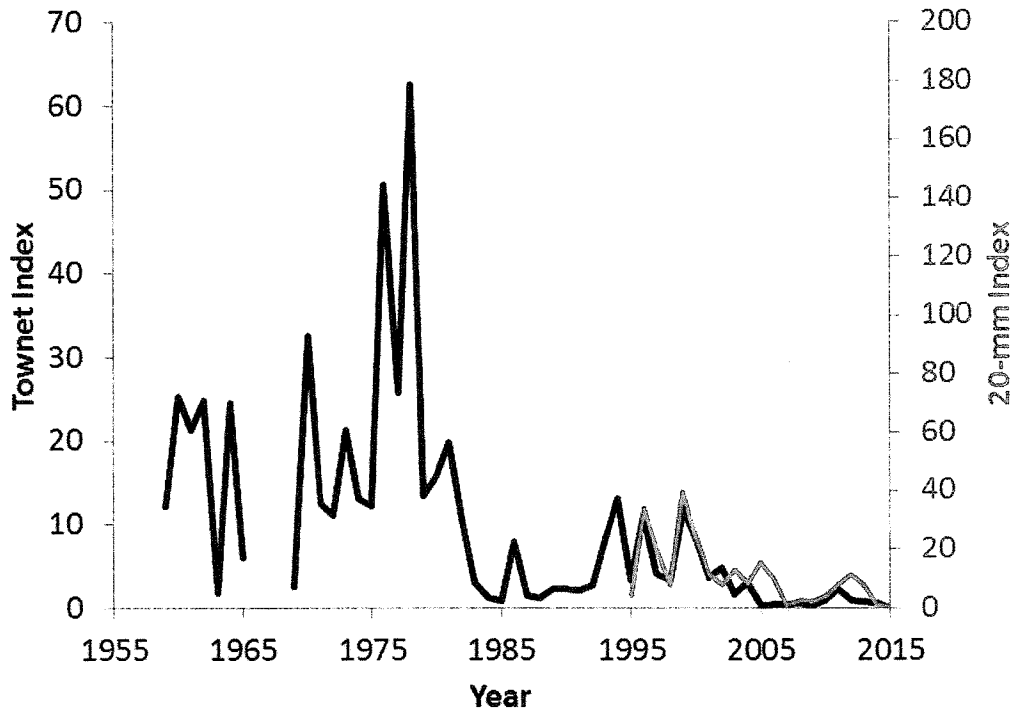
<sup>1</sup> The Service completed a new adult delta smelt abundance estimation procedure based on CDFW's SKT data for January and February (see Table 1). This procedure has recently been updated from that used in 2016. While these estimates likely represent a minimum population size due to the method's reliance on survey data, this is our current best estimate of population size.

2012	343	130.2	772.3
2013	42	20.4	212.5
2014	18	30.1	207.6
2015	9	13.8	139.3
2016	7	1.8	16.2
2017	8	3.8	47.8

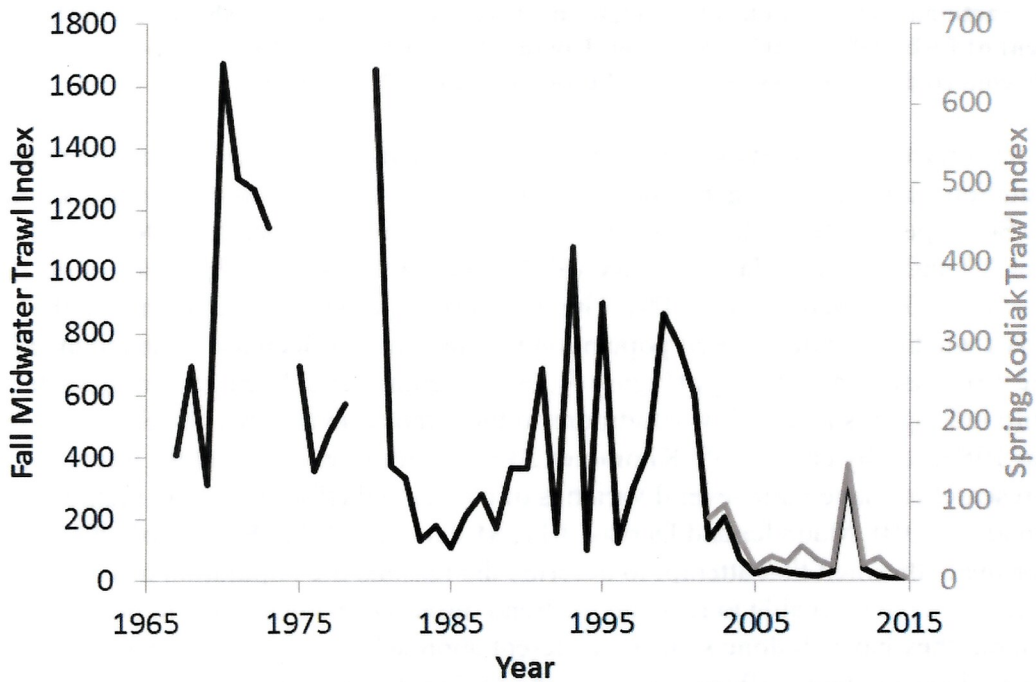
In addition to the abundance estimates, the CDFW conducts four fish surveys from which it develops indices of delta smelt's relative abundance (Figures 3-1 and 3-2). Each survey has variable and unquantified capture efficiency, and in each, the frequency of zero catches of delta smelt is very high, largely due to the species' rarity (*e.g.*, Latour 2015; Polansky *et al.* in review). The [summer] Towntnet Survey (TNS) is the longest running indicator of delta smelt relative abundance; it has been conducted since 1959. Although this survey was designed to index the relative abundance of metamorphosing juvenile striped bass (*Morone saxatilis*) (Turner and Chadwick 1972), delta smelt have been collected incidentally; most of the delta smelt captured are age-0 and about 20-40 mm in length (Miller 2000). The FMWT is the second longest running indicator of delta smelt relative abundance; it has been conducted since 1967. This survey was also designed to index the relative abundance of age-0 striped bass (Stevens 1977), but as with the TNS, delta smelt are collected incidentally (Stevens and Miller 1983). Most of the delta smelt captured by the FMWT are age-0 "subadults" and are about 50-70 mm in length (Sweetnam 1999). The 20-mm Survey is the third longest running indicator of delta smelt relative abundance; it has been conducted since 1995. This survey was designed to monitor the distribution of late larval or metamorphosing juvenile delta smelt to assess their distribution and risk of entrainment into the large water export diversions of the Central Valley Project (CVP) and State Water Project (SWP) (Dege and Brown 2004). As its name suggests, most of the delta smelt collected by the 20-mm Survey are about 10-30 mm in length, with a peak catch of fish just under 20 mm (Kimmerer 2008). The newest indicator of delta smelt relative abundance is the SKT, which has been conducted since 2002. This survey was designed to monitor the distribution of pre-spawn and spawning adult delta smelt to assess their distribution and risk of entrainment. Most of the delta smelt captured in the SKT are 60-80 mm in length (Bennett 2005).

The TNS and FMWT abundance indices for delta smelt have documented the species' long-term decline, while the newer 20-mm and SKT abundance indices have generally confirmed the recent portions of the trends implied by the older surveys (Figures 3-1 and 3-2). During the period of record, juvenile delta smelt relative abundance has declined from peak levels observed during the latter 1970s (Figure 3-1), while subadult relative abundance was at its highest in 1970 and again in 1980 (Figure 3-2). Juvenile and subadult abundance indices both declined rapidly during the early 1980s, increased somewhat during the 1990s, and then collapsed in the early 2000s. Since 2005, the TNS and the FMWT have produced indices that reflect less year to year variation than their 20-mm and SKT analogs, but overall, the trends in both sets of indices are similar. During the past decade, each index has frequently reached new record low levels. The TNS index was 0.0 in 2015 and 2016, and the 2015 FMWT index and subsequent 2016 SKT index were record lows (about one half of one percent of the relative abundance recorded in 1970-1971).

The abundance of adult delta smelt may have exceeded twenty million in 1980-1981 (Rose *et al.* 2013b). This may sound like a large number – and it is compared to the contemporary estimates listed in Table 1. However, decades of monitoring by CDFW has shown that the delta smelt has usually not been very abundant when compared to other pelagic (meaning offshore-oriented or open-water) fishes (Figure 4). In the TNS, delta smelt catches have usually been lower than age-0 striped bass, and in recent years, also lower than gobies and threadfin shad. In the FMWT, delta smelt catches have been persistently lower than at least five other species. Research and monitoring in shallower habitats like Suisun Marsh (Moyle 1986; Matern *et al.* 2002), Delta

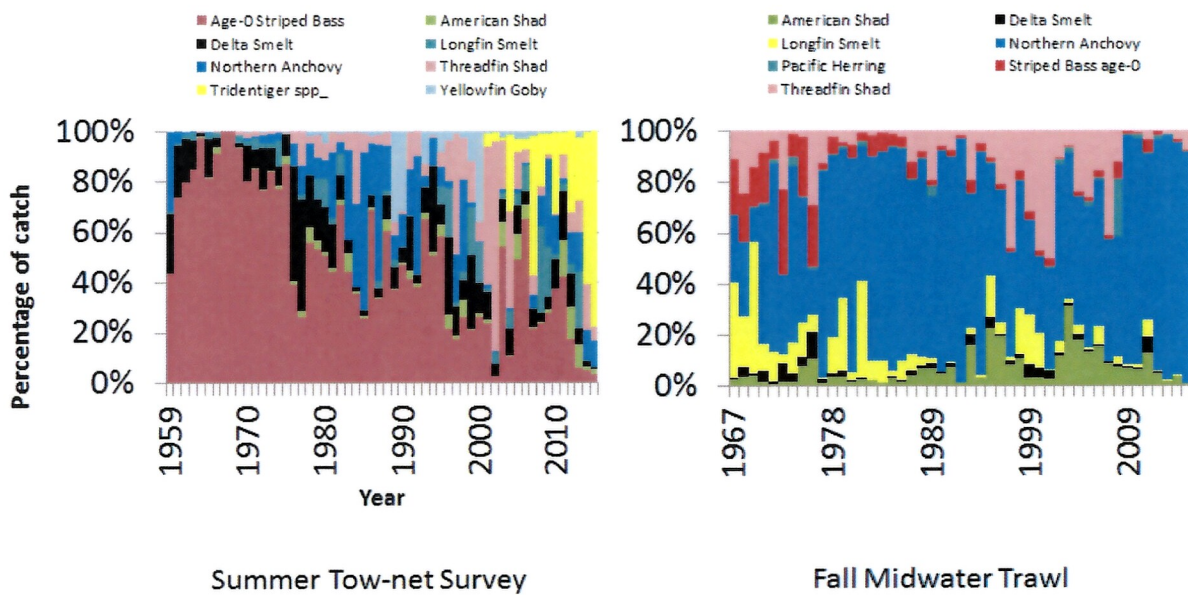


**Figure 3-1. Time series of the California Department of Fish and Wildlife’s Summer Townet Survey (black line; primary y-axis) and 20-mm Survey (gray line; secondary y-axis) abundance indices for delta smelt.**



**Figure 3-2. Time series of the California Department of Fish and Wildlife’s Fall Midwater Trawl (black line; primary y-axis) and Spring Kodiak Trawl (gray line; secondary y-axis) abundance indices for delta smelt.**

beaches (Nobriga *et al.* 2005), and small tidal marshes in the upper estuary (Gewant and Bollens 2012) have reported even lower relative abundances of delta smelt. In each of the studies cited, the catches of delta smelt represented less than one percent of the total fish catch and there were usually more than a dozen more abundant fish species.



Summer Tow-net Survey

Fall Midwater Trawl

**Figure 4. Fractional compositions of the eight most frequently collected fish species in the California Department of Fish and Wildlife's Summer Tow-net Survey (1959-2015), and the seven most frequently collected fish species in the Fall Midwater Trawl (1967-2015).**

The long-term rarity of the delta smelt has had a consequence for understanding the reasons for their population decline, which generates uncertainty about how resource managers should intervene. Some pelagic fishes have shown long-term relationships between Delta inflow, Delta outflow, or X2 and their abundance or survival (Stevens and Miller 1983; Jassby *et al.* 1995; Kimmerer 2002a; Kimmerer *et al.* 2009). There does seem to be some difference in the likelihood of whether the delta smelt population will increase or decrease in abundance from one year to the next based on hydrology (Figure 5), but there has never been any predictable relationship linking freshwater flow conditions to the relative abundance of delta smelt (Stevens and Miller 1983; Jassby *et al.* 1995; Kimmerer 2002a; Kimmerer *et al.* 2009). Recently, several teams of researchers have built several varieties of conceptual (IEP 2015) and mathematical (Thomson *et al.* 2010; Maunder and Deriso 2011; Miller *et al.* 2012; Rose *et al.* 2013a) life cycle models for the delta smelt that attempt to describe the reasons the population has declined. Some of these models have been able to recreate the trend observed in abundance indices very well (Figure 6), but they have all done so using different approaches and different variables to do so. Collectively, these modeling efforts have been helpful in that they generally support water temperature and changes in the estuary's food web as 'universally supported' factors affecting delta smelt. However, they have also come to very different conclusions about the conservation value of more readily manageable factors like water project operations.

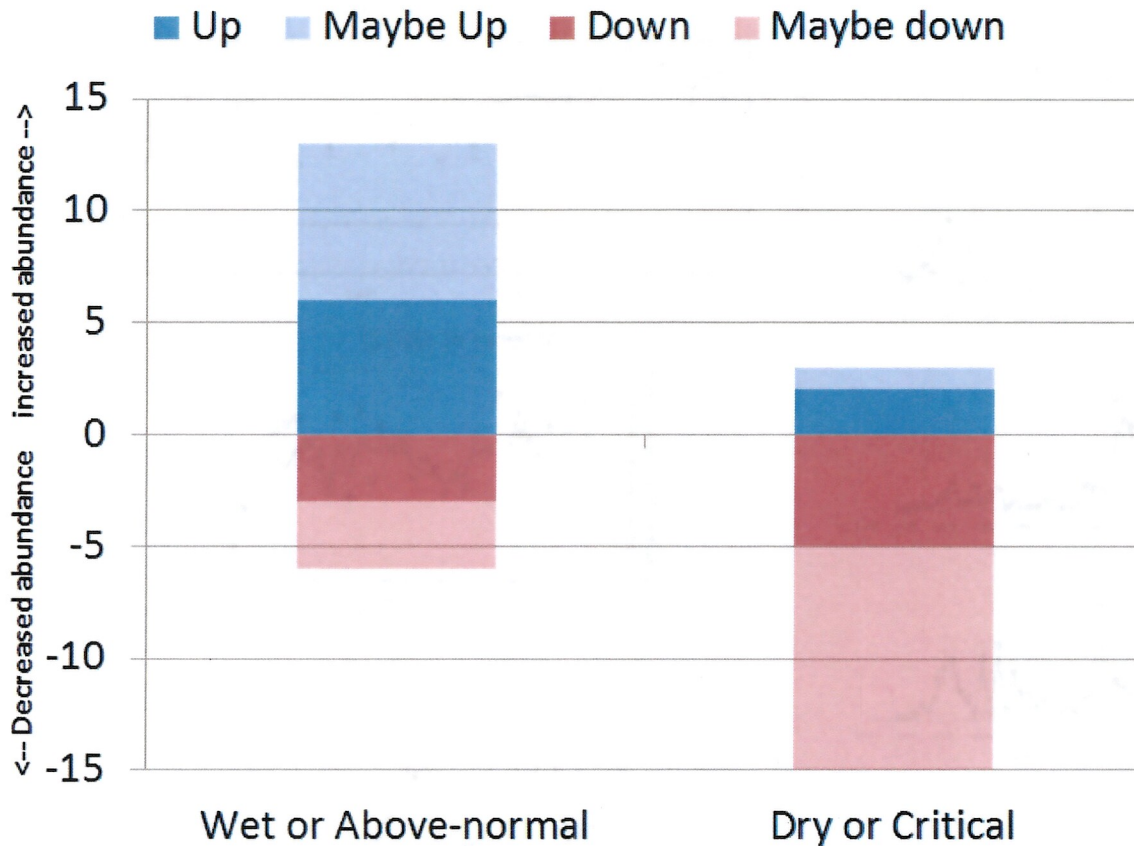
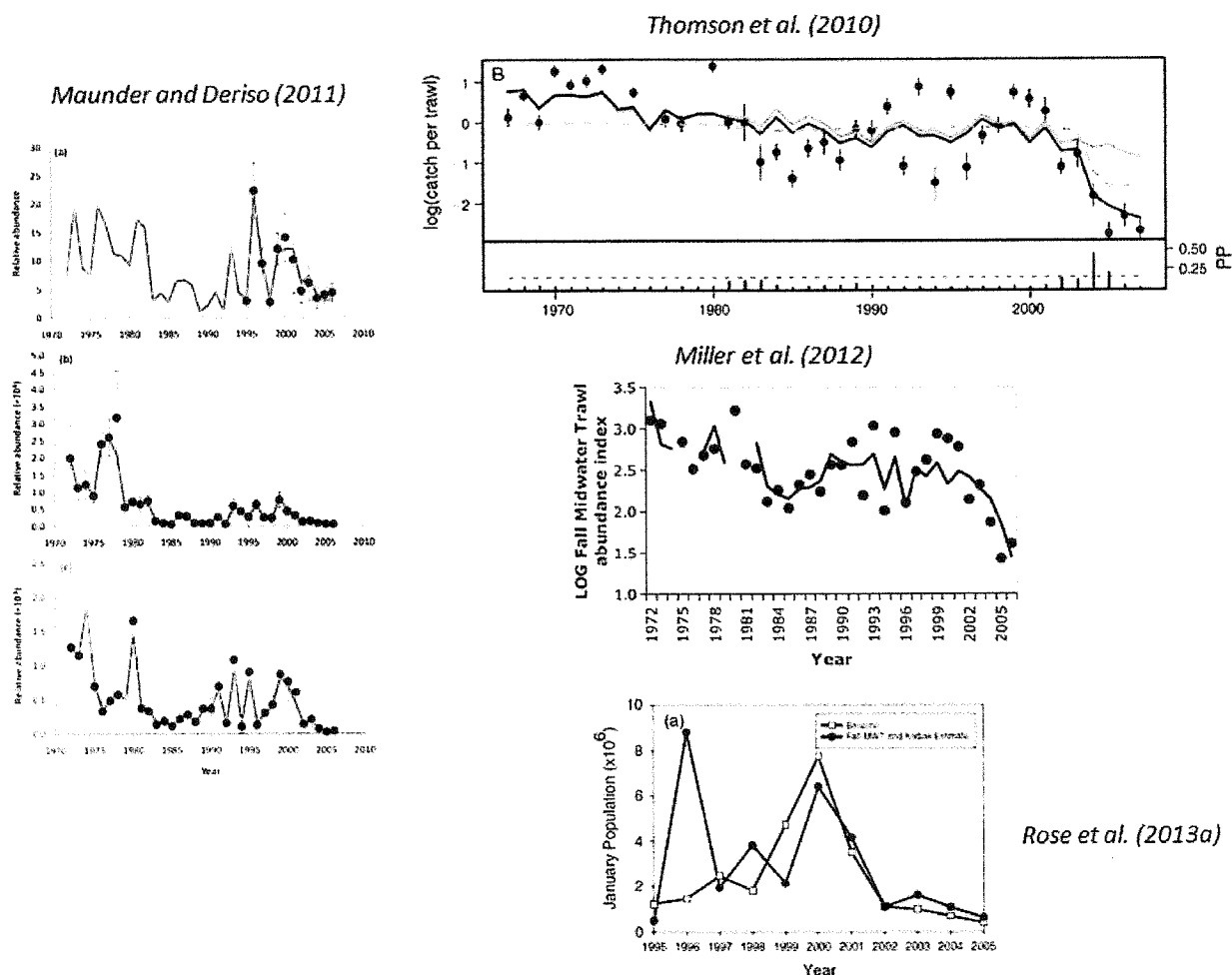


Figure 5. Frequencies of delta smelt population increases or decreases (red colored portions of each bar occurring below zero) based on the California Department of Fish and Wildlife’s Fall Midwater Trawl Survey, 1967-2015. A population increase reflects an increase in relative abundance over the prior year’s index and a population decrease reflects a decrease in relative abundance compared to the prior year’s index. The Service performed bootstrap resampling on each year’s catch per tow to generate a mean catch per tow with 95 percent confidence intervals. This resulted in four possible outcomes: (1) a statistically significant increase in relative abundance from one year to the next in which the confidence intervals of the two years did not overlap (“Up”; solid blue bar segments), (2) a statistically non-significant increase in relative abundance from one year to the next in which the confidence intervals of the two years overlapped (“Maybe Up”; lighter blue bar segments), (3) a statistically significant decrease in relative abundance from one year to the next in which the confidence intervals of the two years did not overlap (“Down”; solid red bar segments), or (4) a statistically non-significant decrease in relative abundance from one year to the next in which the confidence intervals of the two years overlapped (“Maybe Down”; lighter red bar segments). The counts in each of the four categories were combined by Sacramento Valley Water Year Types except that below-normal years were not plotted. The frequencies of population decline were converted into a negative number so that population increases would count up from the zero line on the y-axis and population decreases would count down from the zero line.





**Figure 6.** Examples of recent published model fits to time series of delta smelt relative abundance data. The source of each is referenced above or alongside each time series. In each plot, observed catches are depicted as black dots and model predictions of the data as gray or black lines. Model predictions from Rose *et al.* (2013a) are a black line with open symbols. In Maunder and Deriso (2011), the three panels represent the 20-mm Survey, Summer Tow-net Survey, and Fall Midwater Trawl (FMWT) Survey from top to bottom, respectively. The other three studies are fit to estimates of adult delta smelt relative abundance (FMWT catch in Thomson *et al.* 2010 and the FMWT index in Miller *et al.* 2012) or absolute abundance (Rose *et al.* 2013a). See each study for further details on Methods, Results, and the authors’ interpretations of their Results.

Habitat and Distribution

Because the delta smelt only lives in one part of one comprehensively monitored estuary, its general distribution is well understood (Moyle *et al.* 1992; Bennett 2005; Hobbs *et al.* 2006; 2007; Feyrer *et al.* 2007; Nobriga *et al.* 2008; Kimmerer *et al.* 2009; Merz *et al.* 2011; Murphy and Hamilton 2013; Sommer and Mejia 2013). There are both location-based (*e.g.*, Sacramento River around Decker Island) and conditions-based (low-salinity zone) habitats that delta smelt permanently occupy. There are habitats that delta smelt occupy seasonally (*e.g.*, for spawning), and there are habitats that delta smelt occupy transiently, which we define here as occasional

seasonal use. These include distribution extremes from which delta smelt are not collected every year or even in most years.

Most delta smelt complete their entire life cycle within or immediately upstream of the estuary's low-salinity zone. The low-salinity zone is frequently defined as waters with a salinity range of about 0.5 to 6 parts per thousand (ppt) (Kimmerer 2004). The 0.5 to 6 ppt and similar salinity ranges reported by different authors were chosen based on analyses of historical peaks in phytoplankton and zooplankton abundance, but recent physiological and molecular biological research has indicated that the salinities that typify the low-salinity zone are also optimal for delta smelt (Komoroske *et al.* 2016). The low-salinity zone is a dynamic habitat with size and location that respond rapidly to changes in tidal and river flows. The U.S. Environmental Protection Agency (EPA) recently finished a comprehensive set of maps that show how the low-salinity zone changes in size and shape when freshwater flows change the location of X2 (EPA 2012). This document can be found at: [http://www.waterboards.ca.gov/waterrights/water\\_issues/programs/bay\\_delta/docs/cmnt081712/karen\\_schwinn.pdf](http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/docs/cmnt081712/karen_schwinn.pdf).

The low-salinity zone expands and moves downstream when river flows into the estuary are high, placing low-salinity water over a larger and more diverse set of nominal habitat types than occurs under low flow conditions. During periods of low outflow, the low-salinity zone contracts and moves upstream. Due to its historical importance as a fish nursery habitat, there is a long research history into the physics and biology of the San Francisco Estuary's low-salinity zone (Kimmerer 2004).

The ecological function of the low-salinity zone also varies depending mainly on freshwater flow (Jassby *et al.* 1995; Kimmerer 2002b; Kimmerer 2004). Low outflow can decrease the capacity of the low-salinity zone and adjacent habitats to support the production of delta smelt by reducing habitat diversity and concentrating the fish with their predators and competitors (Service 1993; 1994). During the past four decades, the low-salinity zone ecosystem has undergone substantial changes in turbidity (Schoellhamer 2011) and food web function (Winder and Jassby 2011) that cannot be undone by increasing Delta outflow. These habitat changes, which extend into parts of the Delta where water is fresher than 0.5 ppt, have also decreased the ability of the low-salinity zone and adjacent habitats to support the production of delta smelt (Thomson *et al.* 2010; Rose *et al.* 2013b; IEP 2015).

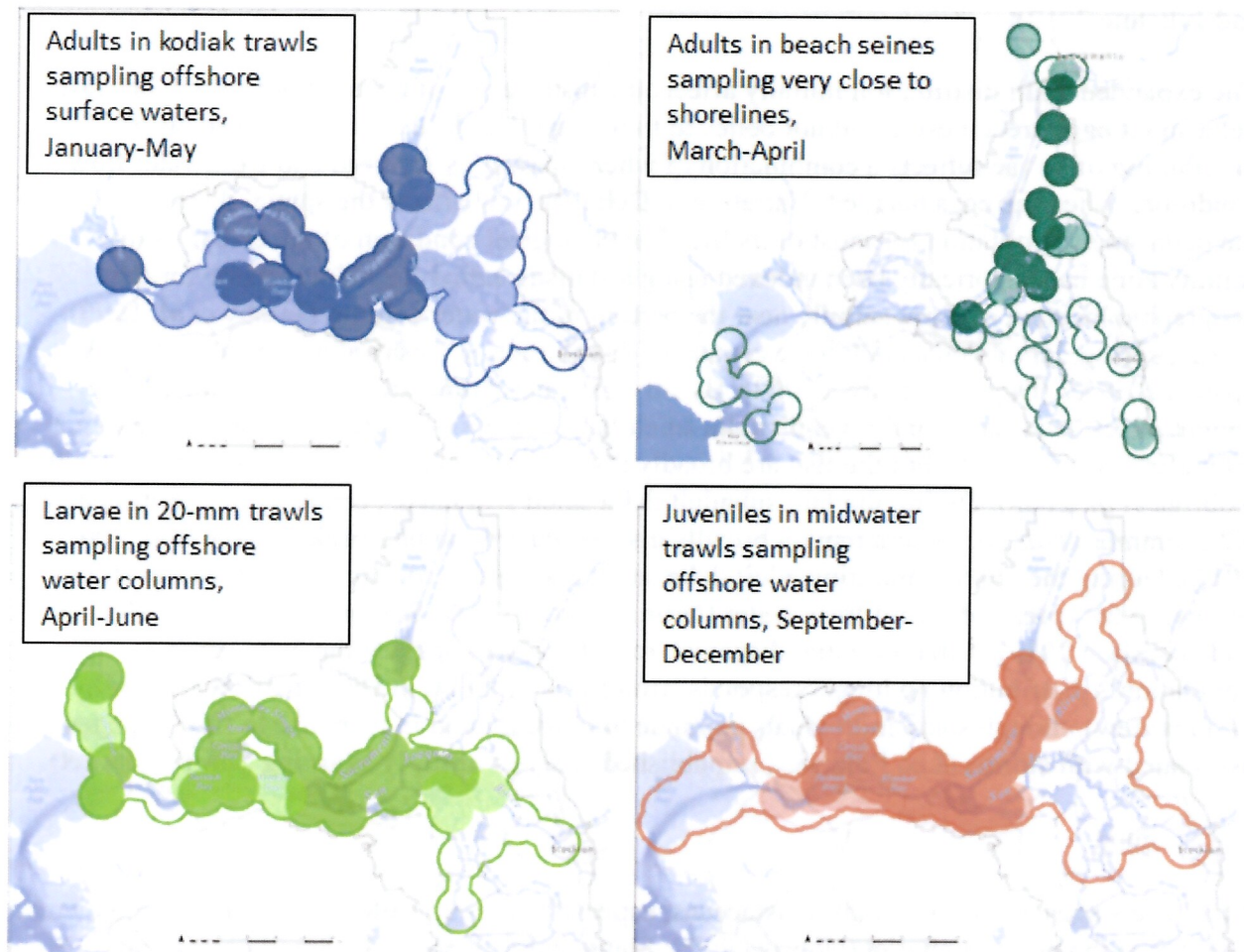
Delta smelt have been observed as far west as San Francisco Bay, as far north as Knight's Landing on the Sacramento River, as far east as Woodbridge on the Mokelumne River and Stockton on the Calaveras River, and as far south as Mossdale on the San Joaquin River (Figure 7). This distribution represents a range of salinity from essentially zero ppt up to about 20 ppt, which represents a salinity range well beyond definitions of the low-salinity zone or mixing zone near a salinity of 2 ppt emphasized in the critical habitat rule (Service 1994). It is also well beyond the geographic extent of the critical habitat rule (described below). However, most delta smelt that have been collected in the extensively surveyed San Francisco Estuary have been collected from locations within the bounds defined in the critical habitat rule. In addition, all habitats known to be occupied year-round by delta smelt occur within the bounds defined in the critical habitat rule.



Figure 7. Delta smelt range map. Waterways colored in purple depict the delta smelt distribution described by Merz *et al.* (2011). The Service has used newer information to expand the transient range of delta smelt further up the Napa and Sacramento rivers than indicated by Merz *et al.* (2011). The red polygon depicts the designated critical habitat for the delta smelt.

Delta smelt permanently occupy the Cache Slough ‘complex’ including Liberty Island and the adjacent reach of the Sacramento Deepwater Shipping Channel (Sommer and Mejia 2013),

Cache Slough to its confluence with the Sacramento River and the Sacramento River from that confluence downstream to Chipps Island, Honker Bay, and the eastern part of Montezuma Slough (Figure 8). The reasons delta smelt are believed to permanently occupy this part of the estuary are the presence of fresh- to low-salinity water year around that is comparatively turbid and of a tolerable water temperature year around. These appropriate water quality conditions overlap an underwater landscape featuring variation in depth, tidal current velocities, edge habitats, and food production (Sweetnam 1999; Nobriga *et al.* 2008; Feyrer *et al.* 2011; Murphy and Hamilton 2013; Hammock *et al.* 2015; Bever *et al.* 2016). Field observations are increasingly being supported by laboratory research that explains how delta smelt respond physiologically to variation in salinity, turbidity, water temperature, and other aspects of their habitat that can vary with changes in climate, freshwater flow and estuarine bathymetry (Hasenbein *et al.* 2014, 2016; Komoroske *et al.* 2014, 2016).



**Figure 8. Maps of multi-year average distributions of delta smelt collected in four monitoring programs. The sampling regions covered by each survey are outlined. The areas with dark shading surround sampling stations in which 90 percent of the delta smelt collections occurred, the areas with light shading surround sampling stations in which the next 9 percent of delta smelt collections occurred. Source: Murphy and Hamilton (2013).**

Each year, the distribution of delta smelt seasonally expands when adults disperse in response to winter flow increases that also coincide with seasonal increases in turbidity and decreases in water temperature (Figure 8). The annual range expansion of adult delta smelt extends up the Sacramento River to about Garcia Bend in the Pocket neighborhood of Sacramento, up the San Joaquin River from Antioch to areas near Stockton, up the lower Mokelumne River system, and west throughout Suisun Bay and marsh. Some delta smelt seasonally and transiently occupy Old and Middle rivers in the south Delta each year, but face a high risk of entrainment when they do (Grimaldo *et al.* 2009).

The distribution of delta smelt occasionally expands beyond this area (Figure 7). For instance, during high outflow winters, adult delta smelt also disperse west into San Pablo Bay and up into the Napa River (Hobbs *et al.* 2007). Similarly, delta smelt have occasionally been reported from the Sacramento River north of Garcia Bend up to Knights Landing (*e.g.*, Merz *et al.* 2011; Vincik and Julienne 2012).

The expanded adult distribution initially affects the distribution of the next generation because delta smelt eggs are adhesive and not believed to be highly mobile once they are spawned. The distribution of larvae reflects a combination of where spawning occurred and freshwater flow conditions when the eggs hatched. Variation in Delta outflow affects the spatial distribution of the delta smelt population for most of its life. The ecological condition of the estuary's low-salinity zone has historically been indexed using a statistic called X2, a local name for the geographic location of 2 ppt salinity near the bottom of the water column (Jassby *et al.* 1995). During spring, larval delta smelt have centers of distribution in freshwater, typically 20-40 km upstream of X2 (Dege and Brown 2004). By July, as water temperatures in the Delta reach annual peaks, post-larval and juvenile delta smelt have centers of distribution very close to X2 (Dege and Brown 2004), but the fish are broadly distributed around that peak (Sweetnam 1999; Nobriga *et al.* 2008). During the fall, subadult delta smelt still have a center of distribution near X2 (Sommer *et al.* 2011), and remain broadly distributed around that peak (Feyrer *et al.* 2007; 2011). During the winter, maturing adult delta smelt disperse in connection with winter storms following the spread of turbid fresh water (Grimaldo *et al.* 2009; Sommer *et al.* 2011; Murphy and Hamilton 2013). After an initial dispersal, recent analyses suggest the delta smelt population's distribution no longer responds strongly to variation in Delta outflow (Polansky *et al.* in review), though some individuals continue to move around in response to flow changes associated with storms (Leo Polansky, unpublished analysis of Early Warning Survey data set).

### Food

At all life stages, numerous small crustaceans, especially a group called calanoid copepods, make up most of the delta smelt diet (Nobriga 2002; Slater and Baxter 2014). Small crustaceans are ubiquitously distributed throughout the estuary, but which prey species are present at particular times and locations has changed dramatically over time (Winder and Jassby 2011; Kratina *et al.* 2014). This has likely affected delta smelt feeding success, particularly during Central California's warm summers.

### Reproductive Strategy

The reproductive behavior of delta smelt is only known from captive specimens spawned in artificial environments and most of the information has never been published. Spawning likely occurs mainly at night with several males attending a female that broadcasts her eggs onto bottom substrate (Bennett 2005). Although preferred spawning substrate is unknown, spawning habits of delta smelt's closest relative, the Surf smelt (*Hypomesus pretiosus*), as well as unpublished experimental trials, suggest that sand may be the preferred substrate (Bennett 2005; Sommer and Mejia 2013). Hatching success peaks at temperatures of 15-16°C (59-61°F) and decreases at cooler and warmer temperatures. Hatching success nears zero percent as water temperatures exceed 20°C (68°F) (Bennett 2005). Water temperatures suitable for spawning occur most frequently during the months of March-May, but ripe female delta smelt have been observed as early as January and larvae have been collected as late as July. Delta smelt spawn in the estuary and have one spawning season for each generation, which makes the timing and duration of the spawning season important every year. As stated above, delta smelt are believed to spawn on sandy substrates in fresh and possibly low-salinity water (Bennett 2005). Therefore, freshwater flow affects how much of the estuary is available for delta smelt to spawn (Hobbs *et al.* 2007).

Delta smelt can start spawning when water temperatures reach about 10°C (50°F) and can continue until temperatures reach about 20°C (Bennett 2005). The ideal spawning condition occurs when water temperatures remain cool throughout the spring (*e.g.*, March-May). Few delta smelt  $\leq 55$  mm in length are sexually mature and 50% of delta smelt reach sexual maturity at 60 to 65 mm in length (Rose *et al.* 2013b). Thus, if water temperatures raise much above 10°C in the winter, the "spawning season" can start before most individuals are mature enough to actually spawn. If temperatures continue to warm rapidly toward 20°C in early spring, that can end the spawning season with only a small fraction of 'adult' fish having had an opportunity to spawn. Delta smelt were initially believed to spawn only once before dying (Moyle *et al.* 1992). It has since been confirmed that like many other ecologically similar forage fishes (Winemiller and Rose 1992) individual delta smelt can spawn more than once if water temperatures remain suitable for a long enough time, and if the adults find enough food to support the production of another batch of eggs (Lindberg *et al.* 2013; Kurobe *et al.* 2016). As a result, the longer water temperatures remain cool, the more fish have time to mature and the more times individual fish can spawn.

Although adult delta smelt can spawn more than once, mortality is high during the spawning season and most adults die by May (Polansky *et al.* in review). The egg stage averages about 10 days before the embryos hatch into larvae. The larval stage averages about 30 days. Metamorphosing "post-larvae" appear in monitoring surveys from April into July of most years. By July, most delta smelt have reached the juvenile life stage. Delta smelt collected during the fall are called "subadults", a stage which lasts until the following winter when fish disperse toward spawning habitats. This winter dispersal usually precedes sexual maturity (Sommer *et al.* 2011).

### Recovery and Management

Following Moyle *et al.* (1992), the Service (1993) indicated that SWP and CVP exports were the primary factors contributing to the decline of delta smelt due to entrainment of larvae and juveniles and the effects of low flow on the location and function of the estuary mixing zone (now called the low-salinity zone). In addition, prolonged drought during 1987-1992, in-Delta water diversions, reduction in food supplies by nonindigenous aquatic species -specifically overbite clam and nonnative copepods, and toxicity due to agricultural and industrial chemicals were also factors considered to be threatening the delta smelt. In the Formal Endangered Species Act Consultation on the Proposed Coordinated Long-Term Operations of the State Water Project and Central Valley Project (2008 Service BiOp), the Service's Reasonable and Prudent Alternative required protection of all life stages from entrainment and augmentation of Delta outflow during the fall of Wet or Above-Normal years as classified by the State of California (Service 2008). The expansion of entrainment protection for delta smelt in the 2008 Service BiOp was in response to large increases in juvenile and adult salvage in the early 2000s (Kimmerer 2008). The fall X2 requirement was in response to increased fall exports that had resulted in greatly reduced variability in Delta outflow during the fall months (Feyrer *et al.* 2011).

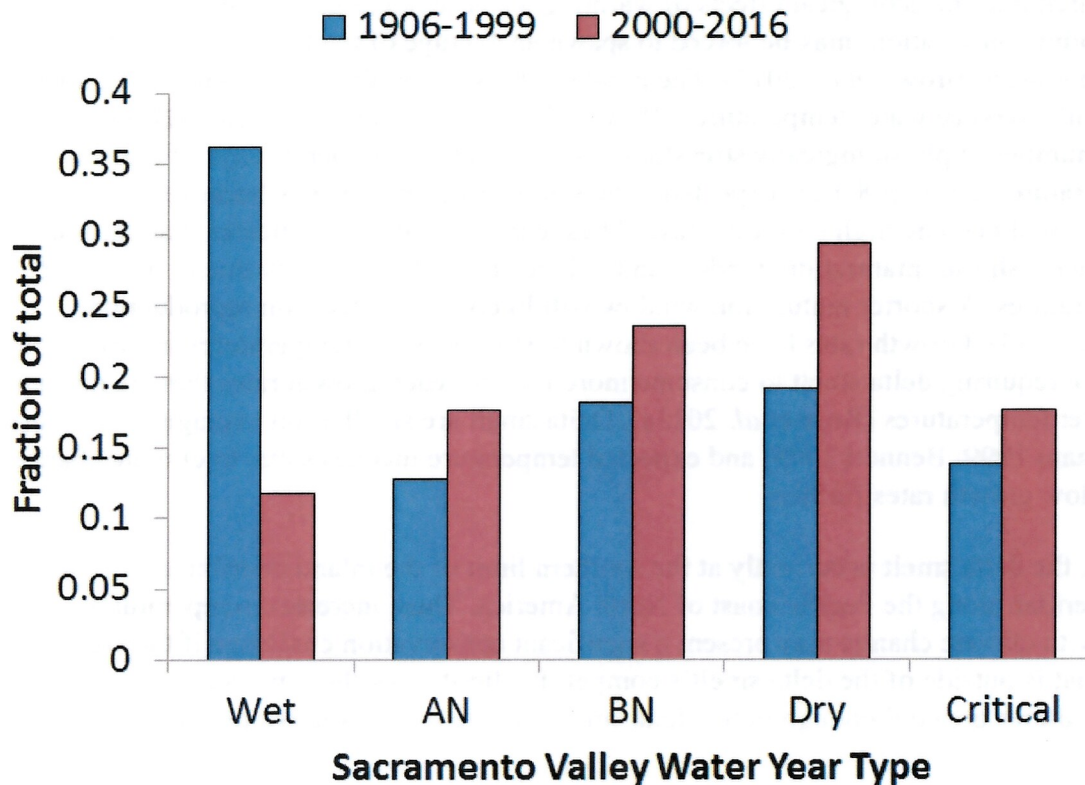
The Service's (2010c) recommendation to uplist delta smelt from threatened to endangered included reservoir operations and water diversions upstream of the estuary as mechanisms interacting with exports to restrict the low-salinity zone and concentrate delta smelt with competing fish species. In addition, Brazilian waterweed (*Egeria densa*) and increasing water transparency were considered new detrimental habitat changes. Predation was considered a low-level threat linked to increasing waterweed abundance and increasing water transparency. Additional threats considered potentially significant by the Service in 2010 were entrainment into power plant diversions, contaminants, and reproductive problems that can stem from small population sizes. Conservation recommendations included: establish Delta outflows proportionate to unimpaired flows to set outflow targets as fractions of runoff in the Central Valley watersheds; minimize reverse flows in Old and Middle rivers; and, establish a genetic management plan with the goals of minimizing the loss of genetic diversity and limiting risk of extinction caused by unpredictable catastrophic events. The Service (2012b) recently added climate change to the list of threats to the delta smelt.

Continued protection of the delta smelt from excessive entrainment, improving the estuary's flow regime, suppression of nonnative species, increasing zooplankton abundance, and improving water quality are among the actions needed to recover the delta smelt.

### Climate Change

Climate projections for the San Francisco Bay-Delta and its watershed indicate that temperature and precipitation changes will diminish snowpack in the Sierra-Nevada, changing the availability of natural water supplies (Knowles and Cayan 2002; Dettinger 2005). Warming may result in more precipitation falling as rain which will mean less water stored in spring snowpacks. This would increase the frequency of rain-on-snow events and increase winter runoff with an

associated decrease in runoff for the remainder of the year (Hayhoe *et al.* 2004). Overall, these and other storm track changes may lead to increased frequency of flood and drought cycles during the 21<sup>st</sup> century (Dettinger *et al.* 2015). Thus far, the 21<sup>st</sup> century has been substantially drier than the 20<sup>th</sup> century (Figure 9).



**Figure 9. Frequency distribution of Sacramento Valley Water Year Types for: blue= 1906-1999 and red= 2000-2016.**

Sea level rise is also anticipated as a consequence of a warming global climate and if it is not mitigated, sea level rise will likely influence saltwater intrusion into the Bay-Delta. Salinity within the northern San Francisco Bay is projected to rise by 4.5 ppt by the end of the century (Cloern *et al.* 2011). Elevated salinity could push X2 farther up the estuary if outflows were not increased to compensate. Fall X2 mean values are projected to increase by about 7 km to the area near the City of Antioch approximately 90 km from the Golden Gate Bridge by 2100 (Brown *et al.* 2013). This projected change in the location of X2 in the fall is expected to decrease suitable physical habitat if current levees and channel structures are maintained.

Central California's warm summers are already a source of energetic stress for delta smelt and warm springs already severely compress the duration of their spawning season (Rose *et al.* 2013a, b). Central California's climate is anticipated to get warmer (Dettinger 2005). We expect warmer estuary temperatures to present a significant conservation challenge for delta smelt. Mean annual water temperatures within the Delta are expected to increase steadily during the second half of this century (Cloern *et al.* 2011). Warmer water temperatures could further reduce



delta smelt spawning opportunities, decrease juvenile growth during the warmest months, and increase mortality via several food web pathways including: increased vulnerability to predators, increased vulnerability to toxins, and decreased capacity for delta smelt to successfully compete in an estuary that is energetically more optimal for warm water-tolerant fishes.

Recent research into the ecological effects of warming water temperatures suggests that delta smelt, depending on location, may be forced to spawn an average of ten to twenty-five days earlier in the season (Brown *et al.* 2013). The number of high mortality days (cumulative number of days of daily average water temperature  $>25^{\circ}\text{C}$  ( $77^{\circ}\text{F}$ )) is expected to increase (Brown *et al.* 2013). The number of physiologically stressful days (cumulative number of days of daily average water temperature  $>20^{\circ}\text{C}$  ( $68^{\circ}\text{F}$ )) is expected to be stable or decrease partly because many stressful days will become high mortality days. Thus, current modeling indicates that delta smelt will likely face a shorter maturation window and reduced habitat availability due to increased water temperatures. A shorter maturation window will likely have effects on reproduction (Brown *et al.* 2013). Growth rates have been shown to slow as water temperatures increase above  $20^{\circ}\text{C}$  ( $68^{\circ}\text{F}$ ), requiring delta smelt to consume more food to reach growth rates that are normal at lower water temperatures (Rose *et al.* 2013a). Delta smelt are smaller, on average, than in the past (Sweetnam 1999; Bennett 2005) and expected temperature increases due to climate change will likely slow growth rates further.

In summary, the delta smelt is currently at the southern limit of the inland distribution of the family Osmeridae along the Pacific coast of North America. Thus, increased temperatures associated with climate change may present a significant conservation challenge if they result in a Bay-Delta that is outside of the delta smelt's competitive limits. For the time being however, water temperatures are cool enough in the delta smelt's range for the species to complete its life cycle.

#### Summary of the Status of Delta Smelt

The relative abundance of delta smelt has reached very low numbers (Table 1) for a small forage fish in an ecosystem the size of the San Francisco Estuary. The recent record-low relative abundance reflects decades of habitat change, marginalization by non-native species that prey on and out-compete delta smelt, and remarkably dry hydrology occurring over recent years. The anticipated effects of climate change on the San Francisco Estuary and watershed such as warmer water temperatures, greater salinity intrusion, and the potential for frequent extreme drought, which has been experienced for the 21<sup>st</sup> century thus far (Figure 9) indicate challenges to delta smelt survival will increase. However, a rebound in relative abundance during the very wet and cool conditions during 2011 and again in 2017, indicate that delta smelt has retained some population resilience in years of increased spring outflows from the Delta (IEP 2015).

### Valley Elderberry Longhorn Beetle

For the most recent comprehensive assessment of the range-wide status of the beetle, please refer to the Withdrawal of the Proposed Rule To Remove the Valley Elderberry Longhorn Beetle From the Federal List of Endangered and Threatened Wildlife (Service 2014). Threats discussed in the withdrawal continue to act on the beetle, with loss of habitat being the most significant effect. While there continue to be losses of beetle habitat throughout its range, to date no project has proposed a level of effect for which the Service has issued a biological opinion of jeopardy for the beetle.

### **Environmental Baseline**

#### Delta Smelt

The action area is located within the northern part of the range for the delta smelt. The delta smelt occur in the action area as they move into upper reaches of the system in the winter and spawn in this fresh water environment in the spring (IEP 2015). During the summer, the majority of the fish are expected to migrate downstream, towards the low salinity zone or the Cache Slough complex. The habitat conditions within the Delta and Sacramento River are variable by season and year, influencing delta smelt abundance and presence in the system.

The project occurs within the range of delta smelt and delta smelt are found year around within the project area in one part of their life stage or another. Currently, the delta smelt is experiencing the lowest abundance on record. The 2016 FMWT index of delta smelt abundance was 8. Following record low abundance indices from survey data in 2015, delta smelt survey results in water year 2016 continued to decline and exhibit record low abundance. The 2017 SKT index is 3.8 a modest increase from the record low 1.8 in 2016. The SKT monitors the adult spawning stock of delta smelt. The Service has recently begun the Enhanced Delta Smelt Monitoring Program to estimate abundance of delta smelt.

#### Valley Elderberry Longhorn Beetle

The project site is within the range of the valley elderberry longhorn beetle and the nearest record of the species is approximately 0.5 mile north of the project site along the west bank of the Sacramento River (CDFW 2015a). The Applicant has conducted surveys of the project site for elderberry bushes, the host plant of the valley elderberry longhorn beetle. The Applicant identified a total of seven elderberry bushes on the project site, with five on the West Sacramento side of the project site and two on the Sacramento side of the project site. The elderberry bushes ranged from 6 to 26 feet in height. Exits holes were not identified at the time of the survey but all bushes contained one or more stems equal to or greater than 1 inch diameter at ground level for a total of 42 stems that provide suitable habitat for the valley elderberry longhorn beetle.

## Effects of the Action

### Delta Smelt

Impacts on most delta smelt migrating adults and all spawning and egg incubation would be avoided by limiting any in-channel construction to the season when these sensitive life stages are considered to be absent or in very low densities (between May 1-November 30 for each construction year). However, some adults and juvenile delta smelt would be subject to potential harassment, injury, or mortality during work activities occurring in or near the stream channel. Most juveniles would be expected to move upstream or downstream of the immediate project area in response to disturbance. Displacement could affect survival by increasing the exposure of juveniles to predators and possibly increasing competition with other juveniles, especially if suitable rearing habitat is limited or not readily available. Although juveniles are capable of actively moving away from disturbances, some juveniles may seek cover in active work areas, where they may be injured or killed by exposure to harmful levels of suspended sediment or other factors. Implementation of the conservation measures would minimize these effects but not eliminate them.

### Pile Driving Hydroacoustics

Delta smelt may be subjected to harassment and injury from the generation of noise and underwater sound pressure levels due to installation of new piles and their associated equipment. Barotraumas are pathologies in fish linked to the exposure to drastic changes in pressure which include hemorrhage and rupture of internal organs either immediately or a few days after exposure. Fish with swimbladders are susceptible to tissue damage from impulsive sounds. When pressure waves strike a gas-filled swimbladder, vibration occurs with expansion and contraction of the organ. If the amplitude of the vibration is high, the swimbladder can press against and strain adjacent organs. This compression can cause obvious injury in the form of ruptured capillaries, internal bleeding and destruction of highly vascular organs (Gaspin 1975; Hastings and Popper 2005). Elevated noise levels can cause sublethal injuries affecting survival and fitness. Similarly, if injury does not occur, noise may modify fish behaviors that may make them more susceptible to predation. Fish suffering damage to hearing organs may suffer equilibrium problems, and may have a reduced ability to detect predators and prey. Other types of sub-lethal injuries can place the fish at increased risk of predation and disease. Adverse effects on survival and fitness can occur even in the absence of overt injury. Exposure to elevated noise levels can cause a temporary shift in hearing sensitivity (referred to as a temporary threshold shift), decreasing sensory capability for periods lasting from hours to days (Turnpenny *et al.* 1994; Hastings *et al.* 1996).

The Fisheries Hydroacoustic Working Group, an interagency working group that includes the Service, has established interim criteria for evaluating underwater noise impacts from pile driving on fish. These criteria are defined in the document entitled "Agreement in Principle for Interim Criteria for Injury to Fish from Pile Driving Activities" dated June 12, 2008 (Fisheries Hydroacoustic Working Group 2008). This agreement identifies a peak sound pressure level of 206 decibels (dB) and an accumulated SEL of 187 dB as thresholds for injury to fish less than 2

grams. Although there has been no formal agreement on a “behavioral” threshold, the Service and NMFS use 150 dB root mean square (RMS) as the threshold for adverse behavioral effects. Distances to the aforementioned injury and behavioral thresholds were modeled using NMFS’ Underwater Noise Calculation Spreadsheet for pile driving, using sound source levels derived from literature and the NMFS-recommended underwater attenuation rate of 4.5 dB per doubling of distance (NMFS 2009).

#### *16-inch Diameter Steel or Square Precast Concrete Piles Installation for Abutments 1 and 6*

The Applicant will install a total of 100 (50 per abutment) 16-inch diameter steel or square precast concrete piles proposed for supporting Abutments 1 and 6 using an impact hammer. When steel or concrete piles are used in conjunction with an impact hammer, high sound levels are likely to be generated during construction. Noise generated by impact pile driving is impulsive in nature. Impulsive noises have short duration and consist of a broad range of frequencies. Impulsive waveforms are characterized by a rapid pressure rise time (the time in milliseconds it takes the wave form to rise from 10 percent to 90 percent of its highest peak) that occurs within the first few milliseconds followed by rapid fluctuation (under-pressure and over-pressure) about the ambient pressure.

The Applicant estimates that driving the 16-inch diameter steel or concrete piles would require approximately 16,000 strikes per day to drive and test each pile (20 piles per day at 800 strikes per pile). The Applicant will drive these piles on land and there would be no opportunities to attenuate noise levels. Without the use of sound attenuation techniques, the distance at which the pile driving noise for 16-inch steel attenuates to below the threshold level (150 dB RMS) for behavioral effects is approximately 5,200 feet and approximately 3,825 feet for concrete piles. The distance at which the pile driving noise for 16-inch steel attenuates to below the sublethal/injury threshold (183-187 dB cumulative SEL) is approximately 824 feet and approximately 1,305 feet for concrete piles.

#### *16-inch Diameter Steel or Square Precast Concrete Piles Installation for Piers 2 and 5*

The Applicant will install the 100 16-inch diameter steel or square precast concrete piles proposed for supporting Piers 2 and 5 in dewatered cofferdams using an impact hammer. The Applicant estimates that driving the 16-inch diameter steel or concrete piles would require approximately 16,000 strikes per day to drive and test each pile (20 piles per day at 800 strikes per pile). The Applicant will drive these piles within dewatered cofferdams and there would be no opportunity to attenuate noise levels. Without the use of sound attenuation techniques, the distance at which the pile driving noise for 16-inch steel attenuates to below the threshold level (150 dB RMS) for behavioral effects is approximately 4,459 feet and approximately 824 feet for concrete piles. The distance at which the pile driving noise for 16-inch steel attenuates to below the sublethal/injury threshold (183-187 dB sound equivalency level cumulative) is approximately 824 feet and approximately 177 feet for concrete piles.

*108-inch Diameter Steel Casing Installation for Piers 3 and 4*

The Applicant will install 8 108-inch steel casings proposed for supporting Piers 3 and 4 using a vibratory pile driver and/or hydraulic-driven oscillator/rotator system. This installation method would not generate high levels of underwater noise.

*16-inch Diameter Concrete Pile Installation for Bridge Fender System*

The Applicant will install the 60 16-inch diameter concrete piles proposed for supporting the bridge fender system using an impact hammer. The Applicant estimates that driving the 16-inch diameter steel or concrete piles would require approximately 20,000 strikes per day to drive and test each pile (20 piles per day at 1,000 strikes per pile). The Applicant will install a bubble curtain to attenuate noise levels. Without the use of sound attenuation techniques, the distance at which the pile driving noise for 16-inch concrete piles attenuates to below the threshold level (150 dB RMS) for behavioral effects is approximately 1,775 feet. The distance at which the pile driving noise for 16-inch steel or concrete piles attenuates to below the sublethal/injury threshold (183-187 dB sound equivalency level cumulative) is approximately 384 feet. With the use of a bubble curtain to attenuate the noise these distances are reduced to 823 and 177 feet, respectively.

*16-inch Diameter Steel Piles for Barge Installation*

The Applicant will install the 8 temporary 16-inch diameter steel piles proposed for supporting barge installation using an impact hammer. The Applicant estimates that driving the 16-inch diameter steel or concrete piles would require approximately 6,400 strikes per day to drive and test each pile (8 piles per day at 800 strikes per pile). The Applicant will install a bubble curtain to attenuate noise levels. Without the use of sound attenuation techniques, the distance at which the pile driving noise for 16-inch steel piles attenuates to below the threshold level (150 dB RMS) for behavioral effects is approximately 9,610 feet. The distance at which the pile driving noise for 16-inch steel or concrete piles attenuates to below the sublethal/injury threshold (183-187 dB sound equivalency level cumulative) is approximately 1,775 feet. With the use of a bubble curtain to attenuate the noise these distances are reduced to 4,459 and 823 feet, respectively.

*16-inch Diameter Steel or H Piles for Temporary Trestle Installation*

The Applicant will install the 160 temporary 16-inch diameter steel piles proposed for supporting barge installation using an impact hammer. The Applicant estimates that driving the 16-inch diameter steel or H piles would require approximately 16,000 strikes per day to drive and test each pile for a total of up to (20 piles per day at 800 strikes per pile). The Applicant will install a bubble curtain to attenuate noise levels. Without the use of sound attenuation techniques, the distance at which the pile driving noise for 16-inch steel piles attenuates to below the threshold level (150 dB RMS) for behavioral effects is approximately 9,610 feet and approximately 3281 feet for H piles. The distance at which the pile driving noise for 16-inch steel piles attenuates to below the sublethal/injury threshold (183-187 dB sound equivalency level cumulative) is

approximately 1,775 feet and approximately 705 feet for H piles. With the use of a bubble curtain to attenuate the noise these distances are reduced to 4,459 and 823 feet, respectively for the 16-inch steel piles and 1,522 and 328 feet, respectively for H piles.

### *Sheet Piles for Temporary Cofferdam Installation*

The Applicant will install the 180 sheet piles proposed to construct a temporary cofferdam using a vibratory hammer. This installation method would not generate high levels of underwater noise.

Pile driving activities will not be continuous but would start and stop during the course of each day of pile driving (including cessation of pile driving activities at night), providing opportunities for delta smelt to continue with their movements and feeding without substantial delays. For pile types that require driving with an impact hammer, the Applicant will first drive each pile as deeply as possible using a vibratory hammer to minimize underwater sound. In addition, general construction noise may act to disperse fish away from the construction area before impact driving is initiated.

Based on the area of disturbance and timing of pile driving operations, we anticipate some disturbance to the movement and feeding of delta smelt in the area. The calculated distance at which the 150 dB RMS threshold for behavioral effects would be exceeded is up to 9,610 feet away from the project site during pile driving for installation of the temporary trestles and supporting barge installation, without accounting for attenuation of sound energy using bubble curtains as proposed by the Applicant. However, the Sacramento River has river channel bends and the straight line distance of open water is 5,400 feet upstream and 5,600 feet downstream of the proposed bridge crossing. These distances are considerably shorter than the 9,610 feet at which the 150 dB RMS threshold for behavioral effects would be exceeded. Consequently, Caltrans has estimated that after accounting for diffraction and attenuation because of the physical geography of the river the 150 dB RMS threshold for behavioral effects would be exceeded only within 7,400 feet upstream and 7,600 feet downstream of the project site.

### Mobilization of Sediment from Construction Activities

Construction activities are expected to generate small sediment plumes which will increase turbidity in the action area. Exposure to excessive suspended sediment concentrations could lead to physiological stresses such as clogged gills, eroded gill and epithelial tissue, impaired foraging activity and feeding success, and altered movement and migration patterns of juvenile and adult fish (Clarke and Wilber 2000; Newcombe and Jensen 1996; Newcombe and MacDonald 1991). Exposure of fish to elevated suspended sediment concentrations could result in behavioral avoidance and exclusion from otherwise suitable habitat, disrupt movement and migration patterns, reduce feeding rates and growth, result in sublethal and lethal physiological stress, habitat degradation or delayed hatching; and, under serve circumstances, could result in mortality (Newcombe and Jensen 1996; Clarke and Wilber 2000). The response of fish to suspended sediments varies among species and lifestages as a function of suspended particle size, particle shape, water velocities, suspended sediment concentrations, water temperature, depressed dissolved oxygen concentrations, contaminants, and exposure duration (O'Connor 1991; Sherk

Jr. 1971; Newcombe and Jensen 1996). Short-duration exposure to elevated suspended sediment concentration associated could result in sublethal effects; however, potential exposure and dosage of suspended sediment concentrations drops exponentially from the source of the plume.

While adult delta smelt already live in an environment with high background levels of turbidity and increased turbidity generally correlates with higher abundance of delta smelt (Feyrer *et al.* 2007; Nobriga *et al.* 2008), it is possible that excessive sedimentation may exceed turbidity levels ideal for delta smelt. If adult delta smelt were present within the plume, the behavioral avoidance response of this lifestage is expected to substantially reduce or eliminate the risk of lethal or sublethal exposure the farther they are from the plume source. However, turbidity would be minimized by implementing Conservation Measure 10 and monitoring turbidity throughout in-water construction.

#### Exposure to Contaminants

Disturbance and resuspension of river bottom sediments during in-water construction pose a risk to delta smelt because of potential increases in the exposure to contaminated sediments. Sand, silt, and gravel characterize bottom substrate in the action area. Non-soluble contaminants with a tendency to adsorb to sediments (as opposed to soluble contaminants which have the tendency to be readily diluted in water) can accumulate in the substrate over time. Non-soluble contaminants that are known to be present in the Sacramento River include polychlorinated biphenyls (PCBs), mercury, pesticides and insecticides (i.e., dieldrin, chlorodane, DDT), and other unknown toxicities (State Water Resources Control Board 2011). Resuspension of sediments with adsorbed metals during in-water construction potentially may lead to degradation of water quality and food resources in the action area. In addition, resuspended particulate material may be transported to other locations in the Sacramento River as a result of transport by river currents, thus leading to potential degradation of water quality and food resources in the action area. Although delta smelt may be present in the action area during May and June, restricting in-water construction to May 1–November 30 will reduce the exposure of delta smelt to contaminants because delta smelt occur less frequently than other months, or not at all, during this time of year.

In-water construction would be limited to pile driving, installation and removal of sheet piles for cofferdams, and rock slope protection placement. In addition, in-water construction would be limited to daylight hours each day. Thus, disturbance of channel substrate and the potential for increased contaminants would be temporary and localized. Assuming that mobilization of sediment is also an indication of contaminant mobilization, the proposed in-water construction methods and construction BMPs should minimize the increase in contaminants in the river.

#### *Contaminant Spills*

Construction activities that occur in or near the Sacramento River channel may result in the discharge of contaminants that are potentially lethal to fish, including delta smelt. The operation of heavy equipment, cranes, pile drivers, drilling rigs, tug boats, and other construction equipment during bridge construction may result in spills and leakage of fuel, lubricants, hydraulic fluids, and coolants. Other sources of potential contamination include asphalt, wet

concrete, and other materials that may come into direct contact with surface water during construction activities.

The potential magnitude of biological effects resulting from contaminants depends on a number of factors, including the proximity of spills to the river; the type, volume, concentration, and solubility of the contaminant; and the timing and duration of the spill or release of the contaminant into the water column. Contaminants can affect survival, growth, and reproductive success of fish and other aquatic organisms. The level of effect depends on the species, life stage sensitivity, duration of exposure, condition or health of exposed individuals, and the physical and chemical properties of the water (e.g., temperature, pH, dissolved oxygen, and other factors). Implementation of Conservation Measure 10 will minimize the risk of contaminant spills and potential effects of contaminant spills on fish, including delta smelt, and other aquatic organisms.

### *Water Quality*

The proposed project could involve the storage, use, or discharge of toxic and other harmful substances near streams and other water-bodies that could result in contamination of these waterbodies and potentially affect fish and other aquatic organisms. Potential impacts range from avoidance of the project site to mortality, which could occur through exposure to lethal concentrations of contaminants or exposure to non-lethal levels that cause physiological stress and increased susceptibility to other sources of mortality (e.g., predation and disease). Project activities that could result in the accidental or unintentional runoff or discharge of toxic materials and other harmful substances to streams include the following:

- Potential accidental spill of petroleum products
- Operation of vehicles and equipment in or adjacent to stream channels or drainages
- Storage of pavement, petroleum products, concrete, and other construction materials
- Discharge of water from construction areas
- Disturbance and mobilization of contaminants with adsorbed metals

The operation of heavy equipment, cranes, vibratory and/or impact hammer rigs, and other construction equipment in or near the river can result in accidental spills and leakage of fuel, lubricants, hydraulic fluids, and coolants. In addition, re-suspension of sediments with adsorbed metals during in-water construction potentially could lead to localized degradation of water quality and food resources. Re-suspended particulate material also could be transported to downstream locations as a result of transport by flow, thus leading to potential degradation of water quality and food resources beyond the immediate construction area. Potential water quality effects that would expose delta smelt to hazardous contaminants would be minimized and avoided by implementation of the conservation measures including the BMPs and a spill prevention plan.

### Fish Entrapment in Cofferdams

The Applicant will require temporary dewatering using cofferdams to construct piers 2 and 5 for the new bridge. The potential exists for entrapment and mortality of delta smelt following closure



and dewatering of the cofferdam. The proposed timing of cofferdam installation (May) would potentially overlap adult and juvenile occurrence in the river. Implementation of Conservation Measures 12 and 13 will potentially minimize the risk of mortality for delta smelt potentially stranded during cofferdam installation, closure, and dewatering.

#### Increase in Direct Lighting on the Sacramento River

Temporary lighting of work areas to facilitate nighttime construction, especially at construction sites adjacent to or over the Sacramento River, may result in increased nighttime light intensity on the water surface of the Sacramento River. Increases in direct lighting of the Sacramento River at night may affect the migratory behavior of fish; alter behavior of animals that prey on fish (e.g., piscivorous birds, mammals, and fish) in adjacent and affected habitats; or make juvenile fish more visible to predators, thereby leading to increased mortality of fish through increased predation (Tabor *et al.* 2001). Implementation of Conservation Measure 15 would minimize the potential for effects of lighting on fish, including delta smelt, by requiring shielding and focusing of temporary lights on work areas to avoid and minimize the amount of nighttime lighting that directly radiates on to the Sacramento River, to the extent practicable.

#### Introduction of Aquatic Invasive Species

During construction, the operation of barges and other in-water equipment originating from regions or areas outside the project area could result in the introduction and spread of aquatic invasive species, including the Asian overbite clam (*Corbula amurensis*), quagga mussel (*Dreissena bugensis*), zebra mussel (*Dreissena polymorpha*), hydrilla (*Hydrilla verticillata*), and Brazilian elodea (*Egeria densa*) (California Department of Fish and Game 2008). The Applicant will minimize this impact by implementing Conservation Measure 14.

#### Temporary and Permanent Loss of Aquatic Habitat

The proposed project components include the placement of 0.095 acres of temporary and 0.36 acre of permanent fill (bridge piers and rock slope protection) below the OHWM and would result in the shading of 1.26 acres of aquatic habitat. The Applicant has proposed to minimize the loss of permanent fill in shallow water habitat by purchasing 0.108 delta smelt credits at a Service-approved conservation bank but not the shading from the new bridge.

#### Valley Elderberry Longhorn Beetle

Project construction will adversely affect all 7 elderberry shrubs in the project area with at least one stem one inch or greater in diameter at ground level. Compensation for the loss of 42 stems measuring one inch or greater diameter at ground level would require plantings of 34 elderberry cuttings/seedlings and 34 associated riparian species. Any valley elderberry longhorn beetle larvae occupying the shrub could be killed when a shrub is removed; however, exit holes were not observed during surveys conducted the Applicant. The effects to the beetle are small and discrete, relative to the range of the species, and although the loss of habitat would contribute to the overall reduction of habitat within the range of the valley elderberry longhorn beetle, the

conservation measures would contribute to the long-term preservation and management of beetle habitat. The proposed project will contribute to the conservation of the valley elderberry longhorn beetle by preserving habitat at a conservation bank that would manage large contiguous sections of habitat for the benefit of the species.

### **Cumulative Effects**

Cumulative effects include the effects of future State, Tribal, local or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions that are unrelated to the proposed project are not considered in this section because they require separate consultation pursuant to section 7 of the Act. The Service is not aware of specific projects that might affect listed species or its critical habitat in the action area that are currently under review by State, county, or local authorities.

### **Conclusion**

After reviewing the current status of the delta smelt and valley elderberry longhorn beetle, the environmental baseline for the action area; the effects of the proposed project and the cumulative effects, it is the Service's biological opinion that the I Street Bridge Replacement Project, as proposed, is not likely to jeopardize the continued existence of the delta smelt or valley elderberry longhorn beetle. This is based on: (1) the implementation of conservation measures to minimize adverse effects on listed species; (2) the low likelihood that the delta smelt would be in the action area during in-water construction activities; and (3) the capability of the delta smelt to continue to utilize the project area following construction.

## **INCIDENTAL TAKE STATEMENT**

Section 9(a)(1) of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered and threatened fish and wildlife species without special exemption. Take is defined as harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harass is defined by the Service as an intentional or negligent act or omission which creates the likelihood of injury to a listed animals by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering. Harm is defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns including breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with this *Incidental Take Statement*.

The measures described below are non-discretionary, and must be implemented by Caltrans so that they become binding conditions of any grant or permit issued to Caltrans as appropriate, in order for the exemption in section 7(o)(2) to apply. Caltrans has a continuing duty to regulate the activity covered by this *Incidental Take Statement*. If Caltrans (1) fails to assume and implement

the *Terms and Conditions* or (2) fails to adhere to the *Terms and Conditions* of the *Incidental Take Statement* through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, Caltrans must report the progress of the action and its impact on the species to the Service as specified in the *Incidental Take Statement* [50 CFR §402.14(i)(3)].

### **Amount or Extent of Take**

The Service anticipates that all delta smelt juveniles and adults within 7,400 feet upstream and 7,600 feet downstream from the point of pile driving within the project area would be subject to harassment through effects resulting from construction activities. Incidental take in the form of harassment is expected to occur from construction and pile driving. Caltrans has proposed avoidance and minimization measures to reduce adverse effects and therefore take in the form of harassment is anticipated to be low. Incidental take in the form of injury or mortality is anticipated to occur through pile driving-related hydroacoustic effects and stranding behind cofferdams; however, the Service anticipates that take of adult delta smelt through injury or mortality would be low based on the proposed timing of in-water work when delta smelt are least likely to be in the action area and the proposed conservation measures. Upon implementation of the following reasonable and prudent measures, incidental take of delta smelt resulting from the project in the form of harassment, harm, injury, and mortality within the action area would become exempt from the prohibitions described under Section 9 of the Act.

The Service expects that incidental take of the valley elderberry longhorn beetle would be difficult to detect or quantify because the life cycle of the beetle and its small body size make the finding of a dead specimen unlikely, losses may be masked by seasonal fluctuations in numbers or other causes and the species occurs in habitat that makes them difficult to detect. It is not possible to make an accurate estimate of the number of valley elderberry longhorn beetles that would be harassed, harmed, injured, or killed during construction activities. In instances when take is difficult to detect, the Service may estimate take in numbers of individuals per number of elderberry stems one inch or greater in diameter lost or degraded as a result of the action. Therefore, the Service estimates that all valley elderberry longhorn beetles inhabiting the 42 stems of one inch or greater in the 7 identified shrubs may be harassed, harmed, injured, or killed, as a result of the proposed action. Upon implementation of the following reasonable and prudent measures, incidental take of the valley elderberry longhorn beetle would be exempted from prohibitions of take under Section 9 of the Act.

### **Effect of the Take**

In the accompanying biological opinion, the Service determines that this level of take is not likely to result in jeopardy to the valley elderberry longhorn beetle or the delta smelt.

### **Reasonable and Prudent Measure**

The Service has determined that the following reasonable and prudent measures are necessary and appropriate to minimize the effect of the action on the delta smelt and valley elderberry

longhorn beetle. Caltrans will be responsible for the implementation and compliance with these measures:

1. Minimize adverse effects to the delta smelt and valley elderberry longhorn beetle and their habitats in the action area by implementing the proposed project, including the conservation measures as described, with the following terms and conditions.
2. Minimize adverse effects to the delta and its critical habitat to fullest extent practicable.

### **Terms and Conditions**

In order to be exempt from the prohibitions of section 9 of the Act, Caltrans must comply with the following terms and conditions, which implement the reasonable and prudent measures described above. These terms and conditions are nondiscretionary.

1. The following *Terms and Conditions* implement *Reasonable and Prudent Measure* one (1):
  - a. Caltrans shall include language in their contracts that expressly requires contractors and subcontractors to work within the boundaries of the project footprint identified in this BO, including staging and access.
  - b. If requested, before, during, or upon completion of groundbreaking and construction activities, Caltrans shall allow access by Service personnel into the project footprint to inspect the project and its activities.
  - c. At least 30 days prior to the onset of any construction-related activities, Caltrans shall submit to the Service, for approval, the name(s) and credentials of biological monitors it requests to conduct activities specified for this project. Information included in a request for authorization must include, at a minimum: (1) relevant education; (2) relevant training on species identification, survey techniques, handling individuals of different age classes, and handling of different life stages by a permitted biologist or recognized species expert authorized for such activities by the Service; (3) a summary of field experience conducting requested activities (to include project/research information and actual experience with the species); (4) a summary of biological opinions and/or informal consultations under which they were authorized to work with the listed species and at what level (such as construction monitoring versus handling), this should also include the names and qualifications of persons under which the work was supervised as well as the amount of work experience on the actual project including detail on whether the species was encountered or not; and (5) a list of Federal Recovery Permits [10(a)1(A)] if any, held or under which individuals are authorized to work with the species (to include permit number, authorized activities, and name of permit holder).

No project activities shall begin until the Caltrans has received written Service approval for biologists to conduct specified activities.

2. The following *Terms and Conditions* implement *Reasonable and Prudent Measure* two (2):
  - a. The Applicant and/or Caltrans shall use a Service-approved delta smelt conservation bank if using off-site compensation, as proposed in the biological assessment, to minimize adverse effects to delta smelt and its critical habitat.

#### *Reporting Requirements*

In order to monitor whether the amount or extent of incidental take anticipated from implementation of the project is approached or exceeded, Caltrans shall adhere to the following reporting requirements. Should this anticipated amount or extent of incidental take be exceeded, Caltrans must reinitiate formal consultation as per 50 CFR 402.16.

1. Notification of living, injured, or dead listed species will be made to the Assistant Field Supervisor of the Endangered Species Division at the San Francisco Bay Delta Fish and Wildlife Office. When an injured or dead individual of the listed species is found, Caltrans shall follow the steps outlined in the following *Disposition of Individuals Taken* section.
2. Sightings of any listed or sensitive animal species should be reported to the Service and CNDDDB (<https://www.wildlife.ca.gov/Data/CNDDDB/Submitting-Data>).
3. Construction compliance reports will be addressed to the Assistant Field Supervisor of the Endangered Species Division at the San Francisco Bay Delta Fish and Wildlife Office.
4. Caltrans shall submit post-construction compliance reports prepared by the Service-approved biologist to the Service within 60 calendar days following completion of each construction season or within 60 calendar days of any break in construction activity lasting more than 60 calendar days. This report shall detail (1) dates that relevant project activities occurred; (2) pertinent information concerning the success of the project in implementing avoidance and minimization measures; (3) an explanation of failure to meet such measures, if any; (4) known project effects on the delta smelt and valley elderberry longhorn beetle; (5) occurrences of incidental take of any listed species; (6) documentation of employee environmental education; and (7) other pertinent information.

#### *Disposition of Individuals Taken*

Injured listed species must be cared for by a licensed veterinarian or other qualified person(s), such as the Service-approved biologist. Dead individuals must be sealed in a resealable plastic bag containing a paper with the date and time when the animal was found, the location where it was found, and the name of the person who found it, and the bag containing the specimen frozen in a freezer located in a secure site, until instructions are received from the Service regarding the disposition of the dead specimen. The Service contact person is the Assistant Field Supervisor of the Endangered Species Division at the San Francisco Bay Delta Fish and Wildlife Office.

## CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information. The Service recommends the following actions:

1. Caltrans should consider participating in the planning for a regional habitat conservation plan for the delta smelt, valley elderberry longhorn beetle, other listed species, and sensitive species.
2. Caltrans should consider establishing functioning preservation and creation conservation banking systems to further the conservation of the delta smelt and giant garter snake. Such banking systems also could be utilized for other required mitigation (i.e., seasonal wetlands, riparian habitats, etc.) where appropriate. Particular emphasis should be on the preservation of habitat along roadways in association with wildlife crossings.
3. The Service appreciates Caltrans' proposals to use native plants as part of their restoration plans and right of way seed mix. The Service encourages Caltrans to incorporate native milkweed species into their restoration seed mixes. The Service encourages Caltrans to implement a roadside management program that is compatible with the monarch's life cycle. Compatible maintenance would exclude the use of herbicides/pesticides as well as limiting mowing to one swath closest to the shoulder, outside the butterfly's peak activity and milkweed blooming period.

In order for the Service to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

## REINITIATION-CLOSING STATEMENT

This concludes formal consultation on the I Street Bridge Replacement Project. As provided in 50 CFR § 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been maintained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this biological opinion, including work outside of the described project footprint, including vehicle parking, staging, lay down areas, and access roads; (3) the agency action is subsequently modified in a manner that causes an effect to listed species or critical habitat that was not considered in this biological opinion, including use of rodenticides or herbicides, relocation of utilities, and use of vehicle parking, staging, lay down areas, and access roads; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any additional take will not

be exempt from the prohibitions of section 9 of the Act, pending reinitiation.

Please address any questions or concerns regarding this response to Kim Squires, Section Division Chief, at [Kim\\_Squires@fws.gov](mailto:Kim_Squires@fws.gov). Please refer to Service file number 08FBDT00-2016-F-0227 in any future correspondence regarding this project.

Sincerely,

A handwritten signature in black ink, appearing to read "Kaylee Allen". The signature is fluid and cursive, with a large initial "K" and a long, sweeping underline.

Kaylee Allen  
Field Supervisor

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## **Native American Consultation**

## Hoffman, Robin

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**From:** Hoffman, Robin  
**Sent:** Tuesday, April 07, 2015 7:17 AM  
**To:** 'nahc@nahc.ca.gov'  
**Subject:** SLF and Contacts Request - City of Sacramento I St. Bridge Replacement Project  
**Attachments:** I-St-Bridge\_NAHC-request\_04072015.pdf

**Importance:** High

**Follow Up Flag:** Follow up  
**Flag Status:** Flagged

I would like to request a Sacred Lands File search and list of Native American contacts for the City of Sacramento's I St. Bridge Replacement Project. The formal request form and APE map is attached. Please let me know if you have any questions.

Thank you,

Robin D. Hoffman, MA, RPA | Senior Consultant – Archaeologist | [916.231.7684](tel:916.231.7684) (w) | [707.494.3349](tel:707.494.3349) (c)  
ICF INTERNATIONAL | 630 K Street, Suite 400, Sacramento, CA 95814

## Sacred Lands File & Native American Contacts List Request

### NATIVE AMERICAN HERITAGE COMMISSION

1550 Harbor Blvd, Suite 100  
West Sacramento, CA 95501  
(916) 373-3710  
(916) 373-5471 – Fax  
[nahc@nahc.ca.gov](mailto:nahc@nahc.ca.gov)

*Information Below is Required for a Sacred Lands File Search*

Project: \_\_\_\_\_

County: \_\_\_\_\_

USGS Quadrangle

Name: \_\_\_\_\_

Township: \_\_\_\_\_ Range: \_\_\_\_\_ Section(s): \_\_\_\_\_

Company/Firm/Agency:

\_\_\_\_\_  
Contact Person: \_\_\_\_\_

Street Address: \_\_\_\_\_

City: \_\_\_\_\_ Zip: \_\_\_\_\_

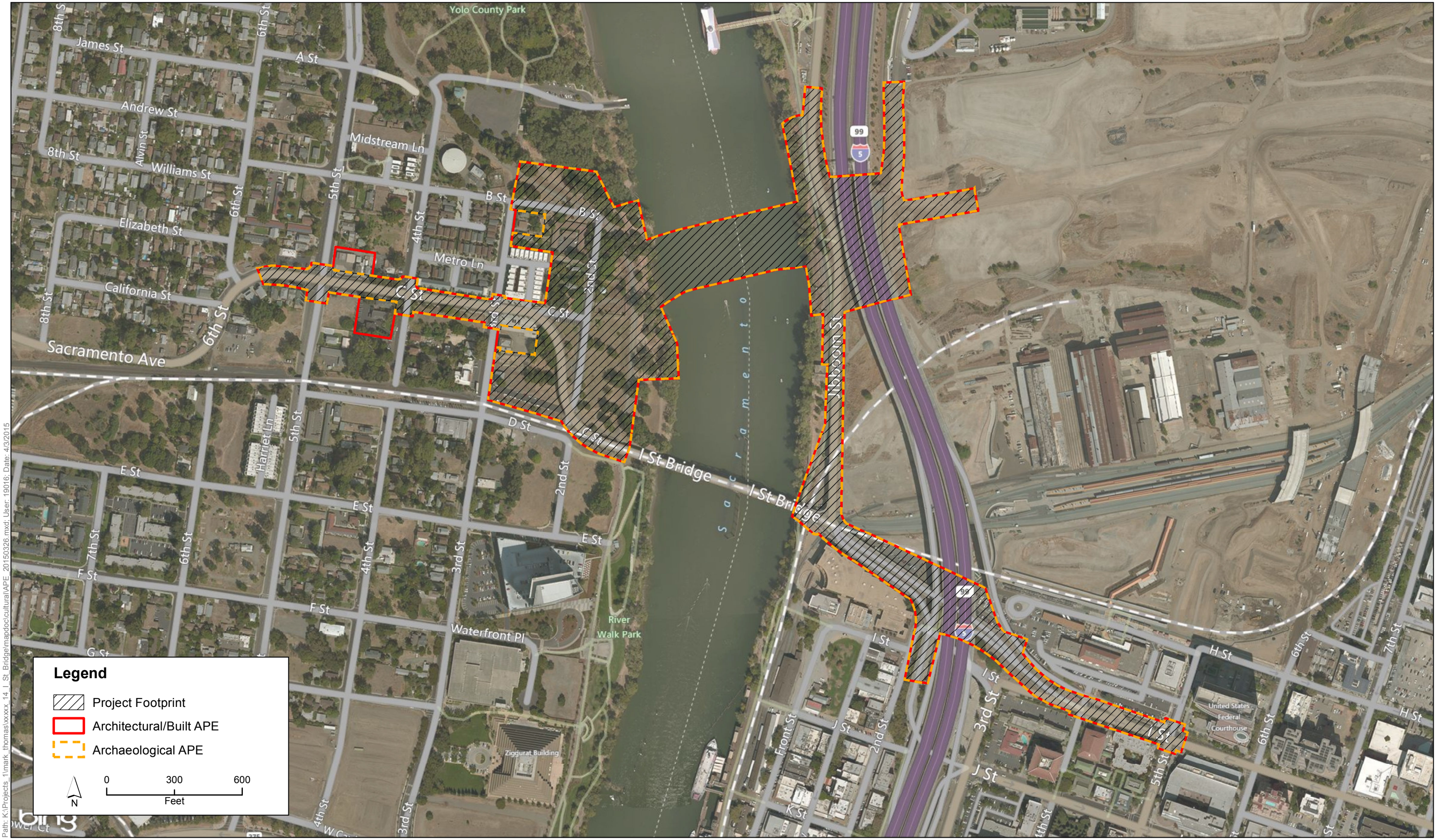
Phone: \_\_\_\_\_ Extension: \_\_\_\_\_

Fax: \_\_\_\_\_

Email: \_\_\_\_\_

Project Description:

\_\_\_\_ Project Location Map is attached



Path: K:\Projects\1\mark\_thomas\xxxxx\_14\_I\_Street\_Bridge\mapdoc\cultural\APE\_20150326.mxd; User: 19016; Date: 4/3/2015



**Figure 1**  
**Area of Potential Effects**  
**I Street Bridge**

**From:** [Microsoft Outlook](#)  
**To:** ["Debbie Pilas-Treadway"](#)  
**Subject:** Relayed: FW: SLF and Contacts Request - City of Sacramento I St. Bridge Replacement Project  
**Date:** Thursday, April 09, 2015 9:18:47 AM  
**Attachments:** [FW SLF and Contacts Request - City of Sacramento I St. Bridge Replacement Project.msg](#)

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Delivery to these recipients or groups is complete, but no delivery notification was sent by the destination server:  
'Debbie Pilas-Treadway' (dpt\_nahc@pacbell.net) <mailto:dpt\_nahc@pacbell.net>  
Subject: FW: SLF and Contacts Request - City of Sacramento I St. Bridge Replacement Project

**From:** Hoffman, Robin  
**To:** ["Debbie Pilas-Treadway"](#)  
**Bcc:** [Sorvari, Tina](#); [Havelaar, Christiaan](#)  
**Subject:** FW: SLF and Contacts Request - City of Sacramento I St. Bridge Replacement Project  
**Date:** Tuesday, April 28, 2015 9:19:00 AM  
**Attachments:** [I-St-Bridge\\_NAHC-request\\_04072015.pdf](#)  
**Importance:** High

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Ms. Pilas-Treadway,

Could you please confirm that the NAHC is still processing the Sacred Lands File request referred to in the subject line of this email. If so, do you have any estimate on when the request might be completed? For your use, the original request with attached documentation is included as an attachment to this email.

Thank you,  
-Robin

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**From:** dpt\_nahc@pacbell.net [mailto:dpt\_nahc@pacbell.net]  
**Sent:** Thursday, April 09, 2015 9:32 AM  
**To:** Hoffman, Robin  
**Subject:** Re: SLF and Contacts Request - City of Sacramento I St. Bridge Replacement Project

Thanks Robin, we will start to process your request.

Debbie

On Thursday, April 9, 2015 9:18 AM, "Hoffman, Robin" <[Robin.Hoffman@icfi.com](mailto:Robin.Hoffman@icfi.com)> wrote:

Ms. Pilas-Treadway,

I am forwarding you the SLF and contacts request below, with attached documentation, that was sent Tuesday to [nahc@nahc.ca.gov](mailto:nahc@nahc.ca.gov). I have yet to receive a receipt of delivery or read receipt, so I would like to confirm that the NAHC received it. If not, could you please process the request at your convenience.

Thank you,

Robin D. Hoffman, MA, RPA | Senior Consultant – Archaeologist | [916.231.7684](tel:916.231.7684) (w) | [707.494.3349](tel:707.494.3349) (c)  
ICF INTERNATIONAL | 630 K Street, Suite 400, Sacramento, CA 95814

---

**From:** Hoffman, Robin  
**Sent:** Tuesday, April 07, 2015 7:17 AM  
**To:** 'nahc@nahc.ca.gov'  
**Subject:** SLF and Contacts Request - City of Sacramento I St. Bridge Replacement Project  
**Importance:** High

I would like to request a Sacred Lands File search and list of Native American



contacts for the City of Sacramento's I St. Bridge Replacement Project. The formal request form and APE map is attached. Please let me know if you have any questions.

Thank you,

**Robin D. Hoffman, MA, RPA** | Senior Consultant – Archaeologist | [916.231.7684](tel:916.231.7684) (w) | [707.494.3349](tel:707.494.3349) (c)  
**ICF INTERNATIONAL** | 630 K Street, Suite 400, Sacramento, CA 95814

## Sacred Lands File & Native American Contacts List Request

### NATIVE AMERICAN HERITAGE COMMISSION

1550 Harbor Blvd, Suite 100  
West Sacramento, CA 95501  
(916) 373-3710  
(916) 373-5471 – Fax  
[nahc@nahc.ca.gov](mailto:nahc@nahc.ca.gov)

*Information Below is Required for a Sacred Lands File Search*

Project: \_\_\_\_\_

County: \_\_\_\_\_

USGS Quadrangle

Name: \_\_\_\_\_

Township: \_\_\_\_\_ Range: \_\_\_\_\_ Section(s): \_\_\_\_\_

Company/Firm/Agency:

\_\_\_\_\_

Contact Person: \_\_\_\_\_

Street Address: \_\_\_\_\_

City: \_\_\_\_\_ Zip: \_\_\_\_\_

Phone: \_\_\_\_\_ Extension: \_\_\_\_\_

Fax: \_\_\_\_\_

Email: \_\_\_\_\_

Project Description:

\_\_\_\_ Project Location Map is attached

**From:** [Microsoft Outlook](#)  
**To:** ["Debbie Pilas-Treadway"](#)  
**Subject:** Relayed: FW: SLF and Contacts Request - City of Sacramento I St. Bridge Replacement Project  
**Date:** Tuesday, April 28, 2015 9:20:15 AM  
**Attachments:** [FW SLF and Contacts Request - City of Sacramento I St. Bridge Replacement Project.msg](#)

---

Delivery to these recipients or groups is complete, but no delivery notification was sent by the destination server:  
'Debbie Pilas-Treadway' (dpt\_nahc@pacbell.net) <mailto:dpt\_nahc@pacbell.net>  
Subject: FW: SLF and Contacts Request - City of Sacramento I St. Bridge Replacement Project

**From:** [dpt\\_nahc@pacbell.net](mailto:dpt_nahc@pacbell.net)  
**To:** [Hoffman, Robin](#)  
**Subject:** Re: SLF and Contacts Request - City of Sacramento I St. Bridge Replacement Project  
**Date:** Tuesday, April 28, 2015 9:36:24 AM

---

The letter was typed up yesterday and will be faxed out today. Thanks for the follow up.

Debbie Treadway  
Native American Heritage Commission

On Tuesday, April 28, 2015 9:19 AM, "Hoffman, Robin" <[Robin.Hoffman@icfi.com](mailto:Robin.Hoffman@icfi.com)> wrote:

Ms. Pilas-Treadway,

Could you please confirm that the NAHC is still processing the Sacred Lands File request referred to in the subject line of this email. If so, do you have any estimate on when the request might be completed? For your use, the original request with attached documentation is included as an attachment to this email.

Thank you,  
-Robin

---

**From:** [dpt\\_nahc@pacbell.net](mailto:dpt_nahc@pacbell.net) [[mailto:dpt\\_nahc@pacbell.net](mailto:dpt_nahc@pacbell.net)]  
**Sent:** Thursday, April 09, 2015 9:32 AM  
**To:** Hoffman, Robin  
**Subject:** Re: SLF and Contacts Request - City of Sacramento I St. Bridge Replacement Project

Thanks Robin, we will start to process your request.

Debbie

On Thursday, April 9, 2015 9:18 AM, "Hoffman, Robin" <[Robin.Hoffman@icfi.com](mailto:Robin.Hoffman@icfi.com)> wrote:

Ms. Pilas-Treadway,

I am forwarding you the SLF and contacts request below, with attached documentation, that was sent Tuesday to [nahc@nahc.ca.gov](mailto:nahc@nahc.ca.gov). I have yet to receive a receipt of delivery or read receipt, so I would like to confirm that the NAHC received it. If not, could you please process the request at your convenience.

Thank you,

**Robin D. Hoffman, MA, RPA** | Senior Consultant – Archaeologist | [916.231.7684](tel:916.231.7684) (w) | [707.494.3349](tel:707.494.3349) (c)  
**ICF INTERNATIONAL** | 630 K Street, Suite 400, Sacramento, CA 95814

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**From:** Hoffman, Robin

**Sent:** Tuesday, April 07, 2015 7:17 AM

**To:** 'nahc@nahc.ca.gov'

**Subject:** SLF and Contacts Request - City of Sacramento I St. Bridge Replacement Project

**Importance:** High

I would like to request a Sacred Lands File search and list of Native American contacts for the City of Sacramento's I St. Bridge Replacement Project. The formal request form and APE map is attached. Please let me know if you have any questions.

Thank you,

**Robin D. Hoffman, MA, RPA** | Senior Consultant – Archaeologist | [916.231.7684](tel:916.231.7684) (w) | [707.494.3349](tel:707.494.3349) (c)  
**ICF INTERNATIONAL** | 630 K Street, Suite 400, Sacramento, CA 95814

STATE OF CALIFORNIA

Edmund G. Brown, Jr., Governor

**NATIVE AMERICAN HERITAGE COMMISSION**

1550 Harbor Blvd.  
West Sacramento, CA 95691  
(916) 373-3710  
Fax (916) 373-5471



April 27, 2015

Robin D. Hoffman  
ICF International  
630 K Street, Ste 400  
Sacramento, CA 95814

**VIA FAX: 916-737-3030**  
~~mailto:Karon.Reichardt@dot.ca.gov~~

3 Pages

I Street Bridge Replacement project, Sacramento and Yolo Counties

Mr. Hoffman;

A record search of the sacred land file has failed to indicate the presence of Native American cultural resources in the immediate project area. The absence of specific site information in the sacred lands file does not indicate the absence of cultural resources in any project area. Other sources of cultural resources should also be contacted for information regarding known and recorded sites.

Enclosed is a list of Native Americans individuals/organizations who may have knowledge of cultural resources in the project area. The Commission makes no recommendation or preference of a single individual, or group over another. This list should provide a starting place in locating areas of potential adverse impact within the proposed project area. I suggest you contact all of those indicated, if they cannot supply information, they might recommend others with specific knowledge. By contacting all those listed, your organization will be better able to respond to claims of failure to consult with the appropriate tribe or group. If a response has not been received within two weeks of notification, the Commission requests that you follow-up with a telephone call to ensure that the project information has been received.

If you receive notification of change of addresses and phone numbers from any of these individuals or groups, please notify me. With your assistance we are able to assure that our lists contain current information. If you have any questions or need additional information, please contact me at (916) 373-3713.

Sincerely,

*Debbie Pilas-Treadway*  
Debbie Pilas-Treadway  
Environmental Specialist III

**Native American Contacts  
Sacramento and Yolo Counties  
April 24, 2015**

Rose Enos  
15310 Bancroft Road  
Auburn, CA 95603  
(530) 878-2378

Maidu  
Washoe

Shingle Springs Band of Miwok Indians  
Nicholas Fonseca, Chairperson  
P.O. Box 1340  
Shingle Springs, CA 95682  
nfonseca@ssband.org  
(530) 676-8010 Office

Miwok  
Maidu

(530) 676-8033 Fax

Kesner Flores  
P.O. Box 1047  
Wheatland, CA 95692  
(925) 586-8919

Wintun / Patwin

Shingle Springs Band of Miwok Indians  
Daniel Fonseca, Cultural Resource Director  
P.O. Box 1340  
Shingle Springs, CA 95682  
(530) 676-8010 Office

Miwok  
Maidu

(530) 676-8033 Fax

April Wallace Moore  
19630 Placer Hills Road  
Colfax, CA 95713  
(530) 637-4279

Nisenan - So Maidu  
Konkow  
Washoe

T' si-Akim Maidu  
Eileen Moon, Vice Chairperson  
P.O. Box 1246  
Grass Valley, CA 95945  
(530) 274-7497

Maidu

Cortina Band of Indians  
Charlie Wright, Chairperson  
P.O. Box 1630  
Williams, CA 95987  
(530) 473-3274 Office

Wintun / Patwin

T' si-Akim Maidu  
Grayson Coney, Cultural Director  
P.O. Box 1316  
Colfax, CA 95713  
akimmaidu@att.net  
(530) 383-7234

Maidu

(530) 473-3301 Fax

Shingle Springs Band of Miwok Indians  
Hermo Olanio, Vice Chairperson  
P.O. Box 1340  
Shingle Springs, CA 95682  
holanio@ssband.org  
(530) 676-8010 Office

Miwok  
Maidu

T' si-Akim Maidu  
Don Ryberg, Chairperson  
P.O. Box 1246  
Grass Valley, CA 95945  
(530) 274-7497

Maidu

(530) 676-8033 Fax

This list is current only as of the date of this document.

Distribution of this list does not relieve any person of statutory responsibility as defined in Section 7050.5 of the Health and Safety Code, Section 5097.94 of the Public Resource Section 5097.98 of the Public Resources Code

This list is only applicable for contacting local Native Americans with regard to cultural resources for the proposed I Street Bridge Replacement project, Sacramento and Yolo Counties

**Native American Contacts  
Sacramento and Yolo Counties  
April 24, 2015**

United Auburn Indian Community of the Auburn Rancheria  
Gene Whitehouse, Chairperson  
10720 Indian Hill Road Maidu  
Auburn, CA 95603 Miwok  
(530) 883-2390 Office  
  
(530) 883-2380 Fax

Yocha Dehe Wintun Nation  
Cynthia Clarke, Native Cultural Renewal Committee  
P.O. Box 18 Wintun (Patwin)  
Brooks, CA 95606  
(530) 796-3400 Office  
  
(530) 796-2143 Fax

United Auburn Indian Community of the Auburn Rancheria  
Marcos Guerrero, Tribal Preservation Committee  
10720 Indian Hill Road Maidu  
Auburn, CA 95603 Miwok  
mguerrero@auburnrancheria.com  
(530) 883-2364 Office  
  
(530) 883-2320 Fax

United Auburn Indian Community of the Auburn Rancheria  
Jason Camp, THPO  
10720 Indian Hill Road Maidu  
Auburn, CA 95603 Miwok  
jcamp@auburnrancheria.com  
(916) 316-3772 Cell  
(530) 883-2390  
(530) 888-5476 - Fax

Yocha Dehe Wintun Nation  
Leland Kinter, Chairperson  
P.O. Box 18 Wintun (Patwin)  
Brooks, CA 95606  
lkinter@yochadehe-nsn.gov  
(530) 796-3400  
  
(530) 796-2143 Fax

Yocha Dehe Wintun Nation  
Native Cultural Renewal Committee  
P.O. Box 18 Wintun (Patwin)  
Brooks, CA 95606  
(530) 979-6346  
(530) 796-3400 - office  
(530) 796-2143 Fax

This list is current only as of the date of this document.

Distribution of this list does not relieve any person of statutory responsibility as defined in Section 7050.5 of the Health and Safety Code, Section 5097.94 of the Public Resource Section 5097.98 of the Public Resources Code

This list is only applicable for contacting local Native Americans with regard to cultural resources for the proposed I Street Bridge Replacement project, Sacramento and Yolo Counties



June 10, 2015

The Honorable Jason Camp  
THPO, United Indian Community of the Auburn  
Rancheria  
10720 Indian Hill Road  
Auburn, CA 95603

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

Re: Invitation to Consultation for the I Street Bridge Replacement Project, City of Sacramento and City of West Sacramento

Dear Honorable Jason Camp:

The City of Sacramento, in cooperation with the City of West Sacramento and Caltrans, is proposing to construct a new bridge across the Sacramento River. The new bridge would provide a new vehicle, bicycle, and pedestrian crossing connecting C Street in West Sacramento to Railyards Boulevard in Sacramento (see attached map). The proposed bridge would include a moveable center span to allow passage for watercraft. Additional roadwork would include new signalized intersections at Jibboom Street and Bercut Drive connecting at Railyards Boulevard and the extension of C Street from the intersection of 3rd Street to the proposed bridge. The River Walk Park in West Sacramento and the Sacramento River Parkway trail in Sacramento, which connects to the American River Bike Trail at Discovery Park, would be extended to the new roadway and pass underneath the abutments of the proposed bridge. In West Sacramento, a portion of the existing levee where the proposed bridge alignment connects to C Street would be reconstructed; the improved levee portion would include a slurry cutoff wall. The existing I Street Bridge would continue to be used by the railroad. Vehicle and pedestrian traffic would be removed. The existing approach structures for Jibboom Street, I Street and J Street in the City of Sacramento and C Street in the City of West Sacramento would be demolished. The proposed bridge crossing could also accommodate future transit options, including a streetcar alignment within the bridge. No such use is proposed as part of this project; any future streetcar expansion would be considered separately.

ICF International archaeologist Christiaan Havelaar, Co-Principal Investigator, is a consultant representing the City of Sacramento and will be contacting you to initiate Native American consultation. Mr. Havelaar will be requesting information you may have regarding sites, traditional cultural properties, values, or other cultural resource considerations within the project area so this information may be incorporated into the planning phase of the project.

June 10, 2015

Page 2

Please consider this letter and preliminary project information as the initiation of Section 106 consultation pursuant to the National Historic Preservation Act and the California Environmental Quality Act.

Due to federal funding, Caltrans will provide oversight to ensure compliance with Section 106 of the National Historic Preservation Act as well as other federal laws and regulations.

Your comments and concerns will be important to the City of Sacramento as they move forward with their project. If you have any questions or concerns with the project, please contact Christiaan Havelaar via email ([christiaan.havelaar@icfi.com](mailto:christiaan.havelaar@icfi.com)) or at his office (916-737-3000). Mr. Havelaar's mailing address is:

Christiaan Havelaar  
ICF International  
630 K Street, Suite 400  
Sacramento, CA 95814

If you have questions regarding the content of this letter you can contact me at [DMahaffey@cityofsacramento.org](mailto:DMahaffey@cityofsacramento.org) or 916-808-2762.

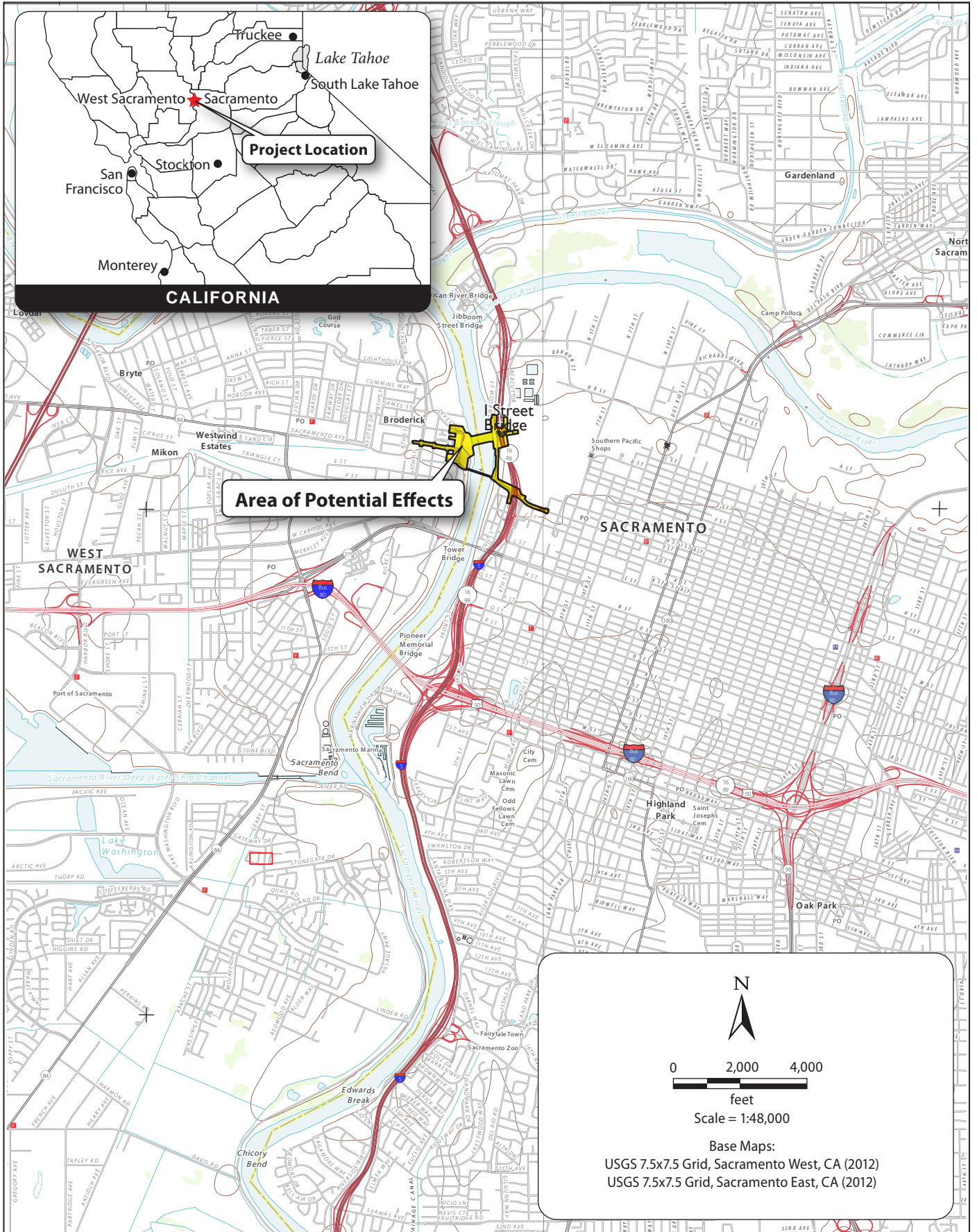
Sincerely,



Dana Mahaffey, Associate Planner  
City of Sacramento Community Development Department

Attachments: Project Location map  
Draft Area of Potential Effects map

cc: Erin Dwyer, Caltrans D3  
Gene Whitehouse, United Indian Community of the Auburn Rancheria  
Marcos Guerrero, United Indian Community of the Auburn Rancheria

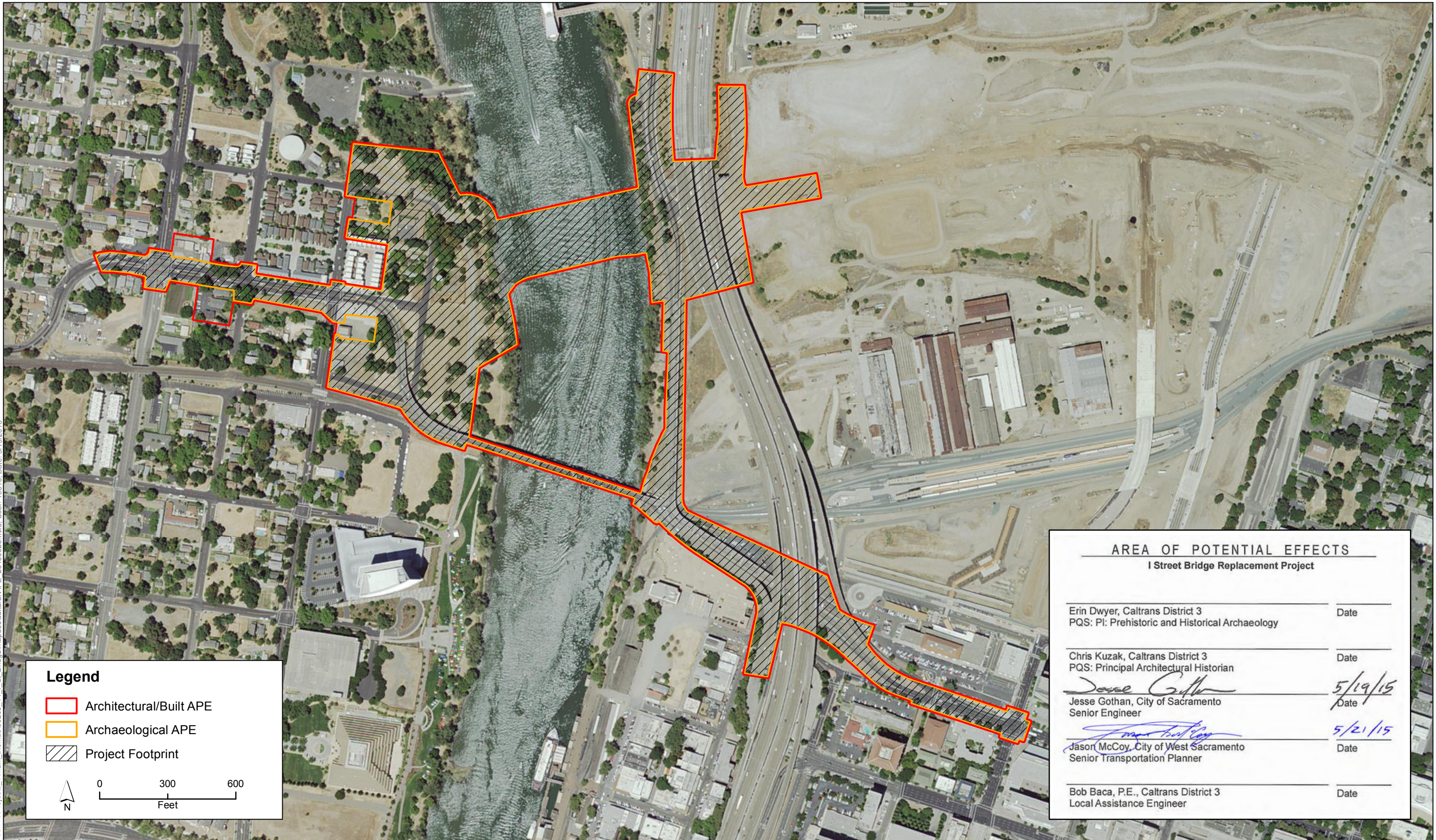


Graphics ... 002033.14 (9/9/14) AB



**Figure 1**  
**Project Location Map**

Path: K:\Projects\1\mark\_thomas\0203\_14\_I\_Street\Bridgemapdoc\cultural\APE\_20150326.mxd; User: 190716; Date: 5/19/2015



**Legend**

- Architectural/Built APE
- Archaeological APE
- Project Footprint

0      300      600  
Feet

N

<b>AREA OF POTENTIAL EFFECTS</b>	
<b>I Street Bridge Replacement Project</b>	
Erin Dwyer, Caltrans District 3 PQS: PI: Prehistoric and Historical Archaeology	Date
Chris Kuzak, Caltrans District 3 PQS: Principal Architectural Historian	Date
<i>Jesse Gothan</i> Jesse Gothan, City of Sacramento Senior Engineer	5/19/15 Date
<i>Jason McCoy</i> Jason McCoy, City of West Sacramento Senior Transportation Planner	5/21/15 Date
Bob Baca, P.E., Caltrans District 3 Local Assistance Engineer	Date



**Figure & Area of Potential Effects I Street Bridge**

June 10, 2015

The Honorable Cynthia Clarke  
Native Cultural Renewal Committee, Yocha Dehe  
Wintun Nation  
P.O. Box 18  
Brooks, CA 95606

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

Re: Invitation to Consultation for the I Street Bridge Replacement Project, City of Sacramento and City of West Sacramento

Dear Honorable Cynthia Clarke:

The City of Sacramento, in cooperation with the City of West Sacramento and Caltrans, is proposing to construct a new bridge across the Sacramento River. The new bridge would provide a new vehicle, bicycle, and pedestrian crossing connecting C Street in West Sacramento to Railyards Boulevard in Sacramento (see attached map). The proposed bridge would include a moveable center span to allow passage for watercraft. Additional roadwork would include new signalized intersections at Jibboom Street and Bercut Drive connecting at Railyards Boulevard and the extension of C Street from the intersection of 3rd Street to the proposed bridge. The River Walk Park in West Sacramento and the Sacramento River Parkway trail in Sacramento, which connects to the American River Bike Trail at Discovery Park, would be extended to the new roadway and pass underneath the abutments of the proposed bridge. In West Sacramento, a portion of the existing levee where the proposed bridge alignment connects to C Street would be reconstructed; the improved levee portion would include a slurry cutoff wall. The existing I Street Bridge would continue to be used by the railroad. Vehicle and pedestrian traffic would be removed. The existing approach structures for Jibboom Street, I Street and J Street in the City of Sacramento and C Street in the City of West Sacramento would be demolished. The proposed bridge crossing could also accommodate future transit options, including a streetcar alignment within the bridge. No such use is proposed as part of this project; any future streetcar expansion would be considered separately.

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June 10, 2015

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Christiaan Havelaar  
ICF International  
630 K Street, Suite 400  
Sacramento, CA 95814

If you have questions regarding the content of this letter you can contact me at [DMahaffey@cityofsacramento.org](mailto:DMahaffey@cityofsacramento.org) or 916-808-2762.

Sincerely,



Dana Mahaffey, Associate Planner  
City of Sacramento Community Development Department

Attachments: Project Location map  
Draft Area of Potential Effects map

cc: Erin Dwyer, Caltrans D3  
Leland Kinter, Yocha Dehe Wintun Nation

June 10, 2015

The Honorable Grayson Coney  
Cultural Director, T'si-Akim Maidu  
P.O. Box 1316  
Colfax, CA 95713

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

Re: Invitation to Consultation for the I Street Bridge Replacement Project, City of Sacramento and City of West Sacramento

Dear Honorable Grayson Coney:

The City of Sacramento, in cooperation with the City of West Sacramento and Caltrans, is proposing to construct a new bridge across the Sacramento River. The new bridge would provide a new vehicle, bicycle, and pedestrian crossing connecting C Street in West Sacramento to Railyards Boulevard in Sacramento (see attached map). The proposed bridge would include a moveable center span to allow passage for watercraft. Additional roadwork would include new signalized intersections at Jibboom Street and Bercut Drive connecting at Railyards Boulevard and the extension of C Street from the intersection of 3rd Street to the proposed bridge. The River Walk Park in West Sacramento and the Sacramento River Parkway trail in Sacramento, which connects to the American River Bike Trail at Discovery Park, would be extended to the new roadway and pass underneath the abutments of the proposed bridge. In West Sacramento, a portion of the existing levee where the proposed bridge alignment connects to C Street would be reconstructed; the improved levee portion would include a slurry cutoff wall. The existing I Street Bridge would continue to be used by the railroad. Vehicle and pedestrian traffic would be removed. The existing approach structures for Jibboom Street, I Street and J Street in the City of Sacramento and C Street in the City of West Sacramento would be demolished. The proposed bridge crossing could also accommodate future transit options, including a streetcar alignment within the bridge. No such use is proposed as part of this project; any future streetcar expansion would be considered separately.

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Please consider this letter and preliminary project information as the initiation of Section 106 consultation pursuant to the National Historic Preservation Act and the California Environmental Quality Act.

300 Richards Blvd., 3rd Floor  
Sacramento, CA 95811

Help Line: 916-264-5011  
[CityofSacramento.org/dsd](http://CityofSacramento.org/dsd)

June 10, 2015

Page 2

Due to federal funding, Caltrans will provide oversight to ensure compliance with Section 106 of the National Historic Preservation Act as well as other federal laws and regulations.

Your comments and concerns will be important to the City of Sacramento as they move forward with their project. If you have any questions or concerns with the project, please contact Christiaan Havelaar via email ([christiaan.havelaar@icfi.com](mailto:christiaan.havelaar@icfi.com)) or at his office (916-737-3000). Mr. Havelaar's mailing address is:

Christiaan Havelaar  
ICF International  
630 K Street, Suite 400  
Sacramento, CA 95814

If you have questions regarding the content of this letter you can contact me at [DMahaffey@cityofsacramento.org](mailto:DMahaffey@cityofsacramento.org) or 916-808-2762.

Sincerely,



Dana Mahaffey, Associate Planner  
City of Sacramento Community Development Department

Attachments: Project Location map  
Draft Area of Potential Effects map

cc: Erin Dwyer, Caltrans D3  
Eileen Moon, T'si-Akim Maidu  
Don Ryberg, T'si-Akim Maidu





June 10, 2015

The Honorable Rose Enos  
15310 Bancroft Road  
Auburn, CA 95603

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

Re: Invitation to Consultation for the I Street Bridge Replacement Project, City of Sacramento and City of West Sacramento

Dear Honorable Rose Enos:

The City of Sacramento, in cooperation with the City of West Sacramento and Caltrans, is proposing to construct a new bridge across the Sacramento River. The new bridge would provide a new vehicle, bicycle, and pedestrian crossing connecting C Street in West Sacramento to Railyards Boulevard in Sacramento (see attached map). The proposed bridge would include a moveable center span to allow passage for watercraft. Additional roadwork would include new signalized intersections at Jibboom Street and Bercut Drive connecting at Railyards Boulevard and the extension of C Street from the intersection of 3rd Street to the proposed bridge. The River Walk Park in West Sacramento and the Sacramento River Parkway trail in Sacramento, which connects to the American River Bike Trail at Discovery Park, would be extended to the new roadway and pass underneath the abutments of the proposed bridge. In West Sacramento, a portion of the existing levee where the proposed bridge alignment connects to C Street would be reconstructed; the improved levee portion would include a slurry cutoff wall. The existing I Street Bridge would continue to be used by the railroad. Vehicle and pedestrian traffic would be removed. The existing approach structures for Jibboom Street, I Street and J Street in the City of Sacramento and C Street in the City of West Sacramento would be demolished. The proposed bridge crossing could also accommodate future transit options, including a streetcar alignment within the bridge. No such use is proposed as part of this project; any future streetcar expansion would be considered separately.

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300 Richards Blvd., 3rd Floor  
Sacramento, CA 95811

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June 10, 2015

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Christiaan Havelaar  
ICF International  
630 K Street, Suite 400  
Sacramento, CA 95814

If you have questions regarding the content of this letter you can contact me at [DMahaffey@cityofsacramento.org](mailto:DMahaffey@cityofsacramento.org) or 916-808-2762.

Sincerely,

A handwritten signature in cursive script, appearing to read "Dana Mahaffey".

Dana Mahaffey, Associate Planner  
City of Sacramento Community Development Department

Attachments: Project Location map  
Draft Area of Potential Effects map

cc: Erin Dwyer, Caltrans D3

June 10, 2015

The Honorable Kesner Flores  
P.O. Box 1047  
Wheatland, CA 95692

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

Re: Invitation to Consultation for the I Street Bridge Replacement Project, City of Sacramento and City of West Sacramento

Dear Honorable Kesner Flores:

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June 10, 2015

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Christiaan Havelaar  
ICF International  
630 K Street, Suite 400  
Sacramento, CA 95814

If you have questions regarding the content of this letter you can contact me at [DMahaffey@cityofsacramento.org](mailto:DMahaffey@cityofsacramento.org) or 916-808-2762.

Sincerely,

A handwritten signature in cursive script, appearing to read "Dana Mahaffey".

Dana Mahaffey, Associate Planner  
City of Sacramento Community Development Department

Attachments: Project Location map  
Draft Area of Potential Effects map

cc: Erin Dwyer, Caltrans D3

June 10, 2015

The Honorable Daniel Fonseca  
Cultural Resources Director, Shingle Springs Band  
of Miwok Indians  
P.O. Box 1340  
Shingle Springs, CA 95682

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

Re: Invitation to Consultation for the I Street Bridge Replacement Project, City of Sacramento and City of West Sacramento

Dear Honorable Daniel Fonseca:

The City of Sacramento, in cooperation with the City of West Sacramento and Caltrans, is proposing to construct a new bridge across the Sacramento River. The new bridge would provide a new vehicle, bicycle, and pedestrian crossing connecting C Street in West Sacramento to Railyards Boulevard in Sacramento (see attached map). The proposed bridge would include a moveable center span to allow passage for watercraft. Additional roadwork would include new signalized intersections at Jibboom Street and Bercut Drive connecting at Railyards Boulevard and the extension of C Street from the intersection of 3rd Street to the proposed bridge. The River Walk Park in West Sacramento and the Sacramento River Parkway trail in Sacramento, which connects to the American River Bike Trail at Discovery Park, would be extended to the new roadway and pass underneath the abutments of the proposed bridge. In West Sacramento, a portion of the existing levee where the proposed bridge alignment connects to C Street would be reconstructed; the improved levee portion would include a slurry cutoff wall. The existing I Street Bridge would continue to be used by the railroad. Vehicle and pedestrian traffic would be removed. The existing approach structures for Jibboom Street, I Street and J Street in the City of Sacramento and C Street in the City of West Sacramento would be demolished. The proposed bridge crossing could also accommodate future transit options, including a streetcar alignment within the bridge. No such use is proposed as part of this project; any future streetcar expansion would be considered separately.

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June 10, 2015

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Sincerely,



Dana Mahaffey, Associate Planner  
City of Sacramento Community Development Department

Attachments: Project Location map  
Draft Area of Potential Effects map

cc: Erin Dwyer, Caltrans D3  
Nicholas Fonseca, Shingle Springs Band of Miwok Indians  
Heremo Olanio, Shingle Springs Band of Miwok Indians

June 10, 2015

The Honorable Nicholas Fonseca  
Chairperson, Shingle Springs Band of Miwok  
Indians  
P.O. Box 1340  
Shingle Springs, CA 95682

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

Re: Invitation to Consultation for the I Street Bridge Replacement Project, City of Sacramento and City of West Sacramento

Dear Honorable Nicholas Fonseca:

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June 10, 2015

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Dana Mahaffey, Associate Planner  
City of Sacramento Community Development Department

Attachments: Project Location map  
Draft Area of Potential Effects map

cc: Erin Dwyer, Caltrans D3  
Daniel Fonseca, Shingle Springs Band of Miwok Indians  
Hermino Olanio, Shingle Springs Band of Miwok Indians





June 10, 2015

The Honorable Marcos Guerrero  
Tribal Preservation Committee, United Indian  
Community of the Auburn Rancheria  
10720 Indian Hill Road  
Auburn, CA 95603

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

Re: Invitation to Consultation for the I Street Bridge Replacement Project, City of Sacramento and City of West Sacramento

Dear Honorable Marcos Guerrero:

The City of Sacramento, in cooperation with the City of West Sacramento and Caltrans, is proposing to construct a new bridge across the Sacramento River. The new bridge would provide a new vehicle, bicycle, and pedestrian crossing connecting C Street in West Sacramento to Railyards Boulevard in Sacramento (see attached map). The proposed bridge would include a moveable center span to allow passage for watercraft. Additional roadwork would include new signalized intersections at Jibboom Street and Bercut Drive connecting at Railyards Boulevard and the extension of C Street from the intersection of 3rd Street to the proposed bridge. The River Walk Park in West Sacramento and the Sacramento River Parkway trail in Sacramento, which connects to the American River Bike Trail at Discovery Park, would be extended to the new roadway and pass underneath the abutments of the proposed bridge. In West Sacramento, a portion of the existing levee where the proposed bridge alignment connects to C Street would be reconstructed; the improved levee portion would include a slurry cutoff wall. The existing I Street Bridge would continue to be used by the railroad. Vehicle and pedestrian traffic would be removed. The existing approach structures for Jibboom Street, I Street and J Street in the City of Sacramento and C Street in the City of West Sacramento would be demolished. The proposed bridge crossing could also accommodate future transit options, including a streetcar alignment within the bridge. No such use is proposed as part of this project; any future streetcar expansion would be considered separately.

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300 Richards Blvd., 3rd Floor  
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Sincerely,



Dana Mahaffey, Associate Planner  
City of Sacramento Community Development Department

Attachments: Project Location map  
Draft Area of Potential Effects map

cc: Erin Dwyer, Caltrans D3  
Gene Whitehouse, United Indian Community of the Auburn Rancheria  
Jason Camp, United Indian Community of the Auburn Rancheria

June 10, 2015

The Honorable Leland Kinter  
Chairperson, Yocha Dehe Wintun Nation  
P.O. Box 18  
Brooks, CA 95606

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

Re: Invitation to Consultation for the I Street Bridge Replacement Project, City of Sacramento and City of West Sacramento

Dear Honorable Leland Kinter:

The City of Sacramento, in cooperation with the City of West Sacramento and Caltrans, is proposing to construct a new bridge across the Sacramento River. The new bridge would provide a new vehicle, bicycle, and pedestrian crossing connecting C Street in West Sacramento to Railyards Boulevard in Sacramento (see attached map). The proposed bridge would include a moveable center span to allow passage for watercraft. Additional roadwork would include new signalized intersections at Jibboom Street and Bercut Drive connecting at Railyards Boulevard and the extension of C Street from the intersection of 3rd Street to the proposed bridge. The River Walk Park in West Sacramento and the Sacramento River Parkway trail in Sacramento, which connects to the American River Bike Trail at Discovery Park, would be extended to the new roadway and pass underneath the abutments of the proposed bridge. In West Sacramento, a portion of the existing levee where the proposed bridge alignment connects to C Street would be reconstructed; the improved levee portion would include a slurry cutoff wall. The existing I Street Bridge would continue to be used by the railroad. Vehicle and pedestrian traffic would be removed. The existing approach structures for Jibboom Street, I Street and J Street in the City of Sacramento and C Street in the City of West Sacramento would be demolished. The proposed bridge crossing could also accommodate future transit options, including a streetcar alignment within the bridge. No such use is proposed as part of this project; any future streetcar expansion would be considered separately.

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Sincerely,

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Dana Mahaffey, Associate Planner  
City of Sacramento Community Development Department

Attachments: Project Location map  
Draft Area of Potential Effects map

cc: Erin Dwyer, Caltrans D3  
Native Cultural Renewal Committee, Yocha Dehe Wintun Nation  
Cynthia Clarke, Yocha Dehe Wintun Nation

June 10, 2015

The Honorable Eileen Moon  
Vice Chairperson, T'si-Akim Maidu  
P.O. Box 1246  
Grass Valley, CA 95945

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

Re: Invitation to Consultation for the I Street Bridge Replacement Project, City of Sacramento and City of West Sacramento

Dear Honorable Eileen Moon:

The City of Sacramento, in cooperation with the City of West Sacramento and Caltrans, is proposing to construct a new bridge across the Sacramento River. The new bridge would provide a new vehicle, bicycle, and pedestrian crossing connecting C Street in West Sacramento to Railyards Boulevard in Sacramento (see attached map). The proposed bridge would include a moveable center span to allow passage for watercraft. Additional roadwork would include new signalized intersections at Jibboom Street and Bercut Drive connecting at Railyards Boulevard and the extension of C Street from the intersection of 3rd Street to the proposed bridge. The River Walk Park in West Sacramento and the Sacramento River Parkway trail in Sacramento, which connects to the American River Bike Trail at Discovery Park, would be extended to the new roadway and pass underneath the abutments of the proposed bridge. In West Sacramento, a portion of the existing levee where the proposed bridge alignment connects to C Street would be reconstructed; the improved levee portion would include a slurry cutoff wall. The existing I Street Bridge would continue to be used by the railroad. Vehicle and pedestrian traffic would be removed. The existing approach structures for Jibboom Street, I Street and J Street in the City of Sacramento and C Street in the City of West Sacramento would be demolished. The proposed bridge crossing could also accommodate future transit options, including a streetcar alignment within the bridge. No such use is proposed as part of this project; any future streetcar expansion would be considered separately.

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Sincerely,



Dana Mahaffey, Associate Planner  
City of Sacramento Community Development Department

Attachments: Project Location map  
Draft Area of Potential Effects map

cc: Erin Dwyer, Caltrans D3  
Grayson Coney, T'si-Akim Maidu  
Don Ryberg, T'si-Akim Maidu

June 10, 2015

The Honorable April Wallace Moore  
19630 Placer Hills Road  
Colfax, CA 95713

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

Re: Invitation to Consultation for the I Street Bridge Replacement Project, City of Sacramento and City of West Sacramento

Dear Honorable April Wallace Moore:

The City of Sacramento, in cooperation with the City of West Sacramento and Caltrans, is proposing to construct a new bridge across the Sacramento River. The new bridge would provide a new vehicle, bicycle, and pedestrian crossing connecting C Street in West Sacramento to Railyards Boulevard in Sacramento (see attached map). The proposed bridge would include a moveable center span to allow passage for watercraft. Additional roadwork would include new signalized intersections at Jibboom Street and Bercut Drive connecting at Railyards Boulevard and the extension of C Street from the intersection of 3rd Street to the proposed bridge. The River Walk Park in West Sacramento and the Sacramento River Parkway trail in Sacramento, which connects to the American River Bike Trail at Discovery Park, would be extended to the new roadway and pass underneath the abutments of the proposed bridge. In West Sacramento, a portion of the existing levee where the proposed bridge alignment connects to C Street would be reconstructed; the improved levee portion would include a slurry cutoff wall. The existing I Street Bridge would continue to be used by the railroad. Vehicle and pedestrian traffic would be removed. The existing approach structures for Jibboom Street, I Street and J Street in the City of Sacramento and C Street in the City of West Sacramento would be demolished. The proposed bridge crossing could also accommodate future transit options, including a streetcar alignment within the bridge. No such use is proposed as part of this project; any future streetcar expansion would be considered separately.

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Dana Mahaffey, Associate Planner  
City of Sacramento Community Development Department

Attachments: Project Location map  
Draft Area of Potential Effects map

cc: Erin Dwyer, Caltrans D3



June 10, 2015

The Honorable  
Native Cultural Renewal Committee, Yocha Dehe  
Wintun Nation  
P.O. Box 18  
Brooks, CA 95606

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

Re: Invitation to Consultation for the I Street Bridge Replacement Project, City of Sacramento and City of West Sacramento

Dear Honorable Native Cultural Renewal Committee:

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cc: Erin Dwyer, Caltrans D3  
Leland Kinter, Yocha Dehe Wintun Nation  
Cynthia Clarke, Yocha Dehe Wintun Nation

June 10, 2015

The Honorable Hermo Olanio  
Vice Chairperson, Shingle Springs Band of Miwok  
Indians  
P.O. Box 1340  
Shingle Springs, CA 95682

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

Re: Invitation to Consultation for the I Street Bridge Replacement Project, City of Sacramento and City of West Sacramento

Dear Honorable Hermo Olanio:

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cc: Erin Dwyer, Caltrans D3  
Daniel Fonseca, Shingle Springs Band of Miwok Indians  
Nicholas Fonseca, Shingle Springs Band of Miwok Indians

June 10, 2015

The Honorable Don Ryberg  
Chairperson, T'si-Akim Maidu  
P.O. Box 1246  
Grass Valley, CA 95945

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

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630 K Street, Suite 400  
Sacramento, CA 95814

If you have questions regarding the content of this letter you can contact me at [DMahaffey@cityofsacramento.org](mailto:DMahaffey@cityofsacramento.org) or 916-808-2762.

Sincerely,



Dana Mahaffey, Associate Planner  
City of Sacramento Community Development Department

Attachments: Project Location map  
Draft Area of Potential Effects map

cc: Erin Dwyer, Caltrans D3  
Eileen Moon, T'si-Akim Maidu  
Grayson Coney, T'si-Akim Maidu

June 10, 2015

The Honorable Gene Whitehouse  
Chairperson, United Indian Community of the  
Auburn Rancheria  
10720 Indian Hill Road  
Auburn, CA 95603

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

Re: Invitation to Consultation for the I Street Bridge Replacement Project, City of Sacramento and City of West Sacramento

Dear Honorable Gene Whitehouse:

The City of Sacramento, in cooperation with the City of West Sacramento and Caltrans, is proposing to construct a new bridge across the Sacramento River. The new bridge would provide a new vehicle, bicycle, and pedestrian crossing connecting C Street in West Sacramento to Railyards Boulevard in Sacramento (see attached map). The proposed bridge would include a moveable center span to allow passage for watercraft. Additional roadwork would include new signalized intersections at Jibboom Street and Bercut Drive connecting at Railyards Boulevard and the extension of C Street from the intersection of 3rd Street to the proposed bridge. The River Walk Park in West Sacramento and the Sacramento River Parkway trail in Sacramento, which connects to the American River Bike Trail at Discovery Park, would be extended to the new roadway and pass underneath the abutments of the proposed bridge. In West Sacramento, a portion of the existing levee where the proposed bridge alignment connects to C Street would be reconstructed; the improved levee portion would include a slurry cutoff wall. The existing I Street Bridge would continue to be used by the railroad. Vehicle and pedestrian traffic would be removed. The existing approach structures for Jibboom Street, I Street and J Street in the City of Sacramento and C Street in the City of West Sacramento would be demolished. The proposed bridge crossing could also accommodate future transit options, including a streetcar alignment within the bridge. No such use is proposed as part of this project; any future streetcar expansion would be considered separately.

ICF International archaeologist Christiaan Havelaar, Co-Principal Investigator, is a consultant representing the City of Sacramento and will be contacting you to initiate Native American consultation. Mr. Havelaar will be requesting information you may have regarding sites, traditional cultural properties, values, or other cultural resource considerations within the project area so this information may be incorporated into the planning phase of the project.

June 10, 2015

Page 2

Please consider this letter and preliminary project information as the initiation of Section 106 consultation pursuant to the National Historic Preservation Act and the California Environmental Quality Act.

Due to federal funding, Caltrans will provide oversight to ensure compliance with Section 106 of the National Historic Preservation Act as well as other federal laws and regulations.

Your comments and concerns will be important to the City of Sacramento as they move forward with their project. If you have any questions or concerns with the project, please contact Christiaan Havelaar via email ([christiaan.havelaar@icfi.com](mailto:christiaan.havelaar@icfi.com)) or at his office (916-737-3000). Mr. Havelaar's mailing address is:

Christiaan Havelaar  
ICF International  
630 K Street, Suite 400  
Sacramento, CA 95814

If you have questions regarding the content of this letter you can contact me at [DMahaffey@cityofsacramento.org](mailto:DMahaffey@cityofsacramento.org) or 916-808-2762.

Sincerely,



Dana Mahaffey, Associate Planner  
City of Sacramento Community Development Department

Attachments: Project Location map  
Draft Area of Potential Effects map

cc: Erin Dwyer, Caltrans D3  
Marcos Guerrero, United Indian Community of the Auburn Rancheria  
Jason Camp, United Indian Community of the Auburn Rancheria



June 10, 2015

The Honorable Charlie Wright  
Chairperson, Cortina Band of Indians  
P.O. Box 1630  
Williams, CA 95987

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

Re: Invitation to Consultation for the I Street Bridge Replacement Project, City of Sacramento and City of West Sacramento

Dear Honorable Charlie Wright:

The City of Sacramento, in cooperation with the City of West Sacramento and Caltrans, is proposing to construct a new bridge across the Sacramento River. The new bridge would provide a new vehicle, bicycle, and pedestrian crossing connecting C Street in West Sacramento to Railyards Boulevard in Sacramento (see attached map). The proposed bridge would include a moveable center span to allow passage for watercraft. Additional roadwork would include new signalized intersections at Jibboom Street and Bercut Drive connecting at Railyards Boulevard and the extension of C Street from the intersection of 3rd Street to the proposed bridge. The River Walk Park in West Sacramento and the Sacramento River Parkway trail in Sacramento, which connects to the American River Bike Trail at Discovery Park, would be extended to the new roadway and pass underneath the abutments of the proposed bridge. In West Sacramento, a portion of the existing levee where the proposed bridge alignment connects to C Street would be reconstructed; the improved levee portion would include a slurry cutoff wall. The existing I Street Bridge would continue to be used by the railroad. Vehicle and pedestrian traffic would be removed. The existing approach structures for Jibboom Street, I Street and J Street in the City of Sacramento and C Street in the City of West Sacramento would be demolished. The proposed bridge crossing could also accommodate future transit options, including a streetcar alignment within the bridge. No such use is proposed as part of this project; any future streetcar expansion would be considered separately.

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Please consider this letter and preliminary project information as the initiation of Section 106 consultation pursuant to the National Historic Preservation Act and the California Environmental Quality Act.

300 Richards Blvd., 3rd Floor  
Sacramento, CA 95811

Help Line: 916-264-5011  
[CityofSacramento.org/dsd](http://CityofSacramento.org/dsd)

June 10, 2015

Page 2

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Christiaan Havelaar  
ICF International  
630 K Street, Suite 400  
Sacramento, CA 95814

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Sincerely,

A handwritten signature in cursive script, appearing to read "Dana Mahaffey".

Dana Mahaffey, Associate Planner  
City of Sacramento Community Development Department

Attachments: Project Location map  
Draft Area of Potential Effects map

cc: Erin Dwyer, Caltrans D3



YOCHA DEHE  
CULTURAL RESOURCES

June 25<sup>th</sup>, 2015

Christiaan Havelaar  
ICF International  
630 K Street, Suite 400  
Sacramento, CA 95814

RE: I Street Bridge Replacement Project

Dear Mr. Havelaar:

Thank you for your project notification letter dated June 10, 2015 regarding cultural information on or near the proposed I Street Bridge Replacement Project, Sacramento and West Sacramento, CA. We appreciate your effort to contact us and wish to respond.

The Cultural Resources Department has reviewed the project and concluded that it is within the aboriginal territories of the Yocha Dehe Wintun Nation. Therefore, we have a cultural interest and authority in the proposed project area.

Based on the information provided, the Tribe has concerns that the project could impact undiscovered archaeological deposits. Additionally, Yocha Dehe Wintun Nation requests a site visit to the project area to evaluate our cultural concerns. Furthermore, we wish to initiate consultation with ICF International and the Caltrans District 3. Please provide our Cultural Resources Department with a project timeline, detailed project information and the latest cultural study for the proposed project.

Also, please contact the following individual to coordinate a date and time for the site visit.

Mr. James Sarmento  
Cultural Resources Manager  
Yocha Dehe Wintun Nation  
Office: (530) 723-0452, Email: [jsarmento@yochadehe-nsn.gov](mailto:jsarmento@yochadehe-nsn.gov)

Please refer to identification number YD – 06232015-01 in any correspondences concerning this project.

Sincerely,

James Kinter  
Tribal Secretary  
Tribal Historic Preservation Officer

Yocha Dehe Wintun Nation

PO Box 18 Brooks, California 95606 p) 530.796.3400 f) 530.796.2143 [www.yochadehe.org](http://www.yochadehe.org)

Cc: Erin Dwyer, Caltrans District 3



## SHINGLE SPRINGS RANCHERIA

Shingle Springs Band of Miwok Indians,  
Shingle Springs Rancheria  
(Verona Tract), California  
5281 Honpie Road, Placerville, CA 95667

June 30, 2015

City Of Sacramento  
300 Richards Blvd, 3<sup>rd</sup> floor  
Sacramento, CA 95811

Dear Dana Mahaffey

The Most likely Descendant, Daniel Fonseca would like to initiate consultation process with you in regard to the I street bridge replacement located in Sacramento County. Among other things, we would like this consultation to address the cultural and historic resource issues, pursuant to the regulations implementing Section 106 of the National Historic Preservation Act.

Prior to meeting we would like to request any and all completed record searches and or surveys that were done in or around the project area up to and including environmental, archaeological and cultural reports.

Please let this letter serve as a formal request for the Shingle Springs Band of Miwok Indians to be added as a consulting party in identifying any Traditional Cultural Properties (TCPs) that may exist within the project's Area of Potential Effects (APE).

Please contact Kara Perry, Administrative Assistant, (530)488-4049 [kperry@ssband.org](mailto:kperry@ssband.org), or Cynthia Franco, Administrative Assistant, [cfranco@ssband.org](mailto:cfranco@ssband.org) to schedule a consultation meeting pursuant to Section 106 of the NHPA.

Sincerely,

Daniel Fonseca  
Cultural Resources Director  
Tribal Historic Preservation Officer (THPO)  
Most Likely Descendent (MLD)



MIWOK United Auburn Indian Community  
MAIDU of the Auburn Rancheria

Gene Whitehouse  
Chairman

John L. Williams  
Vice Chairman

Danny Rey  
Secretary

Brenda Adams  
Treasurer

Calvin Moman  
Council Member

August 7, 2015

Christiaan Havelaar  
City of Sacramento  
630 K Street, Suite 400  
Sacramento, CA 95814

Subject: Consultation for the I Street Bridge Replacement Project, City of Sacramento and City of West Sacramento

Dear Christiaan Havelaar,

Thank you for requesting information regarding the above referenced project. The United Auburn Indian Community (UAIC) of the Auburn Rancheria is comprised of Miwok and Southern Maidu (Nisenan) people whose tribal lands are within Placer County and whose service area includes El Dorado, Nevada, Placer, Sacramento, Sutter, and Yuba counties. The UAIC is concerned about development within its aboriginal territory that has potential to impact the lifeways, cultural sites, and landscapes that may be of sacred or ceremonial significance. We appreciate the opportunity to comment on this and other projects in your jurisdiction.

In order to ascertain whether the project could affect cultural resources that may be of importance to the UAIC, we would like to receive copies of any archaeological reports that are completed for the project. We also request copies of future environmental documents for the proposed project so that we have the opportunity to comment on potential impacts and proposed mitigation measures related to cultural resources. The UAIC would also like the opportunity to have our tribal monitors accompany you during the field survey. The information gathered will provide us with a better understanding of the project and cultural resources on site and is invaluable for consultation purposes.

The UAIC's preservation committee has identified cultural resources in and around your project area, and would like to request a site visit to confirm their locations. Thank you again for taking these matters into consideration, and for involving the UAIC early in the planning process. We look forward to reviewing the documents requested above and consulting on your project. Please contact Marcos Guerrero, Cultural Resources Manager, at (530) 883-2364 or by email at [mguerrero@auburnrancheria.com](mailto:mguerrero@auburnrancheria.com) if you have any questions.

Sincerely,

Gene Whitehouse,  
Chairman

CC: Marcos Guerrero, CRM



November 4, 2015

The Honorable Jason Camp  
THPO, United Indian Community of the Auburn Rancheria  
10720 Indian Hill Road  
Auburn, CA 95603

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

Re: Invitation to Information Meeting for the I Street Bridge Replacement Project

Dear Honorable Jason Camp:

As described in our letter to you dated June 10, 2015, the City of Sacramento (City), in cooperation with the City of West Sacramento and Caltrans, is proposing the I Street Bridge Replacement Project, which would construct a new bridge across the Sacramento River. The new bridge would provide a new vehicle, bicycle, and pedestrian crossing connecting C Street in West Sacramento to Railyards Boulevard in Sacramento.

The City invites you to attend an informational meeting on Monday, November 16, 2015 at 10 a.m. in West Sacramento at the public parking lot located at the intersection of 2nd Street and C Street. The purpose of the meeting is to provide you with additional project information and give you the opportunity to share any information you may have regarding sites, traditional cultural properties, values, or other cultural resources considerations associated with the project. So that the meeting can be as productive as possible, by November 11, please share with us any relevant information or materials (e.g., sensitivity maps) you have so that we may better tailor the discussion.

Your comments and concerns will be important to the City as we move forward with the project. ICF International is an environmental consultant representing the City—please contact their archaeologist Robin Hoffman via email at [robin.hoffman@icfi.com](mailto:robin.hoffman@icfi.com) or telephone at 916-231-7684 with any questions or concerns, or if you are willing to share information prior to the meeting. Mr. Hoffman's mailing address is:

Robin Hoffman  
ICF International  
630 K Street, Suite 400  
Sacramento, CA 95814

If you have questions regarding the content of this letter you can contact me at [DMahaffey@cityofsacramento.org](mailto:DMahaffey@cityofsacramento.org) or 916-808-2762.

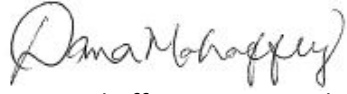
300 Richards Blvd., 3rd Floor  
Sacramento, CA 95811

Help Line: 916-264-5011  
[CityofSacramento.org/dsd](http://CityofSacramento.org/dsd)

November 4, 2015

Page 2

Sincerely,

A handwritten signature in cursive script that reads "Dana Mahaffey".

Dana Mahaffey, Associate Planner

City of Sacramento Community Development Department

cc: Erin Dwyer, Caltrans D3  
Jesse Gothan, City of Sacramento  
Gene Whitehouse, United Indian Community of the Auburn Rancheria  
Marcos Guerrero, United Indian Community of the Auburn Rancheria



November 4, 2015

The Honorable Cynthia Clarke  
Native Cultural Renewal Committee, Yocha Dehe Wintun Nation  
P.O. Box 18  
Brooks, CA 95606

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

Re: Invitation to Information Meeting for the I Street Bridge Replacement Project

Dear Honorable Cynthia Clarke:

As described in our letter to you dated June 10, 2015, the City of Sacramento (City), in cooperation with the City of West Sacramento and Caltrans, is proposing the I Street Bridge Replacement Project, which would construct a new bridge across the Sacramento River. The new bridge would provide a new vehicle, bicycle, and pedestrian crossing connecting C Street in West Sacramento to Railyards Boulevard in Sacramento.

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Robin Hoffman  
ICF International  
630 K Street, Suite 400  
Sacramento, CA 95814

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November 4, 2015

Page 2

Sincerely,

A handwritten signature in cursive script that reads "Dana Mahaffey". The signature is written in black ink and is positioned above the printed name.

Dana Mahaffey, Associate Planner

City of Sacramento Community Development Department

cc: Erin Dwyer, Caltrans D3  
Jesse Gothan, City of Sacramento  
Leland Kinter, Yocha Dehe Wintun Nation



November 4, 2015

The Honorable Grayson Coney  
Cultural Director, T'si-Akim Maidu  
P.O. Box 1316  
Colfax, CA 95713

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

Re: Invitation to Information Meeting for the I Street Bridge Replacement Project

Dear Honorable Grayson Coney:

As described in our letter to you dated June 10, 2015, the City of Sacramento (City), in cooperation with the City of West Sacramento and Caltrans, is proposing the I Street Bridge Replacement Project, which would construct a new bridge across the Sacramento River. The new bridge would provide a new vehicle, bicycle, and pedestrian crossing connecting C Street in West Sacramento to Railyards Boulevard in Sacramento.

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Robin Hoffman  
ICF International  
630 K Street, Suite 400  
Sacramento, CA 95814

If you have questions regarding the content of this letter you can contact me at [DMahaffey@cityofsacramento.org](mailto:DMahaffey@cityofsacramento.org) or 916-808-2762.

300 Richards Blvd., 3rd Floor  
Sacramento, CA 95811

Help Line: 916-264-5011  
[CityofSacramento.org/dsd](http://CityofSacramento.org/dsd)

November 4, 2015

Page 2

Sincerely,

A handwritten signature in cursive script that reads "Dana Mahaffey".

Dana Mahaffey, Associate Planner

City of Sacramento Community Development Department

cc: Erin Dwyer, Caltrans D3  
Jesse Gothan, City of Sacramento  
Eileen Moon, T'si-Akim Maidu  
Don Ryberg, T'si-Akim Maidu



November 4, 2015

The Honorable Rose Enos  
15310 Bancroft Road  
Auburn, CA 95603

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

Re: Invitation to Information Meeting for the I Street Bridge Replacement Project

Dear Honorable Rose Enos:

As described in our letter to you dated June 10, 2015, the City of Sacramento (City), in cooperation with the City of West Sacramento and Caltrans, is proposing the I Street Bridge Replacement Project, which would construct a new bridge across the Sacramento River. The new bridge would provide a new vehicle, bicycle, and pedestrian crossing connecting C Street in West Sacramento to Railyards Boulevard in Sacramento.

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Robin Hoffman  
ICF International  
630 K Street, Suite 400  
Sacramento, CA 95814

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Sacramento, CA 95811

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November 4, 2015

Page 2

Sincerely,

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Dana Mahaffey, Associate Planner

City of Sacramento Community Development Department

cc: Erin Dwyer, Caltrans D3  
Jesse Gothan, City of Sacramento



November 4, 2015

The Honorable Kesner Flores  
P.O. Box 1047  
Wheatland, CA 95692

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

Re: Invitation to Information Meeting for the I Street Bridge Replacement Project

Dear Honorable Kesner Flores:

As described in our letter to you dated June 10, 2015, the City of Sacramento (City), in cooperation with the City of West Sacramento and Caltrans, is proposing the I Street Bridge Replacement Project, which would construct a new bridge across the Sacramento River. The new bridge would provide a new vehicle, bicycle, and pedestrian crossing connecting C Street in West Sacramento to Railyards Boulevard in Sacramento.

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November 4, 2015

Page 2

Sincerely,

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Dana Mahaffey, Associate Planner

City of Sacramento Community Development Department

cc: Erin Dwyer, Caltrans D3  
Jesse Gothan, City of Sacramento





November 4, 2015

The Honorable Daniel Fonseca  
Cultural Resources Director, Shingle Springs Band of Miwok Indians  
P.O. Box 1340  
Shingle Springs, CA 95682

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

Re: Invitation to Information Meeting for the I Street Bridge Replacement Project

Dear Honorable Daniel Fonseca:

As described in our letter to you dated June 10, 2015, the City of Sacramento (City), in cooperation with the City of West Sacramento and Caltrans, is proposing the I Street Bridge Replacement Project, which would construct a new bridge across the Sacramento River. The new bridge would provide a new vehicle, bicycle, and pedestrian crossing connecting C Street in West Sacramento to Railyards Boulevard in Sacramento.

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630 K Street, Suite 400  
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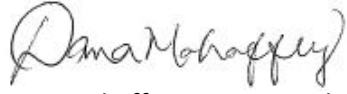
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Dana Mahaffey, Associate Planner

City of Sacramento Community Development Department

cc: Erin Dwyer, Caltrans D3  
Jesse Gothan, City of Sacramento  
Nicholas Fonseca, Shingle Springs Band of Miwok Indians  
Hermon Olanio, Shingle Springs Band of Miwok Indians



November 4, 2015

The Honorable Nicholas Fonseca  
Chairperson, Shingle Springs Band of Miwok Indians  
P.O. Box 1340  
Shingle Springs, CA 95682

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

Re: Invitation to Information Meeting for the I Street Bridge Replacement Project

Dear Honorable Nicholas Fonseca:

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ICF International  
630 K Street, Suite 400  
Sacramento, CA 95814

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November 4, 2015

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Dana Mahaffey, Associate Planner

City of Sacramento Community Development Department

cc: Erin Dwyer, Caltrans D3  
Jesse Gothan, City of Sacramento  
Daniel Fonseca, Shingle Springs Band of Miwok Indians  
Hermon Olanio, Shingle Springs Band of Miwok Indians



November 4, 2015

The Honorable Marcos Guerrero  
Tribal Preservation Committee, United Indian Community of the  
Auburn Rancheria  
10720 Indian Hill Road  
Auburn, CA 95603

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

Re: Invitation to Information Meeting for the I Street Bridge Replacement Project

Dear Honorable Marcos Guerrero:

As described in our letter to you dated June 10, 2015, the City of Sacramento (City), in cooperation with the City of West Sacramento and Caltrans, is proposing the I Street Bridge Replacement Project, which would construct a new bridge across the Sacramento River. The new bridge would provide a new vehicle, bicycle, and pedestrian crossing connecting C Street in West Sacramento to Railyards Boulevard in Sacramento.

The City invites you to attend an informational meeting on Monday, November 16, 2015 at 10 a.m. in West Sacramento at the public parking lot located at the intersection of 2nd Street and C Street. The purpose of the meeting is to provide you with additional project information and give you the opportunity to share any information you may have regarding sites, traditional cultural properties, values, or other cultural resources considerations associated with the project. So that the meeting can be as productive as possible, by November 11, please share with us any relevant information or materials (e.g., sensitivity maps) you have so that we may better tailor the discussion.

Your comments and concerns will be important to the City as we move forward with the project. ICF International is an environmental consultant representing the City—please contact their archaeologist Robin Hoffman via email at [robin.hoffman@icfi.com](mailto:robin.hoffman@icfi.com) or telephone at 916-231-7684 with any questions or concerns, or if you are willing to share information prior to the meeting. Mr. Hoffman's mailing address is:

Robin Hoffman  
ICF International  
630 K Street, Suite 400  
Sacramento, CA 95814

If you have questions regarding the content of this letter you can contact me at [DMahaffey@cityofsacramento.org](mailto:DMahaffey@cityofsacramento.org) or 916-808-2762.

300 Richards Blvd., 3rd Floor  
Sacramento, CA 95811

Help Line: 916-264-5011  
[CityofSacramento.org/dsd](http://CityofSacramento.org/dsd)

November 4, 2015

Page 2

Sincerely,

A handwritten signature in cursive script that reads "Dana Mahaffey".

Dana Mahaffey, Associate Planner

City of Sacramento Community Development Department

cc: Erin Dwyer, Caltrans D3  
Jesse Gothan, City of Sacramento  
Gene Whitehouse, United Indian Community of the Auburn Rancheria  
Jason Camp, United Indian Community of the Auburn Rancheria



November 4, 2015

The Honorable Leland Kinter  
Chairperson, Yocha Dehe Wintun Nation  
P.O. Box 18  
Brooks, CA 95606

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

Re: Invitation to Information Meeting for the I Street Bridge Replacement Project

Dear Honorable Leland Kinter:

As described in our letter to you dated June 10, 2015, the City of Sacramento (City), in cooperation with the City of West Sacramento and Caltrans, is proposing the I Street Bridge Replacement Project, which would construct a new bridge across the Sacramento River. The new bridge would provide a new vehicle, bicycle, and pedestrian crossing connecting C Street in West Sacramento to Railyards Boulevard in Sacramento.

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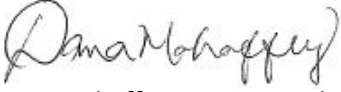
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November 4, 2015

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Sincerely,

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Dana Mahaffey, Associate Planner

City of Sacramento Community Development Department

cc: Erin Dwyer, Caltrans D3  
Jesse Gothan, City of Sacramento  
Native Cultural Renewal Committee, Yocha Dehe Wintun Nation  
Cynthia Clarke, Yocha Dehe Wintun Nation





November 4, 2015

The Honorable Eileen Moon  
Vice Chairperson, T'si-Akim Maidu  
P.O. Box 1246  
Grass Valley, CA 95945

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

Re: Invitation to Information Meeting for the I Street Bridge Replacement Project

Dear Honorable Eileen Moon:

As described in our letter to you dated June 10, 2015, the City of Sacramento (City), in cooperation with the City of West Sacramento and Caltrans, is proposing the I Street Bridge Replacement Project, which would construct a new bridge across the Sacramento River. The new bridge would provide a new vehicle, bicycle, and pedestrian crossing connecting C Street in West Sacramento to Railyards Boulevard in Sacramento.

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November 4, 2015

Page 2

Sincerely,

A handwritten signature in cursive script that reads "Dana Mahaffey".

Dana Mahaffey, Associate Planner

City of Sacramento Community Development Department

cc: Erin Dwyer, Caltrans D3  
Jesse Gothan, City of Sacramento  
Grayson Coney, T'si-Akim Maidu  
Don Ryberg, T'si-Akim Maidu



November 4, 2015

The Honorable April Wallace Moore  
19630 Placer Hills Road  
Colfax, CA 95713

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

Re: Invitation to Information Meeting for the I Street Bridge Replacement Project

Dear Honorable April Wallace Moore:

As described in our letter to you dated June 10, 2015, the City of Sacramento (City), in cooperation with the City of West Sacramento and Caltrans, is proposing the I Street Bridge Replacement Project, which would construct a new bridge across the Sacramento River. The new bridge would provide a new vehicle, bicycle, and pedestrian crossing connecting C Street in West Sacramento to Railyards Boulevard in Sacramento.

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Robin Hoffman  
ICF International  
630 K Street, Suite 400  
Sacramento, CA 95814

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300 Richards Blvd., 3rd Floor  
Sacramento, CA 95811

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November 4, 2015

Page 2

Sincerely,

A handwritten signature in cursive script that reads "Dana Mahaffey". The signature is written in black ink and is positioned above the printed name.

Dana Mahaffey, Associate Planner

City of Sacramento Community Development Department

cc: Erin Dwyer, Caltrans D3  
Jesse Gothan, City of Sacramento



November 4, 2015

The Honorable Native Cultural Renewal Committee  
Yocha Dehe Wintun Nation  
P.O. Box 18  
Brooks, CA 95606

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

Re: Invitation to Information Meeting for the I Street Bridge Replacement Project

Dear Honorable Native Cultural Renewal Committee:

As described in our letter to you dated June 10, 2015, the City of Sacramento (City), in cooperation with the City of West Sacramento and Caltrans, is proposing the I Street Bridge Replacement Project, which would construct a new bridge across the Sacramento River. The new bridge would provide a new vehicle, bicycle, and pedestrian crossing connecting C Street in West Sacramento to Railyards Boulevard in Sacramento.

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Robin Hoffman  
ICF International  
630 K Street, Suite 400  
Sacramento, CA 95814

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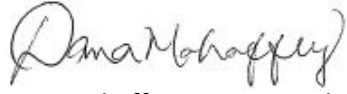
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November 4, 2015

Page 2

Sincerely,

A handwritten signature in cursive script that reads "Dana Mahaffey".

Dana Mahaffey, Associate Planner

City of Sacramento Community Development Department

cc: Erin Dwyer, Caltrans D3  
Jesse Gothan, City of Sacramento  
Leland Kinter, Yocha Dehe Wintun Nation  
Cynthia Clarke, Yocha Dehe Wintun Nation



November 4, 2015

The Honorable Hermo Olanio  
Vice Chairperson, Shingle Springs Band of Miwok Indians  
P.O. Box 1340  
Shingle Springs, CA 95682

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

Re: Invitation to Information Meeting for the I Street Bridge Replacement Project

Dear Honorable Hermo Olanio:

As described in our letter to you dated June 10, 2015, the City of Sacramento (City), in cooperation with the City of West Sacramento and Caltrans, is proposing the I Street Bridge Replacement Project, which would construct a new bridge across the Sacramento River. The new bridge would provide a new vehicle, bicycle, and pedestrian crossing connecting C Street in West Sacramento to Railyards Boulevard in Sacramento.

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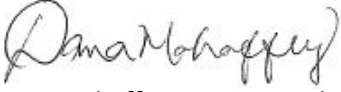
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November 4, 2015

Page 2

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Dana Mahaffey, Associate Planner

City of Sacramento Community Development Department

cc: Erin Dwyer, Caltrans D3  
Jesse Gothan, City of Sacramento  
Daniel Fonseca, Shingle Springs Band of Miwok Indians  
Nicholas Fonseca, Shingle Springs Band of Miwok Indians





November 4, 2015

The Honorable Don Ryberg  
Chairperson, T'si-Akim Maidu  
P.O. Box 1246  
Grass Valley, CA 95945

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

Re: Invitation to Information Meeting for the I Street Bridge Replacement Project

Dear Honorable Don Ryberg:

As described in our letter to you dated June 10, 2015, the City of Sacramento (City), in cooperation with the City of West Sacramento and Caltrans, is proposing the I Street Bridge Replacement Project, which would construct a new bridge across the Sacramento River. The new bridge would provide a new vehicle, bicycle, and pedestrian crossing connecting C Street in West Sacramento to Railyards Boulevard in Sacramento.

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Robin Hoffman  
ICF International  
630 K Street, Suite 400  
Sacramento, CA 95814

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300 Richards Blvd., 3rd Floor  
Sacramento, CA 95811

Help Line: 916-264-5011  
[CityofSacramento.org/dsd](http://CityofSacramento.org/dsd)

November 4, 2015

Page 2

Sincerely,

A handwritten signature in cursive script that reads "Dana Mahaffey".

Dana Mahaffey, Associate Planner

City of Sacramento Community Development Department

cc: Erin Dwyer, Caltrans D3  
Jesse Gothan, City of Sacramento  
Eileen Moon, T'si-Akim Maidu  
Grayson Coney, T'si-Akim Maidu



November 4, 2015

The Honorable Gene Whitehouse  
Chairperson, United Indian Community of the Auburn Rancheria  
10720 Indian Hill Road  
Auburn, CA 95603

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

Re: Invitation to Information Meeting for the I Street Bridge Replacement Project

Dear Honorable Gene Whitehouse:

As described in our letter to you dated June 10, 2015, the City of Sacramento (City), in cooperation with the City of West Sacramento and Caltrans, is proposing the I Street Bridge Replacement Project, which would construct a new bridge across the Sacramento River. The new bridge would provide a new vehicle, bicycle, and pedestrian crossing connecting C Street in West Sacramento to Railyards Boulevard in Sacramento.

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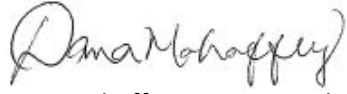
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November 4, 2015

Page 2

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Dana Mahaffey, Associate Planner

City of Sacramento Community Development Department

cc: Erin Dwyer, Caltrans D3  
Jesse Gothan, City of Sacramento  
Marcos Guerrero, United Indian Community of the Auburn Rancheria  
Jason Camp, United Indian Community of the Auburn Rancheria



November 4, 2015

The Honorable Charlie Wright  
Chairperson, Cortina Band of Indians  
P.O. Box 1630  
Williams, CA 95987

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

Re: Invitation to Information Meeting for the I Street Bridge Replacement Project

Dear Honorable Charlie Wright:

As described in our letter to you dated June 10, 2015, the City of Sacramento (City), in cooperation with the City of West Sacramento and Caltrans, is proposing the I Street Bridge Replacement Project, which would construct a new bridge across the Sacramento River. The new bridge would provide a new vehicle, bicycle, and pedestrian crossing connecting C Street in West Sacramento to Railyards Boulevard in Sacramento.

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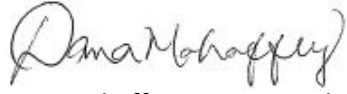
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November 4, 2015

Page 2

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Dana Mahaffey, Associate Planner

City of Sacramento Community Development Department

cc: Erin Dwyer, Caltrans D3  
Jesse Gothan, City of Sacramento

## Hoffman, Robin

---

**From:** Hoffman, Robin  
**Sent:** Friday, November 13, 2015 11:21 AM  
**To:** 'mdelgado@yochadehe-nsn.gov'  
**Subject:** City of Sacramento I St. Bridge Replacement Project Meeting  
**Attachments:** I-St-Bridge\_Letter\_Kinter\_11042015.pdf

Marilyn,

It was nice to talk with you. As you requested, the original meeting invitation letter is attached. Please let me know if you have any questions or comments.

-Robin

**Please note my new contact information below**

**Robin Hoffman, MA, RPA** | Archaeologist | [415.677.7183](tel:415.677.7183) (w) [707.494.3349](tel:707.494.3349) (c)  
**ICF INTERNATIONAL** | 620 Folsom Street, 2nd Floor, San Francisco, CA 94107



November 4, 2015

The Honorable Leland Kinter  
Chairperson, Yocha Dehe Wintun Nation  
P.O. Box 18  
Brooks, CA 95606

03-SAC-0-SAC  
PROJ # BRLS 5002(164)  
I Street Bridge Replacement

Re: Invitation to Information Meeting for the I Street Bridge Replacement Project

Dear Honorable Leland Kinter:

As described in our letter to you dated June 10, 2015, the City of Sacramento (City), in cooperation with the City of West Sacramento and Caltrans, is proposing the I Street Bridge Replacement Project, which would construct a new bridge across the Sacramento River. The new bridge would provide a new vehicle, bicycle, and pedestrian crossing connecting C Street in West Sacramento to Railyards Boulevard in Sacramento.

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Robin Hoffman  
ICF International  
630 K Street, Suite 400  
Sacramento, CA 95814

If you have questions regarding the content of this letter you can contact me at [DMahaffey@cityofsacramento.org](mailto:DMahaffey@cityofsacramento.org) or 916-808-2762.

300 Richards Blvd., 3rd Floor  
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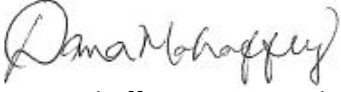
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November 4, 2015

Page 2

Sincerely,

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Dana Mahaffey, Associate Planner

City of Sacramento Community Development Department

cc: Erin Dwyer, Caltrans D3  
Jesse Gothan, City of Sacramento  
Native Cultural Renewal Committee, Yocha Dehe Wintun Nation  
Cynthia Clarke, Yocha Dehe Wintun Nation

## Hoffman, Robin

---

**From:** Hoffman, Robin  
**Sent:** Friday, November 13, 2015 11:26 AM  
**To:** Marcos Guerrero (mguerrero@auburnrancheria.com); 'jcamp@auburnrancheria.com'  
**Subject:** Invitation to Information Meeting for the I Street Bridge Replacement Project

This is a follow-up email to the City of Sacramento's (City['s]) November 4, 2015 letter inviting you to attend an informational meeting regarding the City's I Street Bridge Replacement Project. As noted in the letter, the meeting will be held on Monday, November 16, 2015 at 10 a.m. in West Sacramento at the public parking lot located at the intersection of 2nd Street and C Street. The purpose of the meeting is to provide you with additional project information and give you the opportunity to share any information you may have regarding sites, traditional cultural properties, values, or other cultural resources considerations associated with the project.

Could you please let me know if you are planning on attending the meeting and if you have any information or materials (e.g., sensitivity maps) you have and would like to share regarding the project. Also, please let me know if you have any questions or comments.

Thanks again,  
-Robin

**Please note my new contact information below**

**Robin Hoffman, MA, RPA** | Archaeologist | [415.677.7183](tel:415.677.7183) (w) [707.494.3349](tel:707.494.3349) (c)  
**ICF INTERNATIONAL** | 620 Folsom Street, 2nd Floor, San Francisco, CA 94107

## Hoffman, Robin

---

**From:** Marilyn Delgado <MDelgado@yochadehe-nsn.gov>  
**Sent:** Friday, November 13, 2015 1:27 PM  
**To:** Hoffman, Robin  
**Cc:** Anthony Flores  
**Subject:** RE: City of Sacramento I St. Bridge Replacement Project Meeting

**Importance:** High

**Follow Up Flag:** Follow up  
**Flag Status:** Flagged

Robin,

Thank you for sending me the letter. We will have someone at the meeting and will notify you later today who will be in attendance.

Thank you,  
Marilyn

**Marilyn Delgado**  
*Director of Cultural Resources  
and California Tribal College*

**Tewe Kewe Cultural Center**  
PO Box 18 | Brooks, CA 95606  
c 530.723.0444 | p 530.796.3400 | f 530.796.2143  
[mdelgado@yochadehe-nsn.gov](mailto:mdelgado@yochadehe-nsn.gov)  
[www.yochadehe.org](http://www.yochadehe.org)

---

**From:** Hoffman, Robin [mailto:Robin.Hoffman@icfi.com]  
**Sent:** Friday, November 13, 2015 1:23 PM  
**To:** Marilyn Delgado  
**Subject:** City of Sacramento I St. Bridge Replacement Project Meeting

Marilyn,  
It was nice to talk with you. As you requested, the original meeting invitation letter is attached. Please let me know if you have any questions or comments.

-Robin

**Please note my new contact information below**

**Robin Hoffman, MA, RPA** | Archaeologist | [415.677.7183](tel:415.677.7183) (w) [707.494.3349](tel:707.494.3349) (c)  
**ICF INTERNATIONAL** | 620 Folsom Street, 2nd Floor, San Francisco, CA 94107



# MEETING SIGN-IN SHEET

**Project:** I Street Bridge Replacement Project

**Meeting Date:** November 16, 2015, 10:00 am

**Facilitator:** City of Sacramento and ICF

**Place/Room:** On-site, West Sacramento

Name	Title	Company	Phone	Fax	E-Mail
Tristan Evans	Cultural Resources Admin Assistant	United Auburn Indian Community	916-215-1555		tevans@auburnindian.com
Anthony Flores	site protection manager	Yocha Dehe Wintun Nation	930-723-3477		aflores@yochadehe-nsn.gov
Laraine Bull	Tribal Monitor	Yocha Dehe Wintun Nation	530-723-5891		L.Bull@yochadehe-nsn.gov
DAVID TULLER	Principal Planner	COWS	916-617-4645		dtuller@citywestsacramento.org
Zach Siriglia	Project Manager	Mark Thomas & Company	916-381-9100		zsiriglia@markthomas.com
Megan Johnson	Project Engineer	Mark Thomas & Company	916-381-9100		mjohnson@markthomas.com
JASON MCCOY	SR PLANNER	CITY WEST SAC	916-617-4832		mccoyj@cityofwestsacramento.org
DANA MAHAFFEY	ASSOC PLANNER	CITY OF SAC	808-2762	?	dmahafe@dcityofsacramento.us
Claire Bromund	Project Mgr	ICF	737-3660	737-3630	claire.bromund@icfi.com
Robin Hoffman	Archaeologist	ICF	707-494-3349	—	robin.hoffman@icfi.com
Tina Sorvari	PC/Archaeo	ICF	916-231-9738		tina.sorvari@icfi.com
Jesse GOTHAN	Supervising Engineer	City of Sacto	916-808-6897		jgothan@cityofsacramento.org
Katy Jacobson	Com Investment Mgr	City West Sac			



## Meeting Notes

<b>Project:</b>	I Street Bridge Replacement Project
<b>Date, Time:</b>	November 16, 2015, 10:00 am
<b>Location:</b>	West Sacramento, on-site (parking area at 2nd Street and C Street)
<b>Attendees:</b>	City of Sacramento: Jesse Gotham (Supervising Engineer, Project Manager), Dana Mahaffey (Associate Planner) City of West Sacramento: Jason McCoy (Senior Transportation Planner), David Tilley (Principal Planner), Katy Jacobson (Senior Program Manager) United Auburn Indian Community (UAIC): Tristan Evans (Cultural Resources Administrative Assistant) Yocha Dehe Wintun Nation (YDWN): Anthony Flores (Site Protection Manager), Laverne Bill (Tribal Monitor) Mark Thomas & Company: Zach Siviglia (Project Manager), Megan Johnson (Project Engineer) ICF International (ICF): Claire Bromund (Project Manager), Robin Hoffman (Project Archaeologist), Tina Sorvari (Project Coordinator/Archaeologist)

- Introductions and sign-in
- Robin Hoffman distributed two exhibits: Area of Potential Effects (APE) map (signed by Caltrans) and project design elements drawing
- Zach Siviglia provided an overview of the project:
  - Purpose/need, funding
    - Community-centered bridge needed, vehicular/pedestrian/cyclist safety currently an issue, must be movable for river boat traffic.
    - Federal funds provided to City of Sacramento. Project also involves a large number of regulatory agencies. Caltrans is the lead federal agency, City of Sacramento is the lead local agency.
  - Described project and alternatives (Alts. 1 and 2 in West Sacramento)
    - Alternative 1 has been eliminated from further consideration because it is not feasible to relocate the levee.
    - Removal of existing approach structures will consist of removing the superstructure, cutting existing piers/supports at ground level, breaking up and removing footings to approximately 3 feet deep, then backfilling the area with soil.

- Abutment areas and new roadway approach area will require ground disturbance/excavation of approximately 3 feet deep to remove existing vegetation and organic material, then excavation of approximately 10-15 feet deep on water side of existing levee for installation of abutment. The existing levee will be slightly cut on water side to allow for gradual slope to new levee profile. In West Sacramento, the levee will be extended west (land side) to comply with levee design standards – fill will be used to extend levee. Slurry wall will be installed in middle of new levee profile at new road location plus approximately 50 feet north and south of new road location. Slurry wall will be in a trench approximately 3-4 feet wide and between 70 and 110 feet deep. Abutments will be constructed with approximately 50 piles driven to depths of approximately 70 feet (W. Sac side) and 80 feet (Sac side).
- Two piers will be installed on both sides of river at existing toe of riverbank/levee.
- Two additional piers will be placed within river channel.
- Current dirt path on water side of existing levee on W. Sac side is approximate location of new bike path.
- Bike lane along C Street will require small amount of excavation (maximum 3 feet) on south side of C Street, then a concrete bike path on top.
- Group walked along W. Sac levee portion of project site.
- Anthony Flores (YDWN) asked if the archaeological survey had been conducted and if an Extended Phase I (XPI) will be conducted.
  - Robin Hoffman replied that the pedestrian survey had been completed and explained what resources (all historic-period) had been identified. Hoffman stated that whether an XPI would be necessary was still being determined by Caltrans.
- Hoffman provided Flores with a set of six maps showing historic Sanborn Maps with the APE overlaid. Hoffman stated that he would provide Flores, Laverne Bill, and Tristan Evans, via email, with the maps in electronic format. Hoffman also said he would share the project cultural resources records search results with Flores, Bill, and Evans.
- Hoffman asked Flores, Bill, and Evans if they had any questions or comments.
  - Evans stated that Marcos Guerrero (UAIC) had asked him to tell Hoffman that UAIC knows of a Traditional Cultural Property (TCP) within or close to the APE on both sides of the river, and that UAIC knows of archaeological sites within or close to the APE on both sides of the river. Evans stated that UAIC requests additional consultation and would like to share information the TCPs and archaeological sites, in addition to discussing potential project effects.
  - Flores stated that YDWN would like additional consultation and would be providing the City of Sacramento with a formal letter regarding the project.
- Claire Bromund asked the group if anyone had any additional questions or comments – to which everyone stated they did not.
- Meeting adjourned.

## Hoffman, Robin

---

**From:** Hoffman, Robin  
**Sent:** Monday, November 16, 2015 11:58 AM  
**To:** 'Marilyn Delgado'  
**Subject:** RE: City of Sacramento I St. Bridge Replacement Project Meeting

Marilyn,

We just finished our meeting regarding the I St. Bridge Replacement Project. It was great to see Anthony and Laverne again. We are preparing a summary to send out to the attendees, but I cannot make out Laverne's email address from the sign-in sheet. When you have the chance, could you please send me his address so we can include him in the email.

Thank you,  
-Robin

---

**From:** Marilyn Delgado [mailto:MDelgado@yochadehe-nsn.gov]  
**Sent:** Friday, November 13, 2015 1:27 PM  
**To:** Hoffman, Robin <Robin.Hoffman@icfi.com>  
**Cc:** Anthony Flores <AFlores@yochadehe-nsn.gov>  
**Subject:** RE: City of Sacramento I St. Bridge Replacement Project Meeting  
**Importance:** High

Robin,

Thank you for sending me the letter. We will have someone at the meeting and will notify you later today who will be in attendance.

Thank you,  
Marilyn

### **Marilyn Delgado**

*Director of Cultural Resources  
and California Tribal College*

#### **Tewe Kewe Cultural Center**

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**Please note my new contact information below**

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**ICF INTERNATIONAL** | 620 Folsom Street, 2nd Floor, San Francisco, CA 94107



## Hoffman, Robin

---

**From:** Hoffman, Robin  
**Sent:** Monday, November 16, 2015 4:46 PM  
**To:** 'tevans@auburnrancheria.com'  
**Cc:** Marcos Guerrero (mguerrero@auburnrancheria.com); 'jcamp@auburnrancheria.com'  
**Subject:** I St. Bridge Replacement Project Historic Maps and Records Search Results  
**Attachments:** I-St-Bridge\_HistoricMap\_Overlays.pdf

Tristan,

It was nice to meet you today and to have the chance to discuss the I St. Bridge Replacement Project. Attached are the historic map overlays I promised you.

Thanks again for taking the time to meet,  
-Robin

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## Hoffman, Robin

---

**From:** Hoffman, Robin  
**Sent:** Monday, November 16, 2015 4:49 PM  
**To:** 'aflores@yochadehe-nsn.gov'; 'lbill@yochadehe-nsn.gov'  
**Cc:** 'Marilyn Delgado'  
**Subject:** I Street Bridge Replacement Project Historic Map Overlays  
**Attachments:** I-St-Bridge\_HistoricMap\_Overlays.pdf

Anthony and Laverne,

It was nice to see you today and to have the chance to discuss the I St. Bridge Replacement Project. Attached are electronic copies of the historic map overlays I promised you.

Thanks again for taking the time to meet,  
-Robin

**Please note my new contact information below**

**Robin Hoffman, MA, RPA** | Archaeologist | [415.677.7183](tel:415.677.7183) (w) [707.494.3349](tel:707.494.3349) (c)  
**ICF INTERNATIONAL** | 620 Folsom Street, 2nd Floor, San Francisco, CA 94107

## Hoffman, Robin

---

**From:** Marilyn Delgado <MDelgado@yochadehe-nsn.gov>  
**Sent:** Monday, November 16, 2015 5:03 PM  
**To:** Hoffman, Robin  
**Subject:** RE: City of Sacramento I St. Bridge Replacement Project Meeting

**Follow Up Flag:** Follow up  
**Flag Status:** Completed

Hi Robin,

I'm just catching up on my emails from today. I see that you got Laverne's email address! I am glad they were there to assist.

Thank you,  
Marilyn

### Marilyn Delgado

*Director of Cultural Resources  
and California Tribal College*

### Tewe Kewe Cultural Center

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Thank you,  
-Robin

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**To:** Hoffman, Robin <[Robin.Hoffman@icfi.com](mailto:Robin.Hoffman@icfi.com)>  
**Cc:** Anthony Flores <[AFlores@yochadehe-nsn.gov](mailto:AFlores@yochadehe-nsn.gov)>  
**Subject:** RE: City of Sacramento I St. Bridge Replacement Project Meeting  
**Importance:** High

Robin,

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Marilyn

**Marilyn Delgado**

*Director of Cultural Resources  
and California Tribal College*

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**Sent:** Friday, November 13, 2015 1:23 PM

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-Robin

**Please note my new contact information below**

**Robin Hoffman, MA, RPA** | Archaeologist | [415.677.7183](tel:415.677.7183) (w) [707.494.3349](tel:707.494.3349) (c)  
**ICF INTERNATIONAL** | 620 Folsom Street, 2nd Floor, San Francisco, CA 94107

## Hoffman, Robin

---

**From:** Bromund, Claire  
**Sent:** Monday, November 16, 2015 4:28 PM  
**To:** aflores@yochadehe-nsn.gov; l.bill@yochadehe-nsn.gov; tevens@auburnrancheria.com; (JGothan@cityofsacramento.org); Dana Mahaffey; Jason McCoy (mccoyj@cityofwestsacramento.org); davidt@cityofwestsacramento.org; katyj@cityofwestsacramento.org; Zach Siviglia; Megan Johnson; Hoffman, Robin; Sorvari, Tina  
**Cc:** Dwyer, Erin T@DOT  
**Subject:** I Street Bridge Replacement Project Info Meeting Sign-in Sheet  
**Attachments:** I-St-Bridge\_InfoMtg\_signin-11162015.pdf

Attached is the sign-in list for this morning's meeting. Thank you for your participation. Follow-up communications summarizing what was discussed will be sent out separately.

**CLAIRE BROMUND** | Senior Project Manager | 916.231.9520 (d) | [claire.bromund@icfi.com](mailto:claire.bromund@icfi.com) | [icfi.com](http://icfi.com)  
**ICF INTERNATIONAL** | 630 K Street, Suite 400, Sacramento, CA 95814 | 916.737.3000 (o)  
Connect with us on [social media](#).



# MEETING SIGN-IN SHEET

**Project:** I Street Bridge Replacement Project

**Meeting Date:** November 16, 2015, 10:00 am

**Facilitator:** City of Sacramento and ICF

**Place/Room:** On-site, West Sacramento

Name	Title	Company	Phone	Fax	E-Mail
Tristan Evans	Cultural Resources Admin Assistant	United Auburn Indian Community	916-215-1555		tevans@auburnindian.com
Anthony Flores	Site Protection Manager	Yocha Dehe Wintun Nation	930-723-3477		aflores@yochadehe-nsn.gov
Laraine Bull	Tribal Monitor	Yocha Dehe Wintun Nation	530-723-5891		L.Bull@yochadehe-nsn.gov
DAVID TULLER	Principal Planner	COWS	916-617-4645		dtuller@citywestsacramento.org
Zach Siriglia	Project Manager	Mark Thomas & Company	916-381-9100		zsiriglia@markthomas.com
Megan Johnson	Project Engineer	Mark Thomas & Company	916-381-9100		mjohnson@markthomas.com
JASON MCCOY	SR PLANNER	CITY WEST SAC	916-617-4832		mccoyj@cityofwestsacramento.org
DANA MAHAFFEY	ASSOC PLANNER	CITY OF SAC	808-2762	?	dmahafe@dcityofsacramento.us
Claire Bromund	Project Mgr	ICF	737-3600	737-3630	claire.bromund@icfi.com
Robin Hoffman	Archaeologist	ICF	707-494-3349	—	robin.hoffman@icfi.com
Tina Sorvari	PC/Archaeo	ICF	916-231-9738		tina.sorvari@icfi.com
Jesse GOTHAN	Supervising Engineer	City of Sacto	916-808-6897		jgothan@cityofsacramento.org
Katy Johnson	Com Investment Mgr	City West Sac			

## Hoffman, Robin

---

**From:** Bromund, Claire  
**Sent:** Monday, November 16, 2015 4:47 PM  
**To:** Hoffman, Robin  
**Subject:** FW: I Street Bridge Replacement Project Info Meeting Sign-in Sheet

FYI

---

**From:** Tristan Evans [mailto:tevens@auburnrancheria.com]  
**Sent:** Monday, November 16, 2015 4:44 PM  
**To:** Bromund, Claire <Claire.Bromund@icfi.com>  
**Cc:** Marcos Guerrero <mguerrero@auburnrancheria.com>; Jason Camp <jcamp@auburnrancheria.com>  
**Subject:** RE: I Street Bridge Replacement Project Info Meeting Sign-in Sheet

Hi Claire,

Thank you for sending this over and for taking the time to meet with UAIC. I know Marcos and Jason look forward to following up with further consultation.

-Tristan

---

**From:** Bromund, Claire [<mailto:Claire.Bromund@icfi.com>]  
**Sent:** Monday, November 16, 2015 4:28 PM  
**To:** [aflores@yochadehe-nsn.gov](mailto:aflores@yochadehe-nsn.gov); [l.bill@yochadehe-nsn.gov](mailto:l.bill@yochadehe-nsn.gov); Tristan Evans <[tevens@auburnrancheria.com](mailto:tevens@auburnrancheria.com)>; ([JGothan@cityofsacramento.org](mailto:JGothan@cityofsacramento.org)) <[JGothan@cityofsacramento.org](mailto:JGothan@cityofsacramento.org)>; Dana Mahaffey <[DMahaffey@cityofsacramento.org](mailto:DMahaffey@cityofsacramento.org)>; Jason McCoy ([mccoyj@cityofwestsacramento.org](mailto:mccoyj@cityofwestsacramento.org)) <[mccoyj@cityofwestsacramento.org](mailto:mccoyj@cityofwestsacramento.org)>; [davidt@cityofwestsacramento.org](mailto:davidt@cityofwestsacramento.org); [katyj@cityofwestsacramento.org](mailto:katyj@cityofwestsacramento.org); Zach Siviglia <[zsiviglia@markthomas.com](mailto:zsiviglia@markthomas.com)>; Megan Johnson <[mjohnson@markthomas.com](mailto:mjohnson@markthomas.com)>; Hoffman, Robin <[Robin.Hoffman@icfi.com](mailto:Robin.Hoffman@icfi.com)>; Sorvari, Tina <[Tina.Sorvari@icfi.com](mailto:Tina.Sorvari@icfi.com)>  
**Cc:** Dwyer, Erin T@DOT <[erin.dwyer@dot.ca.gov](mailto:erin.dwyer@dot.ca.gov)>  
**Subject:** I Street Bridge Replacement Project Info Meeting Sign-in Sheet

Attached is the sign-in list for this morning's meeting. Thank you for your participation. Follow-up communications summarizing what was discussed will be sent out separately.

CLAIRE BROMUND | Senior Project Manager | 916.231.9520 (d) | [claire.bromund@icfi.com](mailto:claire.bromund@icfi.com) | [icfi.com](http://icfi.com)  
ICF INTERNATIONAL | 630 K Street, Suite 400, Sacramento, CA 95814 | 916.737.3000 (o)  
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## Hoffman, Robin

---

**From:** Tristan Evans <tevans@auburnrancheria.com>  
**Sent:** Monday, November 16, 2015 5:15 PM  
**To:** Hoffman, Robin  
**Cc:** Marcos Guerrero; Jason Camp  
**Subject:** RE: I St. Bridge Replacement Project Historic Maps and Records Search Results

**Follow Up Flag:** Follow up  
**Flag Status:** Completed

Hi Robin,

Thank you for taking the time to meet with UAIC. I know Jason and Marcos are looking forward to further consultation on the project, but site visits are always appreciated.

-Tristan

---

**From:** Hoffman, Robin [mailto:Robin.Hoffman@icfi.com]  
**Sent:** Monday, November 16, 2015 4:46 PM  
**To:** Tristan Evans <tevans@auburnrancheria.com>  
**Cc:** Marcos Guerrero <mguerrero@auburnrancheria.com>; Jason Camp <jcamp@auburnrancheria.com>  
**Subject:** I St. Bridge Replacement Project Historic Maps and Records Search Results

Tristan,

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Thanks again for taking the time to meet,  
-Robin

**Please note my new contact information below**

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## Hoffman, Robin

---

**From:** Tristan Evans <tevens@auburnrancheria.com>  
**Sent:** Wednesday, November 18, 2015 4:55 PM  
**To:** Hoffman, Robin  
**Cc:** Marcos Guerrero; Jason Camp  
**Subject:** RE: I St. Bridge Replacement Project Historic Maps and Records Search Results

**Follow Up Flag:** Follow Up  
**Flag Status:** Flagged

Hi Robin,

Thank you for taking the time to meet with UAIC and for sending over those maps. Marcos would like to have a follow-up meeting to discuss the project. Does Monday, November 30 work? If not we can schedule some other dates.

---

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## Hoffman, Robin

---

**From:** Hoffman, Robin  
**Sent:** Tuesday, November 24, 2015 11:18 AM  
**To:** Marcos Guerrero  
**Cc:** Jason Camp; 'Tristan Evans'  
**Subject:** RE: I St. Bridge Replacement Project Historic Maps and Records Search Results

Marcos,

Yes, let's set up a meeting, though it'll have to be after November 30. Mark Thomas (the engineering company) is putting together some more detailed maps that will be good to have at the meeting and it might take them another week or so to finish them. We, or the City, will get back to you soon to schedule a meeting.

Best,  
Robin

**Please note my new contact information below**

**Robin Hoffman, MA, RPA** | Archaeologist | [415.677.7183](tel:415.677.7183) (w) [707.494.3349](tel:707.494.3349) (c)  
**ICF INTERNATIONAL** | 620 Folsom Street, 2nd Floor, San Francisco, CA 94107

---

**From:** Tristan Evans [<mailto:tevens@auburnrancheria.com>]  
**Sent:** Wednesday, November 18, 2015 4:55 PM  
**To:** Hoffman, Robin <[Robin.Hoffman@icfi.com](mailto:Robin.Hoffman@icfi.com)>  
**Cc:** Marcos Guerrero <[mguerrero@auburnrancheria.com](mailto:mguerrero@auburnrancheria.com)>; Jason Camp <[jcamp@auburnrancheria.com](mailto:jcamp@auburnrancheria.com)>  
**Subject:** RE: I St. Bridge Replacement Project Historic Maps and Records Search Results

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**Cc:** Marcos Guerrero <[mguerrero@auburnrancheria.com](mailto:mguerrero@auburnrancheria.com)>; Jason Camp <[jcamp@auburnrancheria.com](mailto:jcamp@auburnrancheria.com)>  
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## Robinson, Mark

---

**From:** Robinson, Mark  
**Sent:** Tuesday, July 19, 2016 10:38 AM  
**To:** 'tevens@auburnrancheria.com'  
**Cc:** 'mguerrero@auburnrancheria.com'; 'jcamp@auburnrancheria.com'  
**Subject:** I Street Bridge

Good Morning:

I am an archaeologist at ICF in Sacramento, following up the work of Robin Hoffman on the I Street Bridge Project.

UAIC has stated that the Band has knowledge of a potential Traditional Cultural Property, as well as archaeological sites, that may be located in the I Street Bridge Project APE.

I would like to request a meeting or phone meeting, with UAIC to discuss these potential resources when the Band and its staff are available.

Please let me know if UAIC has times for a conversation about these potential resources.

Thank you for your time concern; I look forward to consulting with UAIC.

Thank you,  
Mark

**Mark Robinson** | Senior Archaeologist/Project Manager | main 916-737-3000 | direct 916-231-7608  
| [Mark.Robinson@icfi.com](mailto:Mark.Robinson@icfi.com) | [icfi.com](http://icfi.com)

**ICF INTERNATIONAL** | 630 K Street, Suite 400, Sacramento, CA 95814 USA | 315-559-5435 mobile

## Robinson, Mark

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**From:** Marcos Guerrero <mguerrero@auburnrancheria.com>  
**Sent:** Monday, July 25, 2016 6:51 PM  
**To:** Robinson, Mark; Tristan Evans  
**Cc:** Matthew Moore  
**Subject:** RE: I Street Bridge

Hello Mr. Robinson,

Yes, we have a significant amount of information regarding the significance of the project site. Would it be possible for you to set up a meeting sometime the week of August 8?

Melodi will send you our records search rates. Thank you,

Marcos Guerrero, RPA  
Cultural Resources Manager  
United Auburn Indian Community  
Tribal Historic Preservation Department  
10720 Indian Hill  
Auburn, CA 95603  
Direct: 530-883-2364  
Cell: 916-300-8792  
Fax: 530-883-2390

---

**From:** Robinson, Mark [<mailto:Mark.Robinson@icfi.com>]  
**Sent:** Tuesday, July 19, 2016 10:38 AM  
**To:** Tristan Evans  
**Cc:** Marcos Guerrero; Jason Camp  
**Subject:** I Street Bridge

Good Morning:

I am an archaeologist at ICF in Sacramento, following up the work of Robin Hoffman on the I Street Bridge Project.

UAIC has stated that the Band has knowledge of a potential Traditional Cultural Property, as well as archaeological sites, that may be located in the I Street Bridge Project APE.

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**Mark Robinson** | Senior Archaeologist/Project Manager | main 916-737-3000 | direct 916-231-7608  
| [Mark.Robinson@icfi.com](mailto:Mark.Robinson@icfi.com) | [icfi.com](http://icfi.com)

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## State Historic Preservation Officer Consultation

**DEPARTMENT OF TRANSPORTATION**

DISTRICT 3  
703 B STREET  
MARYSVILLE, CA 95901  
PHONE (530) 741-7113  
FAX (530) 741-4457  
TTY (530) 741-4509  
TTY 711  
www.dot.ca.gov/dist3



*Serious drought  
Help save water!*

December 27, 2016

Julianne Polanco  
State Historic Preservation Officer  
1725 23<sup>rd</sup> Street, Suite 100  
Sacramento, CA 95816

I Street Bridge Replacement Project  
Sacramento and West Sacramento Cities  
DEM10L-5002(164)

Re: Section 106 Compliance and Historic Property Survey Report Transmittal for the  
I Street Bridge Replacement Project, Sacramento and West Sacramento Cities

Dear Ms. Polanco:

The cities of Sacramento and West Sacramento, in cooperation with the California Department of Transportation (Caltrans), propose to construct a new crossing for vehicular and pedestrian traffic over the Sacramento River that will replace the upper deck of the I Street Bridge, which would no longer carry such traffic. A full project description can be found on page one of the enclosed Historic Property Survey Report (HPSR) and a depiction of the Area of Potential Effect (APE) can be found in Attachment A. Caltrans is initiating consultation for the project with the State Historic Preservation Officer (SHPO) in accordance with the January 2014 *First Amended Programmatic Agreement Among the Federal Highway Administration, the Advisory Council on Historic Preservation, the California State Historic Preservation Officer, and the California Department of Transportation Regarding Compliance with Section 106 of the National Historic Preservation Act, as it Pertains to the Administration of the Federal-Aid Highway Program in California* (PA).

Enclosed you will find an Historic Property Survey Report (HPSR) for the proposed undertaking with attached Archaeological Survey Report (ASR) and Historical Resources Evaluation Report (HRER). We are consulting with you at the present time under Stipulation VIII.C.6 of the PA, which requires that we seek your concurrence on Caltrans' determinations of eligibility for potential historic properties.

Caltrans is transmitting this as the NEPA lead agency under the provisions of the *Memorandum of Understanding (MOU) between the Federal Highway Administration and the California Department of Transportation Concerning the State of California's Participation in the Surface Transportation Project Delivery 23 USC 327 NEPA Assignment*, which became effective on October 1, 2012. The MOU was signed pursuant to Title 23 USC 327, which allows the Secretary of Transportation to assign, and the State of California to assume, responsibility for FHWA's responsibilities under other Federal environmental laws. As this project is covered by the NEPA Assignment MOU, FHWA has



assigned and Caltrans has assumed FHWA responsibility for environmental review, consultation, and coordination on this project. Please direct all future correspondence on this project to Caltrans.

Consultation and identification efforts for the project revealed one built-environment property within the APE was previously listed in the National Register of Historic Places (NRHP):

- I Street Bridge (listed in 1982, NRHP # 82002233)

Efforts also revealed another built-environment property to be within APE that, after evaluation per the NRHP Criteria, was determined eligible for listing in the National Register:

- Sacramento River East Levee Segment (Map ID 8), originally recorded as P-34-000490, along the east bank of the Sacramento River

Pursuant to Stipulation VIII.C.6 of the PA, Caltrans is requesting your concurrence that the Sacramento River East Levee Segment (P-34-00490) is **individually eligible** for listing in the NRHP. The East Levee Segment possesses associative significance under NRHP Criterion A as a physical representation of the precedent set for flood control management in California between 1850 and 1911, more specifically flood control management policy and development in the Sacramento Valley. Levees, canals, and drainages built within this timeframe are associated with early advances in water management in California that resulted in making settlement and expansion of infrastructure in the region possible. The segment was built to a level that no changes were recommended to it by the California Debris Commission in 1911, when the Commission proposed standardizing and expanding the varied and generally privately operated flood control infrastructure along the Sacramento River. It set the standard for post-1911 efforts to achieve a more unified and standardized approach to levee construction in the Sacramento Valley. As part of the first Reclamation District, RD 1, it is a strong example of the pre-1911 era of flood control measures overseen by local interests. As a result, it is eligible for the NRHP.

Several other built-environment properties were also determined to be within the APE through consultation and identification efforts. They include

- 201 3<sup>rd</sup> Street, West Sacramento (APN 010-101-005)(Map ID 1)
- 213 3<sup>rd</sup> Street, West Sacramento (APN 010-101-004)(Map ID 2)
- 212 2<sup>nd</sup> Street, West Sacramento (APN 010-101-009)(Map ID 3)
- 214 2<sup>nd</sup> Street, West Sacramento (APN 010-101-010)(Map ID 4)
- 216 2<sup>nd</sup> Street, West Sacramento (APN 010-101-011)(Map ID 5)
- Washington Water Company Tower at 231 2<sup>nd</sup> Street, West Sacramento (APN 101-102-010)(Map ID 6)
- Reclamation District 811 Levee Segment (Map ID 7)

Julianne Polanco  
December 27, 2016  
Page 3 of 3

Pursuant to Stipulation VIII.C.6 of the PA, Caltrans is requesting your concurrence that the above-listed properties are **not eligible** for listing in the NRHP **individually nor as contributors to a potential NRHP eligible district**.

Finally, one archaeological property is located within the APE:

- CA-SAC-658H

The site consists of 518 pilings associated with the Pioneer Flour Mill wharf located along the east bank of the Sacramento River. It also includes a previously unrecorded feature that consists of a raised concrete foundation and loading ramp. The site is located adjacent to, but outside of, the Area of Direct Impact (ADI) for the project. Pursuant to Stipulation VIII.C.3, Caltrans is considering the property eligible for purposes of the project and proposes to protect it by establishing an Environmentally Sensitive Area (ESA) and using exclusionary fencing to avoid impacts.

Due to the portions of the project area not being accessible prior to construction, Caltrans is proposing to prepare a programmatic agreement (PA) specific to this undertaking to ensure that identification and evaluation of archaeological properties within the APE, and any resolution of adverse effects on those properties, is completed. The PA will have as an attachment an Archaeological Resources Management Plan (Management Plan), which will include a detailed protocol for identification, evaluation, and treatment of any adversely affected historic properties, protocols for archaeological monitoring, and evaluation and treatment of any unanticipated discoveries that may be encountered during implementation of the undertaking.

We look forward to receiving your response within 30 days of receipt of this submittal in accordance with Stipulation VIII.C.6.a of the PA. If no response is received within 30 days, Caltrans will move forward with the project upon notification of its intentions to do so via email or other written communication. Please contact Chris Kuzak, District 3 Architectural Historian, at (530) 741-4017 or [chris.kuzak@dot.ca.gov](mailto:chris.kuzak@dot.ca.gov), if you have any questions regarding the documentation enclosed with this letter. You may also contact project Archaeologist, Erin Dwyer, at (530) 741-4538 or [erin.dwyer@dot.ca.gov](mailto:erin.dwyer@dot.ca.gov).

Sincerely,



Laura Loeffler, Chief  
Environmental Management, M1 Branch

Enclosure

cc: Alexandra Bevk, Caltrans HQ CSO

**OFFICE OF HISTORIC PRESERVATION  
DEPARTMENT OF PARKS AND RECREATION**

1725 23<sup>rd</sup> Street, Suite 100  
SACRAMENTO, CA 95816-7100  
(916) 445-7000 Fax: (916) 445-7053  
calshpo@parks.ca.gov  
www.ohp.parks.ca.gov



February 7, 2017

VIA EMAIL

In reply refer to: FHWA\_2016\_1229\_002

Laura Loeffler, Chief  
Environmental Management, M1 Branch  
Caltrans District 3  
703 B Street  
Marysville, CA 95901

Subject: Determinations of Eligibility for the Proposed I Street Bridge Replacement Project, Sacramento and West Sacramento, CA

Dear Ms. Loeffler:

Thank you for consulting with me about the subject undertaking in accordance with the January 1, 2014 *First Amended Programmatic Agreement Among the Federal Highway Administration, the Advisory Council on Historic Preservation, the California State Historic Preservation Officer, and the California Department of Transportation Regarding Compliance with Section 106 of the National Historic Preservation Act, as it Pertains to the Administration of the Federal-Aid Highway Program in California (PA)*.

The cities of Sacramento and West Sacramento, in cooperation with Caltrans, propose to construct a new crossing for vehicular and pedestrian traffic over the Sacramento River that will replace the upper deck of the I Street Bridge, which would no longer carry such traffic. A full project description and the depiction of the area of potential effect (APE) can be found in Attachment A of the HPSR.

Consultation and identification efforts identified the I Street Bridge, a property listed in the National Register of Historic Places (NRHP), within the APE.

Caltrans also determined that the Sacramento River East Levee Segment (P-34-000490), along the east bank of the Sacramento River, is individually eligible under Criterion A as a physical representation of the precedent set for flood control management in California between 1850 and 1911, more specifically flood control management policy and development in the Sacramento Valley. Levees, canals and drainages built within this timeframe are associated with early advances in water management in California that resulted in making settlement and expansion of infrastructure in the region possible. It set the standard for post-1911 efforts to achieve a more unified and standardized approach to levee construction in the Sacramento Valley. As part of the first Reclamation District, RD 1, it is a strong example of the pre-1911 era of flood control measures overseen by local interests.

Caltrans has also determined that the following properties are not eligible for the NRHP:

- 201 3<sup>rd</sup> Street, West Sacramento, CA
- 213 3<sup>rd</sup> Street, West Sacramento, CA
- 212 2<sup>nd</sup> Street, West Sacramento, CA
- 214 2<sup>nd</sup> Street, West Sacramento, CA
- 216 2<sup>nd</sup> Street, West Sacramento, CA
- Washington Water Company Tower at 231 2<sup>nd</sup> Street, West Sacramento, CA
- Reclamation District 811/900 Levee Segment

Based on my review of the submitted documentation I concur with the above determinations.

Finally, pursuant to Stipulation VII.C.3. of the PA, Caltrans is considering CA-SAC-658H to be eligible for the NRHP for the purposes of the project. The site is located adjacent to, but outside of, the Area of Direct Impact for the project. Caltrans proposes to protect the site by establishing an Environmentally Sensitive Area and using exclusionary fencing to avoid impacts.

Due to portions of the project area not being accessible prior to construction, Caltrans is proposing to prepare a programmatic agreement (PPA) specific to this undertaking to ensure that identification and evaluation of archaeological properties within the APE, and any resolution of adverse effects on those properties, is completed. The PPA will have as an attachment an Archaeological Resources Management Plan which will include a detailed protocol for identification, evaluation, and treatment of any adversely affected historic properties, protocols for archaeological monitoring, and evaluation and treatment of any unanticipated discoveries that may be encountered during implementation.

I look forward to working with Caltrans on the preparation of this agreement document.

Thank you for considering historic properties during project planning. If you have any questions, please contact Natalie Lindquist of my staff at (916) 445-7014 with e-mail at [natalie.lindquist@parks.ca.gov](mailto:natalie.lindquist@parks.ca.gov) or Alicia Perez at (916) 445-7020 with e-mail at [alicia.perez@parks.ca.gov](mailto:alicia.perez@parks.ca.gov).

Sincerely,



Julianne Polanco  
State Historic Preservation Officer

Appendix H  
**List of Technical Studies**

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# Appendix H List of Technical Studies

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Copies of the following technical studies are available on the project website at <http://www.cityofsacramento.org/Public-Works/Engineering-Services/Projects/Current-Projects/I-Street-Bridge-Replacement>.

## **Proposed Project**

- Draft Project Report (Mark Thomas & Company 2016)

## **Human Environment**

- Community Impact Assessment (ICF International 2016)
- Traffic Technical Data and Calculations (Fehr & Peers 2015)
- Visual Impact Assessment (ICF International 2015)
- Historic Property Survey Report, including Archaeological Survey Report (ICF International 2016), Historical Resources Evaluation Report (ICF International 2016)

## **Physical Environment**

- Water Quality Assessment Report (ICF International 2016)
- Scour Analysis (Tetra Tech 2016)
- Preliminary Geotechnical and Foundation Report (GEI Consultants 2014)
- Initial Site Assessment Update (Blackburn Consulting 2016)
- Air Quality Study Report (Terry A. Hayes Associates 2016)
- Noise Study Technical Report (ICF International 2016)

## **Biological Environment**

- Request for Preliminary Jurisdictional Determination (ICF International 2016)
- Natural Environment Study (ICF International 2016)
- Biological Assessment/Essential Fish Habitat Assessment (ICF International 2016)
- Biological Assessment (ICF International 2016)