Standing Analysis for the Streamlined Consultation Framework for the Big Creek Crayfish, St. Francis River Crayfish, and the Species' Critical Habitat

Photo Credit: Chris Lukhaup, Missouri Department of Conservation

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INTRODUCTION

On May 30, 2023, the U.S. Fish and Wildlife Service (Service) listed the Big Creek Crayfish (*Faxonius peruncus)* and the St. Francis River Crayfish (*Faxonius quadruncus*) as threatened under the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 et seq.) (USFWS 2023). Critical habitat was designated for each species at the time of listing, and regulatory measures were defined in a rule under section 4(d) of the Act (USFWS 2023).

Both the Big Creek Crayfish and St. Francis River Crayfish are habitat generalists, occurring in a variety of stream types within the Upper St. Francis River watershed, ranging from intermittent, headwater streams to moderately large rivers. The Big Creek Crayfish's distribution includes 3,032 stream kilometers (km) (1,184 miles) (mi), with the boundaries of critical habitat including 1,720 stream km (1,069 mi) (**Figure 1**). The St. Francis River Crayfish's distribution includes 3,178 stream km (1,975 mi), with critical habitat boundaries including 1,679 stream km (1,043 mi) (**Figure 1**).

Due to the ecology of the species and the physical and biological features (PBFs) comprising the critical habitat, many instream projects have the potential to affect the species or their critical habitat. If a project may affect listed species or critical habitat and the project is authorized, funded, or carried out by a Federal agency, then the Federal agency is required under section 7(a)(2) of the Act to consult with the Service (referred to as "consultation" or "consulting"). When a Federal agency determines that the project may adversely affect listed species or critical habitat, formal consultation is required, a process that can take up to 135 days once initiated.

Because of the potential for instream projects to affect the crayfishes and their critical habitat and the time involved in consulting, particularly during formal consultation, we developed an optional streamlined consultation framework (SCF) for select, recurring actions that are unlikely to affect the species' viability or appreciably diminish the value of critical habitat. The SCF is intended to greatly reduce the time spent by Federal agencies or their designated non-Federal representatives (hereafter referred to collectively as "action agencies") consulting with the Service on these actions while also conserving the Big Creek Crayfish and St. Francis River Crayfish through implementation of reasonable conservation measures.

The *Standing Analysis for the Streamlined Consultation Framework for the Big Creek Crayfish, St. Francis River Crayfish, and the Species' Critical Habitat* (hereafter referred to as the "Standing Analysis" or "SA") supports the SCF by providing a description of actions within the framework's scope and an evaluation of effects of the actions on the two crayfishes and their critical habitat within a 10-year period[1]. The SA also provides a determination on whether the actions and their cumulative effects are likely to jeopardize the continued existence of the species or adversely modify or destroy the species' critical habitat.

[1] We evaluated effects of the actions within a 10-year period because not all actions will occur annually.

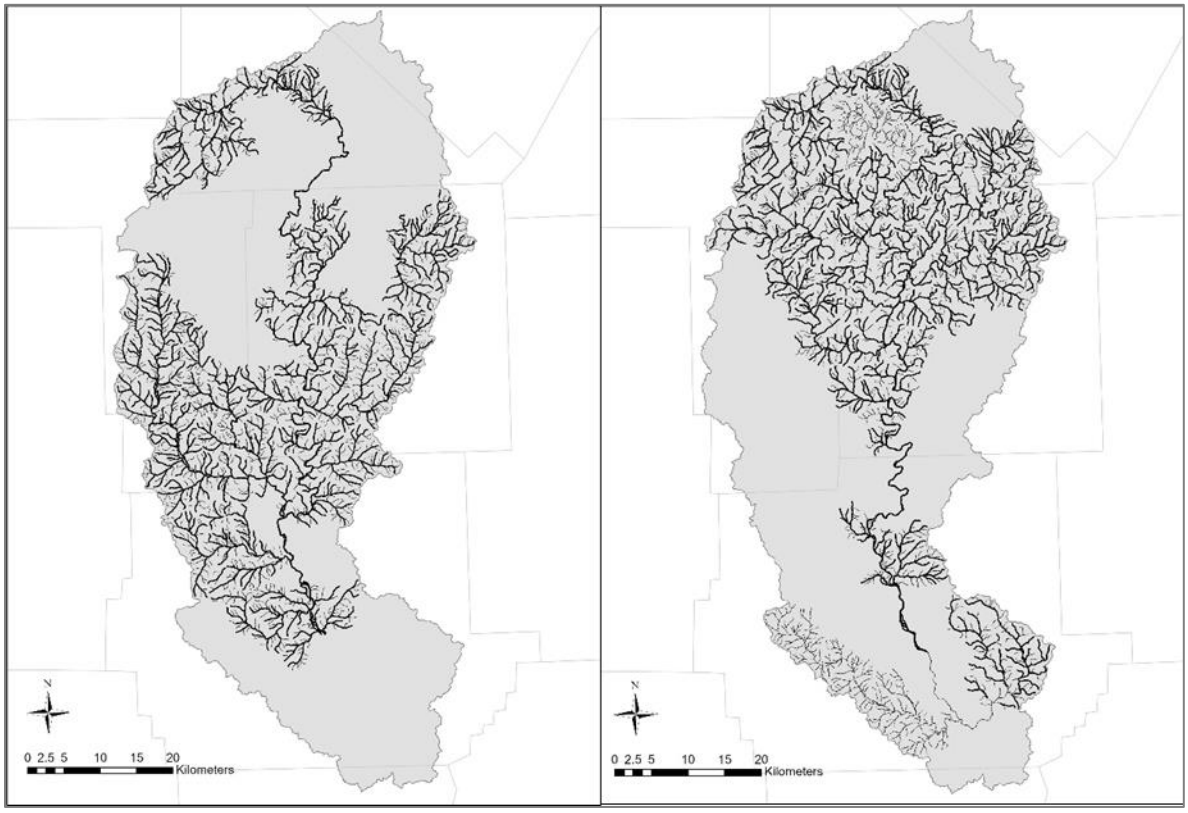

Figure 1. Distribution and critical habitat of the Big Creek Crayfish (left) and St. Francis River Crayfish (right). Darker lines represent designated critical habitat and lighter lines represent additional streams within the species' ranges.

STREAMLINED CONSULTATION FRAMEWORK

As noted above, the SCF is intended to reduce the time action agencies spend consulting with the Service on certain recurring activities that may affect the Big Creek Crayfish, St. Francis River Crayfish, or their critical habitat but are unlikely to affect the species' viability or appreciably diminish the value of the critical habitat. This is achieved by evaluating in the SA the maximum extent of effects of the actions instead of individually evaluating each project when we receive a consultation request.

To further streamline the consultation process under the SCF, we developed a form for action agencies that functions as a biological assessment (referred to as the "streamlined BA form"). We also developed a form for the Service which functions as a biological opinion for projects that may adversely affect one or both crayfishes or their critical habitat (referred to as the "streamlined BO form"). In addition, we developed guidance to assist action agencies in completing the streamlined BA form. Thus, the SCF consists of 3 components: 1) the SA, 2) the streamlined BA form and its instructions, and 3) the streamlined BO form. These documents are available at https://www.fws.gov/office/missouri-ecological-services/library.

Described below are the steps involved in project-level consultations using the SCF. Note that the process only fulfills consultation requirements for the crayfishes and their critical habitat. Therefore, action agencies must evaluate effects to other listed species and designated critical habitat and consult with the Service if actions may affect the species or critical habitat.

1) The action agency generates an Official Species List in IPaC:

A. The action agency uses the Service's Information for Planning and Consultation (IPaC) project planning tool at https://ipac.ecosphere.fws.gov/ to generate an official list of threatened, endangered, proposed or candidate species and proposed or final designated critical habitat that may occur within the boundary of the proposed project and/or may be affected by the proposed project (referred to as the "Species List").

2) The action agency may first assess if a "No Effect" determination is appropriate:

A. If the crayfishes and/or their critical habitat are included in the Species List but will not be affected by project activities, consultation with the Service is not required.

We anticipate that many terrestrial projects will result in no effect to the crayfishes and their critical habitat. A "No Effect" determination is appropriate if the project will not involve intentional take of the species (such as from research activities) or result in ANY: sediment input into streams, increase in stream temperature (from removing canopy cover), or other effects to stream quality. Additional guidance on making effect determinations is provided in the instructions for completing the streamlined BA form.

B. If the crayfishes and/or their critical habitat are included in the Species List and may be affected by project activities, the action agency proceeds to Step 3 and completes the streamlined BA form. Guidance on making effect determinations is provided in the instructions for completing the streamlined BA form.

3) The action agency completes the streamlined BA form:

A. After reviewing instructions for completing the streamlined BA form, the action agency provides basic information about the project(s)[1], including a brief project description, and indicates which conservation measures will be implemented.

B. The action agency defines the action area and determines which species or critical habitat may be present within the action area.

C. The action agency identifies potential effects from project activities on each species and their critical habitat and makes the appropriate effects determinations.

D. For projects that may adversely affect one or both crayfishes or their critical habitat, the action agency provides additional information needed by the Service to complete the streamlined BO form.

4) The action agency sends the streamlined BA form to the Service:

A. The action agency submits the streamlined BA form to the Service via electronic mail. The subject line should include: 1) the project name, 2) the IPaC project code, and 3) whether the action agency made a "may affect, but not likely to adversely affect" (NLAA) determination for all species and critical habitat or a "may affect and likely to adversely affect" (LAA) determination for one or both crayfishes or their critical habitat. Example subject lines include:

"**Route X Bridge Deck Maintenance; 2023-0000001; NLAA**" or
"**Wayne County Streambank Stabilization; 2023-0000002; LAA**"

[1] Action agencies may consult with the Service either on individual actions or a set of actions, referred to as "batched" actions.

B. Note that the Federal agency, rather than the designated non-federal representative, must request initiation of formal consultation for projects that may adversely affect the crayfishes or their critical habitat.

5) The Service reviews the streamlined BA form and if applicable, provides a response:

A. The Service reviews information provided in the streamlined BA form to ensure project activities and their effects are within the scope of those evaluated in the SA.

B. The Service also reviews the information to ensure it is sufficient and supportive of the agencies' effects determinations. For projects for which the Federal agency made a LAA determination for one or both crayfishes or their critical habitat, the Service ensures sufficient information is included in the form to develop the incidental take statement (ITS) portion of the streamlined BO form.

C. The Service has up to 30 days to provide a response for projects for which the Federal agency made NLAA determinations for both crayfishes and their critical habitat. If no response is provided, the action agency may assume the Service concurs with the effect determinations in the streamlined BA form.

D. For projects for which the Federal agency made a LAA determination for one or both crayfishes or their critical habitat, the Service will provide a response within 30 days via the streamlined BO form. If take of one or both crayfishes is anticipated[1], the streamlined BO form will include an incidental take statement (ITS) which exempts the take from prohibition under section 9 of the Act.

DESCRIPTION OF ACTIONS

When deciding which actions to include in the SCF, we considered actions that: 1) are unlikely to affect the viability of the two crayfish species or appreciably reduce the value of critical habitat, 2) result in effects we could sufficiently evaluate in advance, and 3) are likely to occur more than once such that inclusion in the SCF would result in a net time savings. We also considered actions for which use of the SCF would encourage implementation of conservation measures that could provide a meaningful benefit to the Big Creek Crayfish and St. Francis River Crayfish.

Based on these considerations, we identified the groups of actions described below. Actions associated with more than one groups of actions and conducted as part of a bigger action are referred to as "associated activities" and are described separately under **Associated Activities**. The maximum footprint of the actions and activities, as well as their duration and frequency, are described under **EFFECTS OF THE ACTIONS**.

Actions not identified below are outside the scope of the SCF and require separate consultation under section 7 of the Act, as do potential effects to other listed species or critical habitat. Action agencies can contact the Service's Missouri Ecological Services Field Office if they are uncertain whether an action is within the scope of the SCF (https://www.fws.gov/office/missouri-ecological-services/contact-us).

Lastly, actions are only covered under the SCF when consultation with the Service is completed before actions are initiated, unless the action is an emergency response. Per the ESA and regulations, the Service does not consult on actions already completed except during emergency consultation. In the *Endangered Species Consultation Handbook: Procedures for Conducting Consultation and Conference Activities Under Section 7 of the Endangered Species Act*, an emergency is defined as "a situation involving an act

[1] The term "take" only pertains to species and not critical habitat.

of God, disasters, casualties, national defense, or security emergencies, etc. and includes response activities that must be undertaken to prevent imminent loss of human life or property" (USFWS/ NMFS 1998). Example emergency response actions covered by the SCF include the immediate repair or replacement of bridges or culverts following a Presidentially-declared disaster.

Bridge Construction, Maintenance, Replacement, and Removal

Because bridge construction, maintenance, and removal often involve different activities, each action is described separately below. Bridge replacement is not explicitly described as the action is encompassed within the descriptions for bridge removal and bridge construction.

Bridge Construction

Bridges may be constructed either as part of a new construction or to replace an existing bridge. Though bridge construction often requires several other activities, bridge construction itself typically involves installation of support structures and construction of a deck. For construction of a bridge used as a temporary stream crossing, see Construction and Removal of Temporary Stream Crossings.

Bridges may span the entire stream width with no support structures within the stream channel, or they may have one or more support structures within the stream channel. Both types of bridges typically require construction of abutments at either end of the bridge for support. When support structures are installed within the stream channel, sets of long poles (referred to as "piles") are driven into the substrate using impact or vibratory methods or by drilling a hole into the substrate into which the steel or concrete pile is placed. A cap is then placed on top of each set of piles to distribute pressure among the piles and provide the foundation on which a pier is placed. Additional bridge components are then constructed atop the support structures. Though in some instances a crane situated on the streambank may be used to construct a bridge, bridge construction often requires the use of heavy equipment within the stream.

The footprint of instream activities may include the area below and around the bridge and supports and may extend across the entire stream width.

Other activities associated with bridge construction that may affect the crayfishes or their critical habitat (such as streambank grading, geotechnical investigations, and removal of vegetation or trees along the streambank) are described under **Associated Activities**.

Bridge Maintenance

Maintenance of bridges can entail several different activities, including, but not limited to: cleaning, sealing cracks in bridge decks, replacement of asphalt overlays, painting, replacement of planks, sealing joints, and repairing bridge decks. Bridge maintenance may also include activities conducted within the stream channel, such as placing riprap on slopes or around abutments; correcting scour around footings; or clearing sand, gravel, or woody debris from around piers.

The footprint of instream activities may include the area below and around the bridge and may extend across the entire stream width. The footprint of instream activities also may include areas immediately upstream of the bridge or further downstream in which depositional sediment is periodically removed as part of maintenance, with the footprint in these areas likely extending across only part of the stream width.

Other activities associated with the maintenance of bridges that may affect the crayfishes or their critical habitat (such as installation and removal of coffer dams) are described under **Associated Activities**.

Bridge Removal

Bridge removal is conducted when replacing an existing bridge with a new bridge or when removing a bridge entirely (see Construction and Removal of Temporary Stream Crossings for removal of a temporary bridge used for vehicle traffic associated with construction). Like bridge construction, bridge removal typically requires the presence of heavy equipment within the stream channel, especially if support structures will be removed. However, in some instances, a crane may be situated outside of the stream channel to remove a bridge and its components.

The footprint of instream activities will likely be similar to that for bridge construction and may include the area below and around the existing bridge and supports and may extend across the entire stream width.

Other activities associated with the removal of bridges and that may affect the crayfishes or their critical habitat (such as construction and removal of instream work pads) are described under **Associated Activities**.

Culvert Installation, Maintenance, Replacement, and Removal

Culverts function as bridges but are smaller, with widths typically less than 6 meters (m) in width. Installation of culverts may occur independently or as part of a larger road or railway project. Types of culverts often used include: precast concrete boxes, concrete boxes cast in place, corrugated steel pipe (CSP), corrugated steel pipe with an open bottom, and polymer (plastic) pipe. Except in areas consisting of a bedrock streambed, new or replacement culverts must be embedded in the substrate and allow aquatic organism passage in order to use the SCF.

Instream activities may involve using heavy equipment within the stream channel to: place or remove culverts, repair culverts, contour the stream bed or streambanks, pour concrete (if pouring concrete-in place); or remove sand, gravel, or woody debris from around culverts as part of maintenance. When culverts other than box culverts are used, heavy equipment also may be used within the stream channel to place material over the culvert(s) to provide a foundation for the roadway. Therefore, the footprint of instream activities may include the area encompassed by the culvert(s) and the areas immediately upstream and downstream of the culverts, with the footprint likely extending across the entire stream width. The footprint of instream activities also may include areas immediately upstream of the culvert(s) and further downstream in which depositional sediment is periodically removed as part of maintenance, with the footprint in these areas likely extending across only part of the stream width.

Other activities associated with culvert installation, maintenance, replacement, and removal that may affect the crayfishes or their critical habitat (such as streambank grading or removal of vegetation or trees along the streambank) are described under **Associated Activities**.

Pipeline Construction, Repair, Replacement, and Removal

Pipelines are used to transport and distribute fluids and typically consist of sections of metal pipe (such as steel, cast iron, or aluminum), though some pipelines are made of concrete, clay products, and occasionally plastics. The sections are welded together and, in most cases, laid underground. To construct, repair, replace, or remove pipelines, a trench may be excavated within the stream channel to place or access the sections of pipe, often to a depth of 45-60 centimeters (cm), with protective riprap placed over and around the trench. However, in medium and large streams, or in areas containing sensitive environmental resources, pipelines may be installed, removed, and even repaired using a process call horizontal directional drilling (HDD). Instead of digging a trench for or around the pipeline, HDD involves drilling a tunnel underground to install or access the sections of pipe. Because pipelines located above the stream substrate are more likely to impede aquatic organism passage and alter stream

hydraulics, actions involving construction of new pipelines above the stream substrate are outside the scope of the SCF.

The footprint of instream activities may include the area encompassed by pipe sections and the areas immediately upstream and downstream of the pipe sections, with the footprint likely extending across the entire stream width.

Other activities associated with the construction, repair, replacement, and removal of pipelines and that may affect the crayfishes or their critical habitat (such as installation and removal of coffer dams and dewatering or vegetation or tree removal along the streambank) are described under **Associated Activities**.

Construction, Maintenance, Replacement, and Removal of River Accesses

River accesses are locations on streams or rivers that provide either private or public access to the waterway. Accesses can serve as launch facilities for boats or other watercraft or for recreational activities around the water. The construction of new, public river access likely increases fishing opportunities in new areas, thereby increasing the risk of additional Woodland Crayfish introduction if unused crayfish used for bait are released into the stream. Therefore, actions involving construction of a new public river access are outside the scope of the SCF and require separate consultation.

The construction of river accesses may include construction of: an access ramp for watercraft, an access ramps for foot traffic, or stairs. Access ramps can consist of concrete poured in place (using a form), pre-poured concrete slabs, articulating concrete mattresses, or other materials. When ramps are poured in place, they are typically poured during low stream conditions when the area around the ramp is above water.

Instream activities may include using heavy equipment to grade the substrate around the access ramp, place or remove the ramp, or to repair of the ramp. Therefore, the footprint of instream activities may include the area encompassed by the boat ramp and the area around the boat ramp, with the footprint extending across only part of the stream width.

Other activities associated with the construction, maintenance, replacement, and removal of river accesses and that may affect the crayfishes or their critical habitat (such as installation and removal of coffer dams and dewatering or vegetation or tree removal along the streambank) are described under **Associated Activities**.

Construction, Maintenance, Use, and Removal of Hardened Stream Crossings

Hardened stream crossings are hard, stable areas in streams where vehicles, equipment, cattle, horses, and hikers can cross the stream without damaging the streambed or banks. These crossings can be desirable alternatives to culverts and bridges on low-volume roads and trails. They also are an effective alternative to bridges and culverts in areas with highly variable water levels because woody debris and large rocks can often pass over the crossing instead of getting trapped upstream of or within a structure. Hardened stream crossings can be constructed using rock, cable concrete, cement blocks, or interlocking pavers. Rock or geotextile material may also be used to stabilize the stream bed approaches.

Instream activities may involve using heavy equipment within the stream channel to place or remove materials for the stream crossing or to remove sand, gravel, or woody debris from around the crossing as part of maintenance. Therefore, the footprint of instream activities may include the area around and encompassed by the crossing and extend across the entire stream width. The footprint of instream activities also may include areas immediately upstream of the crossing and further downstream in which

depositional sediment is periodically removed, with the footprint in these areas likely extending across only part of the stream width.

Other activities associated with the construction, removal, use, and maintenance of hardened stream crossings and that may affect the crayfishes or their critical habitat (such as vegetation or tree removal along the stream bank) are described under **Associated Activities**.

Stream Restoration

Stream restoration is conducted to improve stream health and can include, but is not limited to: stabilization of streambanks, channel reconfiguration efforts to restore hydrological and geomorphological processes (also referred to as "natural channel design"), and construction of instream structures to help stabilize a section of stream. For the purpose of this SA, we also consider instream heavy metal remediation and reduction a form of stream restoration.

The term "longitudinal length" is used in many of the stream restoration descriptions and represents the distance upstream to downstream (as opposed to the width of a stream).

Stream Channel or Streambed Restoration

Stream channel restoration refers to modifying the path of the stream channel to improve stream stability, whereas streambed restoration refers to modifying the stream bed to improve stability of the stream gradient (downhill slope of the stream channel).

Stream channel and streambed restoration efforts may include using heavy equipment to contour the stream channel and streambed so that the stream maintains its pattern, dimension, and profile such that the channel neither aggrades or degrades (aggradation is the process in which depositional areas fill with sediment, and degradation is the process in which the streambed lowers due to erosional processes). Therefore, the footprint of instream activities may include the entire longitudinal length of the stream channel or streambed being restored and may extend across the entire stream width.

Streambank Stabilization

Streambank stabilization is the practice of protecting streambanks to reduce erosion. Streambanks can be stabilized in a variety of ways, including biotechnical streambank stabilization (using living plant material to reinforce soil and stabilize slopes), engineered log jams (human designed and constructed log structures that simulate the function of naturally-occurring logjams), vegetated riprap, rock armoring, and by planting trees. Articulated concrete revetment mats, which consist of a matrix of individual concrete blocks placed together, may also be used for bank stabilization.

In some instances, the streambank can be contoured from above the streambank. But in other instances, it may be necessary to use heavy equipment within the stream channel. Even when the contouring occurs from above the streambank, the streambank toe (base) is often modified to secure stabilization materials. Therefore, the footprint of instream activities may include the entire longitudinal length of streambank being stabilized, with the footprint likely extending across only part of the stream width.

Construction or Modification of Instream Structures for Stream Stabilization

Certain structures can be constructed within the stream channel to help stabilize a section of stream. These structures include but are not limited to: grade-control structures, weirs, and cross vanes. Grade control structures most often consist of rock or logs and stabilize the stream channel and control erosion of the streambed (head-cutting) by providing a "hard point" in the streambed that resists erosion. Weirs are structures that alter the direction and velocity of stream flow as well as the distribution of sediments to stabilize streams. Cross vanes are a type of weir that are typically constructed of logs and boulders and

that span the stream channel. Cross vanes are used to dissipate energy, deflect stream flow to the center of the channel, create pools, and in some instances, provide grade control. Actions involving construction of structures that prevent or substantially impede aquatic organism passage are outside of the scope of the SCF.

The use of heavy equipment within the stream channel is typically required to install the structures which are often buried in the streambed. Therefore, the footprint of instream activities may include the entire longitudinal length of the area containing the structures and may extend across the entire stream width.

Instream Heavy Metal Remediation and Reduction

As part of efforts to remediate or reduce heavy metal contamination within the Upper St. Francis River watershed, the streambed or gravel bars (both vegetated and un-vegetated) may be excavated in areas with contaminated sediment. Heavy equipment is typically used within the stream channel for the excavation, with the substrate removed to a depth that removes most of the contaminated sediment. Contaminated sediment may be excavated multiple times over several years until remediation levels are reached.

The footprint of instream activities may include the entire longitudinal length of the remediation area and may extend across the entire stream width.

Associated Activities

Some activities are associated with more than one of the actions described above and are not typically the main action, but rather an activity associated with the main action. Thus, they are described separately below. Because each of the associated activities is still a type of action, however, they will be referred to as "actions" throughout the SA.

Construction and Removal of Instream Work Pads

Work pads are stone roadways made of non-erodible material that allow construction equipment to access structures located within a stream. Work pads extending across half or more of a stream often have culverts installed to allow water to pass through the work pad, thereby minimizing impacts to the stream's hydrology.

Work pads are typically constructed using heavy equipment and by repeatedly placing stone in front of the equipment until reaching the location within the stream where work will occur. The removal of work pad material also typically requires the use of heavy equipment within the stream channel. Thus, the footprint of instream activities may include the area encompassed by the work pad and the areas immediately upstream and downstream of the work pad, with the footprint potentially extending across the entire stream width.

Construction, Removal, and Use of Temporary Stream Crossings

Temporary stream crossings are constructed to allow a safe and stable way for construction vehicles to cross a stream. The crossings can also minimize damage to the streambed and channel. As the name suggests, the crossings are intended for short-term use and are removed once a project is completed. Temporary stream crossings may be designed as low water crossings, as bridges, or with non-erodible material, similar to work pads. Temporary crossings may also be fords that do not require any construction. Crossings that are not designed as a low water crossing or bridge or that function as a ford require installation of culverts to allow passage of water through the crossing.

The instream footprint of activities may include the area encompassed by the crossing and the areas immediately upstream and downstream of the crossing, with the footprint likely extending across the entire stream width.

Installation and Removal of Coffer Dams and Dewatering

Cofferdams are often installed to create an isolated work area which can be dewatered. Cofferdams can consist of large casings (hollow cylinders), structures created out of sheet piles, or barriers with an impermeable liner. Installation can be conducted using vibratory hammers, impact pile driving, a crane or excavator, or even by hand stacking (sandbags).

The footprint of instream activities may include the area encompassed by the coffer dam and the area surrounding the coffer dam. The coffer dam is unlikely to extend across the entire stream width unless the stream itself is rerouted, an action outside the scope of the SCF.

Geotechnical Investigations (Borings)

Geotechnical investigations, or borings, are performed to identify the soil and geological conditions of the substrate and assess suitability for construction. The borings are typically conducted by supporting a platform on the substrate and drilling into that substrate.

In some instances, borings can be conducted via a boat. However, heavy equipment is often used to transport the boring equipment to the desired location within the stream. Thus, the footprint of instream activities may include the area encompassed by the boring, the area surrounding the boring, and the path taken by equipment to reach the boring site. Though the footprint will likely extend across only part of the stream width most often, the footprint may extend across most of the stream width if the preferred access is from the side of the stream further from the boring location.

Streambank Grading

Some actions may require a streambank to be graded, meaning the slope of the streambank is modified. For example, the slope of a streambank may need to be reduced to accommodate a temporary stream crossing. Streambanks may also be graded to reduce the amount of erosion or to provide more room for stream water to flow and thus, decrease flow velocity. Though the grading will not involve the use of heavy equipment within the stream channel, the action may release soil into the stream, thereby affecting stream conditions by introducing sediment into the stream.

Vegetation or Tree Removal Required for Other Actions

For some actions, it may be necessary to remove vegetation or trees along the streambank or within the riparian corridor, such as for bridge construction or streambank stabilization. Though the vegetation removal may not involve the use of heavy equipment within the stream channel, the action may release soil into the stream, thereby affecting stream conditions by introducing sediment into the stream. Removal of trees within the riparian corridor may also reduce the tree canopy, subsequently increasing stream temperature.

Other Terrestrial Actions

Terrestrial actions occurring outside of the stream channel and that do not degrade stream conditions, such as water quality and temperature, are also included in the SCF. Examples of terrestrial actions include, but are not limited to: timber management activities, construction or maintenance of gravel roads, construction or maintenance of utility lines (so long as tree removal in the riparian corridor does not increase stream temperature), funding or implementing conservation practices that do not adversely affect stream quality, tree removal when erosion and sedimentation is avoided and the riparian corridor remains intact, and application of pesticides when measures are implemented to prevent chemicals from reaching streams.

Activities Not Explicitly Described

We expect there may be aspects of the actions described above or similar actions that are not explicitly identified but that are within the intent of the SCF, such as removing debris that obstructs stream flow or poses a safety hazard. Therefore, we have included a category for these activities.

Other Activities Caused by the Actions

In a biological opinion, the Service evaluates all consequences to species or critical habitat caused by the proposed Federal action, including the consequences of other activities caused by the proposed action, that are reasonably certain to occur (see definition of "effects of the action" at 50 CFR §402.02). Additional regulations at 50 CFR §402.17(a) identify factors to consider when determining whether activities caused by the proposed action (but not part of the proposed action) are reasonably certain to occur. These factors include, but are not limited to:

1) past experiences with activities that have resulted from actions that are similar in scope, nature, and magnitude to the proposed action;
2) existing plans for the activity; and
3) any remaining economic, administrative, and legal requirements necessary for the activity to go forward.

The Service is not aware of activities likely to be caused by actions included in the SCF that are not already included in the description of the actions. However, when filling out the streamlined BA form, action agencies will consider whether there may be other activities caused by the actions that were not considered in this SA. Should other activities be anticipated, the Service will include them by reference in the streamlined BO form and consider if they affect the conclusions within the SA (on whether actions will jeopardize the continued existence of the crayfishes or result in adverse modification of their critical habitat).

Conservation Measures

Conservation measures represent actions outlined in the project description that the action agency will implement to further recovery of the species under review. Conservation measures implemented to minimize harm to listed species and which are proposed by the action agency in the streamlined BA form are considered part of the project, and their implementation is required to ensure effects are encompassed by those described in this SA.

Outlined below are three sets of conservation measures. The first set of measures are those that must be implemented within all areas of the crayfishes' ranges and critical habitat in order to use the SCF. These measures are considered basic Best Management Practices (BMPs) that should be implemented for any action for which they are applicable.

The second set of measures are those that must be implemented when actions occur within High Priority Crayfish Areas (HPCAs) (**Figure 2**). The HPCAs are areas within the crayfishes' ranges that contribute a greater amount to the species' viability than the rest of the range. These areas include those that: 1) may function as refugia from the Woodland Crayfish, such as streams above dams or other natural barriers; 2) contain unique genetic diversity that may help the species adapt to changing environmental conditions over time; or 3) contain high levels of abundance that may provide resiliency against environmental and demographic stochasticity.

The third set of measures are conservation measures that are recommended, but not required, when using the SCF.

Conservation Measures (BMP's) Required in All Areas

To use the SCF, the conservation measures (BMPs) below must be implemented, where applicable.

Stream Access and Instream Use of Heavy Equipment

- Minimize the footprint of instream activities.
- Refrain from using the wetted portion of stream channels as travel ways for mechanized equipment.
- Design temporary and permanent stream crossings to allow passage of bedload and floating debris, to maintain stable channel configurations, and to allow aquatic organism passage.
- Select culverts that are of sufficient size to avoid water impoundment and allow aquatic organism passage.
- For permanent structures, install culverts below grade (embedded in the substrate) to preserve the natural stream bed and prevent barriers to aquatic organism movement.
- If temporary roadways must be built, ensure that roadways are of low gradient with sufficient roadbed and storm water runoff drains and outlets and do not restrict or interrupt natural stream flow.
- Refrain from removing sand and gravel from the stream for construction purposes (does not apply to maintenance around structures or stream crossings).
- Remove all material from the stream and adjacent wetlands and floodplains that was used to construct temporary stream crossings or work pads.

Water Quality Management

- Implement all relevant erosion and sediment control measures to reduce the amount of sediment entering streams and ensure controls are installed and operational before beginning ground-disturbing activities or work within the stream channel.
- Stage areas for crew, equipment, and materials (especially storage of hazardous chemicals, fuels, and other such substances) at least 30 m from streambanks.
- Only use riprap that is washed, clean, and free of heavy metal contamination.
- Refrain from washing equipment in or adjacent to streams.
- Refrain from depositing concrete washings, grout and bonding material into streams or a location where they can be washed into streams.
- Refrain from using material for stream crossings or work pads that consists of fine sediment that may enter the stream channel and impair water quality.
- Refrain from broadcast application of pesticides, herbicides, or fertilizers within the riparian corridor to avoid water contamination due to overspray or runoff. Follow label instructions when using appropriate chemicals for spot application of fertilizers, pesticides and herbicides.

Riparian Corridor Management

- To shade streams and protect streambanks, limit clearing of vegetation, including both standing and downed timber, to that which is absolutely necessary for construction purposes.
- Revegetate disturbed areas as soon as possible after construction to minimize soil erosion. Native grasses, wildflowers, and trees are recommended for plantings compatible with the local native landscape and wildlife needs. Avoid aggressive exotic perennials such as Crown Vetch (*Securigera varia*) and *Sericea lespedeza.*
- Minimize heavy equipment use within the riparian corridor to reduce vegetation destruction and compaction of soils.

Other

- When private river accesses are constructed, provide information to permit applicants about the impacts of nonnative crayfish and encourage applicants to avoid releasing unused crayfish used as bait.
- Post informational signage at construction sites identifying required conservation measures or include measures in the contract.

Conservation Measures (BMPs) Required in High Priority Crayfish Areas

To use the SCF, the following conservation measures also must be implemented when actions occur within the wetted portion of stream channels within HPCAs (**Figure 2)**. A shapefile of the areas is located at https://www.fws.gov/office/missouri-ecological-services/library will be updated as needed.

- Avoid instream activities March 15 to June 30 to avoid the periods when crayfish are most sensitive to disturbance.
- Use horizontal directional drilling (HDD) or aerial spanning for pipelines.
- When adverse effects cannot be avoided in HPCAs, implement actions or provide funds for actions that aid recovery of the crayfishes. Actions and funding amounts must be approved by the Service's Missouri Ecological Services Field Office. Exempted from this requirement are actions that will result in net benefit to the species (such as stream restoration) and actions that are not implemented or funded by Federal agencies (such as construction of private river accesses).

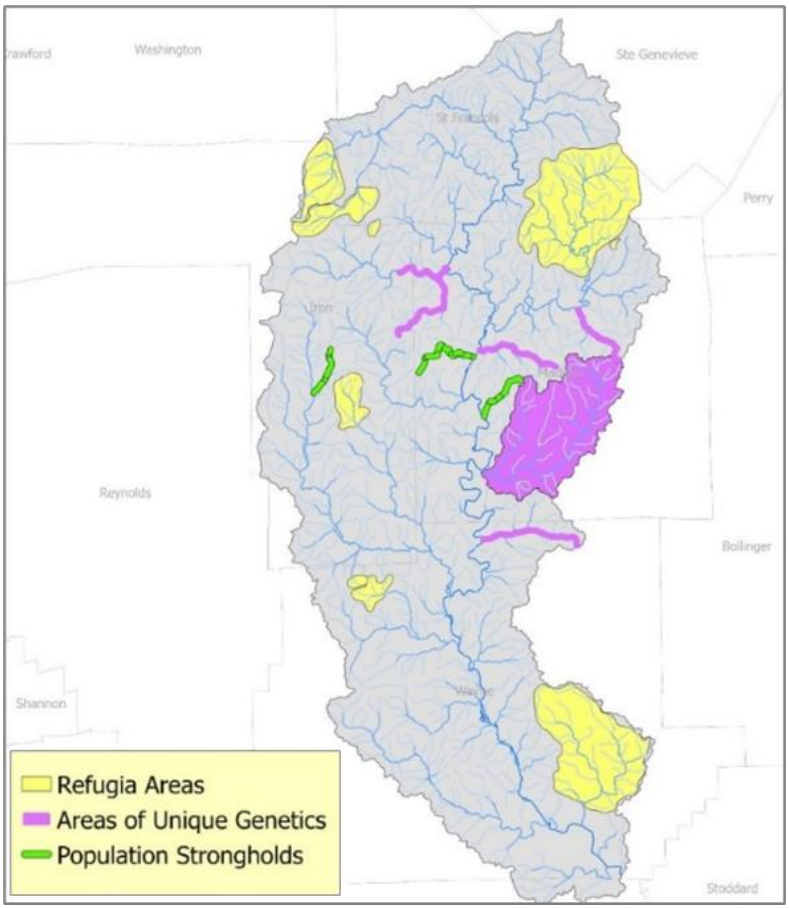

Figure 2. High Priority Crayfish Areas (HPCAs) for the Big Creek Crayfish and St. Francis River Crayfish.

Additional Recommended Conservation Measures (BMPs)

Outlined below are conservation measures that are not required, but recommended, when applicable.

Stream Access and Instream Use of Heavy Equipment

- Construct stream crossings during periods of low streamflow.
- Construct new stream crossings perpendicular to the flow of water, with minimal disturbance to the stream banks and streambed.
- Where possible, use horizontal directional drilling (HDD) or aerial spanning for stream crossings (e.g., pipelines).

Measures to Maintain or Improve Stream Hydraulics and Geomorphology

- Maintain streambeds gradients and streambank contours that promote stream stability.
- Riprap stabilization designs should include appropriate bank slope and rock size to protect the streambank from wave and current action and to prolong the life of the embankment. A final slope ratio of at least 1:2 is recommended, and a more stable 1:3 slope should be used where possible.
- Avoid any other activities that may impact stream dynamics and result in streambed scour.

Water Quality Management

- Design ground-disturbing activities to avoid or minimize soil dislocation and compaction.
- Where possible, replace nonnative vegetation with native vegetation.
- Where possible, increase riparian buffer widths to at least 30 m.

Nonnative Species

- Before utilizing within streams, drain water from boats and machinery that have operated in water. Check motor cavities, live-well, bilge, transom wells, tracks, buckets, and any other water reservoirs.
- Remove any mud, soil, trash, plants (or plant material), or animals from equipment before leaving any water body or work area.

Action Area

The action area is defined as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action" (50 Code of Federal Regulations [CFR] 402.02). The action area is not limited to the "footprint" of the project but rather encompasses the aerial extent of the biotic, chemical, and physical impacts to the environment resulting from the action.

The action area for this SCF includes 12-digit hydrologic unit watersheds encompassing streams occupied by the Big Creek Crayfish's or St. Francis River Crayfish's or designated as critical habitat and stream draining into these streams. Thus, the action area includes the entire Upper St. Francis River Watershed upstream of Lake Wappapello (**Figure 3**).

The action area for individual projects will be provided by the action agency in the streamlined BA form. Guidance on defining the action area, including downstream effects from project activities, is provided in the form's instructions.

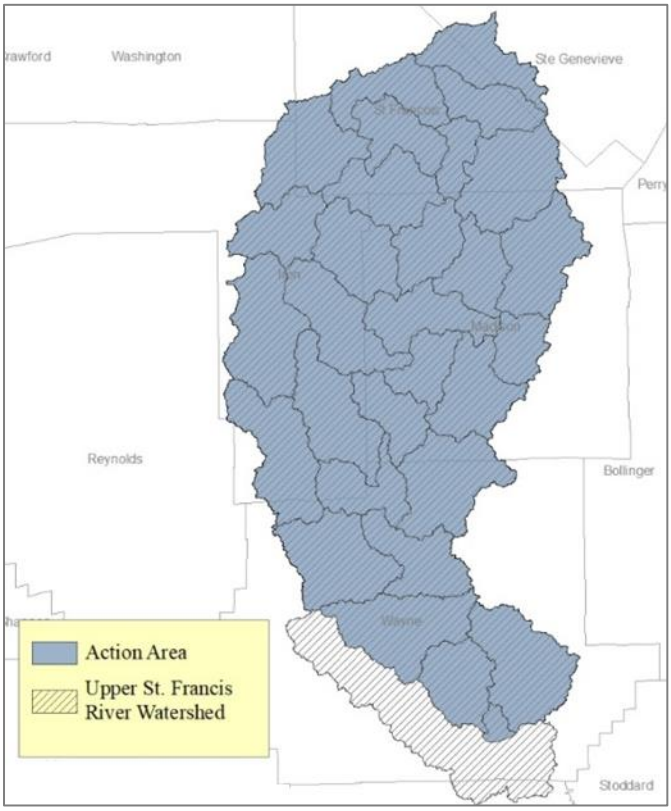

Figure 3. Action area for actions included in the SCF.

STATUS OF THE SPECIES AND CRITICAL HABITAT

This section summarizes the biological or ecological information relevant to evaluating effects to the Big Creek Crayfish, St. Francis River Crayfish, and the species' critical habitat from actions included in the SCF. Additional information on the species' life history, habitat and distribution, other data on factors necessary to their survival, and the physical and biological features essential to the conservation of the species can be found in the Species Status Assessment Report (USFWS 2022) and the final listing rule (USFWS 2023).

Big Creek Crayfish and St. Francis River Crayfish

Life History

The Big Creek Crayfish and St. Francis River Crayfish are small, stream-dwelling crayfish with adults ranging from 2.8 to 5.6 cm in length (Pflieger 1996).

Both species are known to occur in all available macrohabitats (pools, riffles, runs, backwaters) within a site and in a variety of stream types, ranging from intermittent, headwater streams to moderately large rivers (Riggert et al. 1999). However, the Big Creek Crayfish is most abundant in smaller streams with widths less than 10 m and in shallow depths (less than 0.5 m) (Riggert et al. 1999, Westhoff 2011). The St. Francis River Crayfish is most abundant in pools, backwater, and run macrohabitats (Riggert et al. 1999, Westhoff 2011). Both species occur in lower current velocities, generally ranging from 0–0.4 meters per second (m/s) (Riggert et al. 1999, Westhoff 2011) and are found under rocks or in shallow burrows in gravel (Creaser 1931, Williams 1954, Pflieger 1996).
The Big Creek Crayfish and St. Francis River Crayfish mate in the fall, with males depositing a sperm plug in the sperm receptacle of the female (Pflieger 1996). The eggs are fertilized internally, extruded,

and then attached to the female's abdomen the following spring, generally from April until late May (Pflieger 1996; Riggert et al. 1999). Once hatched, the young crayfish remain attached to the female's swimmerets (forked swimming limbs) until they complete two molts. They then begin making brief forays from the female, returning to the safety of her abdomen and clamping themselves to her swimmerets with their pincers when they feel threatened (Pflieger 1996). Based on capture data from Riggert et al. 1999, it appears that juveniles of both species do not become independent until June.

The normal lifespan for both crayfishes appears to be about two years (Pflieger 1996), and their diet is likely similar to other Ozark-endemic crayfishes, consisting of plant detritus, invertebrates, and periphyton.

Distribution and Population Status

Both the Big Creek Crayfish and St. Francis River Crayfish have localized distributions in the Upper St. Francis River watershed upstream of Wappapello dam in Iron, Madison, St. Francois, and Wayne counties in southeastern Missouri (**Figure 4**) (Pflieger 1996, Riggert et al. 1999). The Big Creek Crayfish is most abundant in streams on the west side of the basin and the Twelvemile Creek subwatersheds on the east side of the basin. The St. Francis River Crayfish mainly inhabits the upper St. Francis River tributaries on the upper end of the Upper St. Francis River watershed (**Figure 4**) (Pflieger 1996, Riggert et al. 1999, MDC 2017, unpublished data). Because the species are habitat generalists and not all reaches of streams within the watershed have been sampled, it is likely that the species occur at more locations in the watershed. Therefore, we consider the species' ranges to include all streams within occupied 12-digit hydrologic unit watersheds (referred to as "subwatersheds") **(Figure 4**). Using this approach, the Big Creek Crayfish's range includes 3,032 stream km, and the St. Francis River Crayfish's range includes 3,178 stream km (**Figure 4**).

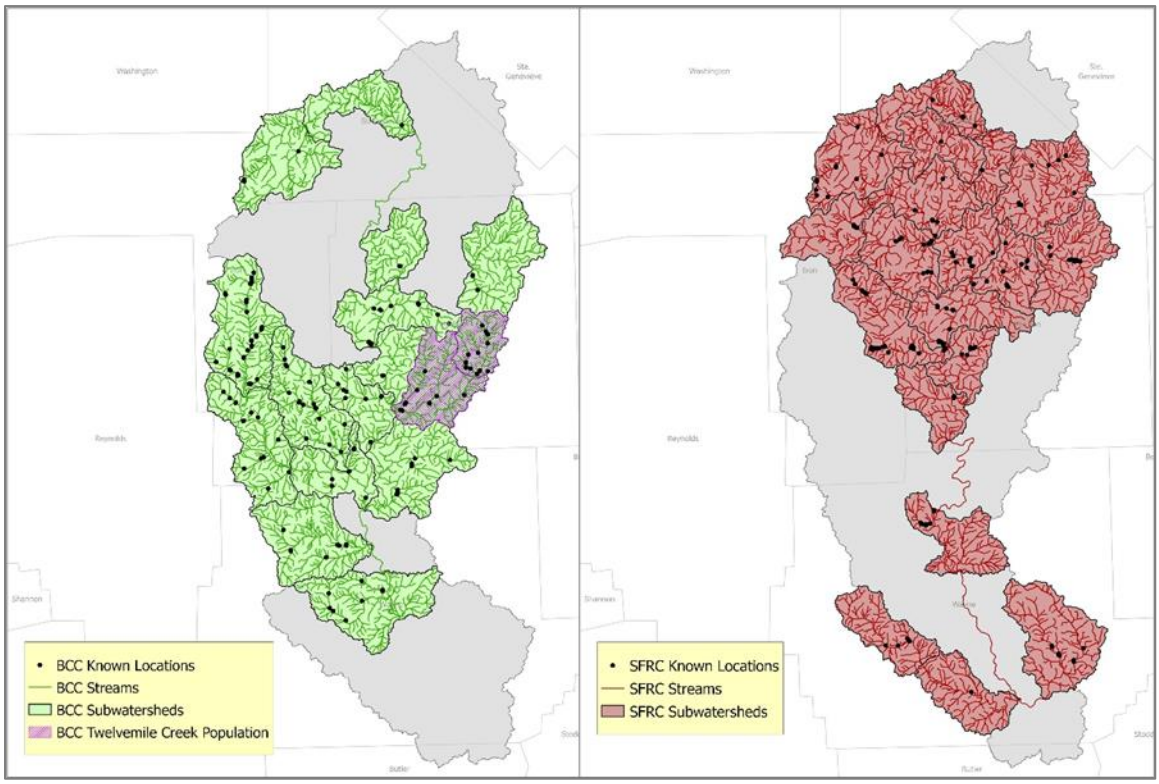

Figure 4. Presumed distribution of the Big Creek Crayfish (left) and St. Francis River Crayfish (right).

We consider the Big Creek Crayfish to be comprised of two populations - the Main population and the Twelvemile Creek population (**Figure 4**), with individuals in the Twelvemile Creek population containing unique haplotypes not found elsewhere in the range (Fetzner and DiStefano 2008). Because results from genetic analyses indicate there is gene flow throughout the St. Francis River Crayfish's range (Fetzner and DiStefano 2008), we presume that the species functions as a single population (**Figure 4**).

Threats to the Species

The primary threats to the Big Creek Crayfish and St. Francis River Crayfish are invasion by the Woodland Crayfish (*Faxonius hylas*) and in portions of the Upper St. Francis River watershed, heavy metal contamination and sedimentation. Presented below is a brief description of these threats.

Invasion by the Woodland Crayfish

The Woodland Crayfish is native to southeastern Missouri in the Black River drainage and the headwaters of the Meramec and Big rivers (Pflieger 1996). In 1984, the species was discovered outside its native range in Stouts Creek, a tributary of the St. Francis River (Pflieger 1996), presumably from a bait bucket introduction (Westhoff et al. 2011). Subsequent sampling has documented the Woodland Crayfish in multiple reaches of the Upper St. Francis River watershed (Riggert et al. 1999, DiStefano et al. 2008a, DiStefano et al. 2008b, DiStefano and Westhoff 2011, MDC 2018a, unpublished data). As of 2011, the Woodland Crayfish was estimated to occupy 166 to 649 stream km in 11 streams (DiStefano and Westhoff 2011). This constitutes 5–20% of the total stream distance in the Upper St. Francis River watershed (DiStefano and Westhoff 2011).

In stream reaches invaded by the Woodland Crayfish, Big Creek Crayfish and St. Francis River Crayfish abundance appears to be substantially reduced, and in some areas the species have been completely displaced (DiStefano and Westhoff 2011). Although it remains unclear exactly how the Woodland Crayfish is displacing the two native crayfishes, results of genetic studies indicate that the mechanism of displacement may be reproductive interference in the form of hybridization (Fetzner et al. 2016).

Heavy Metal Contamination

Though lead mining ceased in the Old Lead Belt portion of southeastern Missouri in the 1970s, waste from mining operations is still present in the landscape (Missouri Natural Resource Trustee Council 2014), resulting in contamination of fish and other aquatic biota, alteration of fish and invertebrate communities, and public health advisories against human consumption of lead-contaminated fish (Czarneski 1985, Schmitt et al. 1993). Several studies from other areas of Missouri indicate that heavy metals and mining-related tailings adversely affect riffle-dwelling crayfish. At sites downstream of mining activities and compared to reference sites, metal concentrations in crayfish are significantly higher, crayfish densities are significantly lower, and crayfish survivorship is significantly lower (Allert et al. 2008, 2009, 2012, 2013).

Sedimentation

Because of the surrounding geology, there is little gravel accumulation in the Upper St. Francis River watershed (Boone 2001). However, some localized areas in the watershed have excessive sedimentation due to eroding or breached mine tailings (Boone 2001, DiStefano 2008a). Excessive deposition of fine sediment from tailings or other sources can cover rocks and cavities used by the Big Creek Crayfish and St. Francis River Crayfish as refugia (areas in which a population of organisms can survive through a period of unfavorable conditions). Because crayfish presence is dependent on open interstitial spaces and rocks embedded in little or no sediment (Loughman et al. 2016, Loughman et al. 2017), sedimentation can reduce carrying capacity and the density of subpopulations. The loss of refugia may also increase predation risk and increase competition with the Woodland Crayfish, potentially facilitating displacement of the Big Creek Crayfish and St. Francis River Crayfish.

Big Creek Crayfish and St. Francis River Crayfish Critical Habitat

In the final listing rule for the species (USFWS 2023), the Service determined that designation of critical habitat for the Big Creek Crayfish and St. Francis Crayfish was prudent and determinable. Therefore, one unit was designated for each species, and the boundaries of each unit are depicted in **Figure 5**.

The following physical or biological features (PBFs) were determined to be essential to the conservation of the species:

1) Stream flow velocity generally between 0 and 0.35 m/s.
2) Stream depths[1] generally between 0.06 and 0.49 m for the Big Creek Crayfish and generally between 0.06 and 0.52 m for the St. Francis River Crayfish.
3) Water temperatures between 1.1 and 28.9 degrees Celsius (°C).
4) Adequately low stream embeddedness so that spaces under rocks and cavities in gravel remain available to the Big Creek Crayfish and St. Francis River Crayfish.
5) An available forage and prey base consisting of invertebrates, periphyton, and plant detritus.
6) Connectivity among occupied stream reaches of the Big Creek Crayfish (both within and among occupied subwatersheds), and connectivity among occupied stream reaches of the St. Francis River Crayfish (both within and among occupied subwatersheds).
7) Ratios or densities of nonnative species low enough to allow for maintaining the populations of the Big Creek Crayfish and St. Francis River Crayfish.

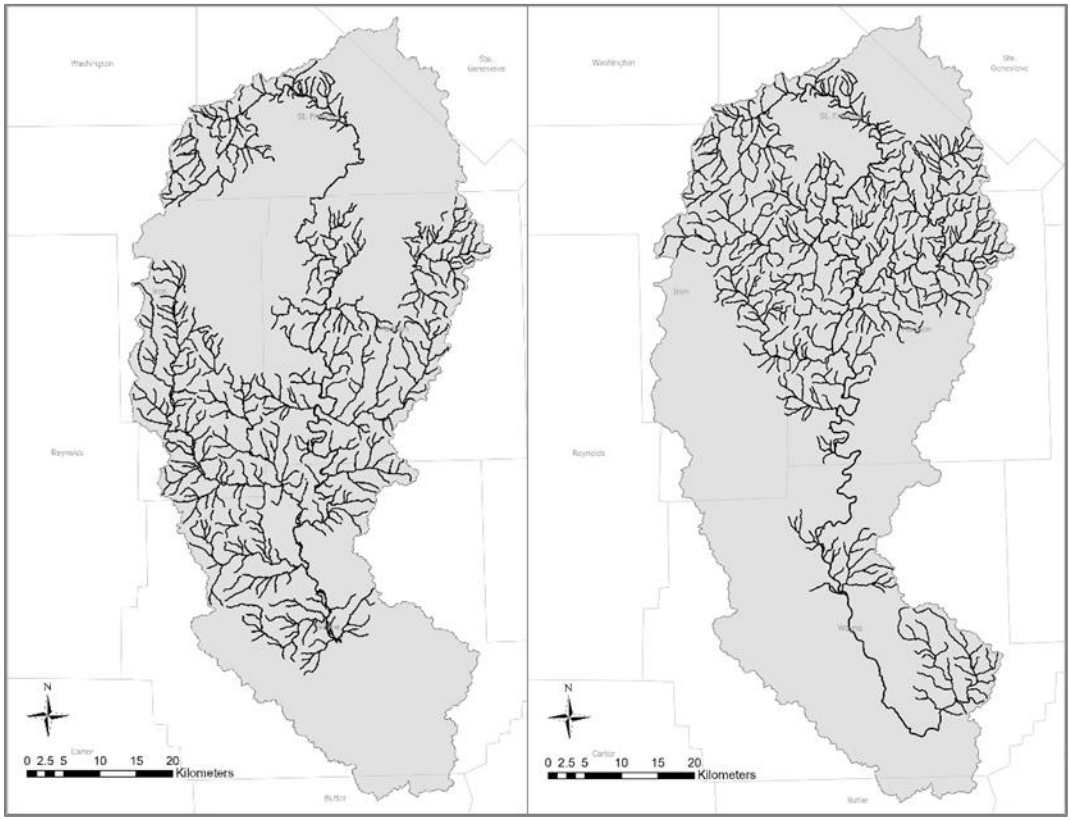

Figure 5. Critical habitat for the Big Creek Crayfish (left) and St. Francis River Crayfish (right).

[1] Water depth at the time of occupancy.

The status of the crayfishes' critical habitat varies within the watershed. Suitable stream flow velocities, stream depths, and water temperatures are likely largely unchanged from historical conditions. However, there are localized areas within the Big Creek Crayfish's and St. Francis River Crayfish's ranges that have excessive sedimentation and increased heavy metal concentrations in sediment due to eroding or breached mine tailings (Boone 2001, DiStefano 2008a, Distefano 2008b). Consequently, stream sediments are above thresholds known to adversely affect benthic organisms, and embeddedness is lower in these areas, resulting in reduced prey base and spaces under rocks for refugia.

Connectivity among occupied stream reaches has likely been reduced from historical conditions somewhat in many streams within the Big Creek Crayfish's and St. Francis River Crayfish's ranges by the installation of stream culverts or low water crossings that do not facilitate aquatic organism passage.

Lastly, the Woodland Crayfish has been documented at numerous locations within the range of the Big Creek Crayfish and St. Francis River Crayfish. The presence of this species, which is not native to the Upper St. Francis River watershed, affects the viability of Big Creek Crayfish and St. Francis River Crayfish populations in invaded areas.

ENVIRONMENTAL BASELINE

The environmental baseline is predicated upon an analysis of the accumulated effects of past and recent or ongoing human-induced and natural factors that have led to the current status of the affected listed species and their habitat. The environmental baseline incorporates: (1) past and present effects of all Federal, State, or private actions or other human activities affecting the species; (2) anticipated effects to the affected species from all proposed Federal projects that have already undergone formal or early section 7 consultations; and (3) effects of non-Federal actions contemporaneous with the consultation process.

Because the action area is the entire range of each species and their critical habitat, the environmental baseline within the action area is the same as that described range-wide for the species and their critical habitat, with the addition of streams draining into the species' ranges and critical habitat (**Figure 3**).

EFFECTS OF THE ACTIONS

To assess effects of the actions covered by the SCF, we considered reasonably certain consequences to the two crayfishes and their critical habitat caused by the actions, including consequences of other activities caused by the actions (because activities caused by the actions would not occur but for the actions). Consequences to species may occur later in time and may occur outside the action area.

Below we describe the types of impacts the Big Creek Crayfish and St. Francis River Crayfish may experience and the ways in which their critical habitat may be affected. We also identify thresholds below which adverse effects are unlikely to occur and describe the areas in which it is meaningful to evaluate effects to critical habitat. Based on this information, we then describe how each action may affect the crayfishes and their critical habitat and the estimated maximum spatial extent, duration, and frequency of impacts within a 10-year period. We identified the maximum, rather than average, extent of effects to ensure actual effects are encompassed by our evaluation, and we used a 10-year period because not all actions will occur annually. Because we are unable to determine the exact threshold at which adverse effects may occur, we also identified thresholds that we expect are below actual thresholds at which adverse effects are likely to occur. In this way, we can ensure that actions resulting in impacts below our identified thresholds are not likely to result in adverse effects.

Lastly, we describe effects of other activities caused by the actions and consider the cumulative effects to determine if the actions covered by the SCF will jeopardize the continued existence of the crayfish or adversely modify their critical habitat.

If any anticipated effects of an action, including the spatial extent, duration, or frequency of impact, are not encompassed in the descriptions below, the action is considered outside the scope of the SCF and requires separate consultation under section 7 of the Act.

Types of Effects and Thresholds at Which Adverse Effects are Likely to Occur

Big Creek Crayfish and St. Francis River Crayfish

The ways in which the crayfishes may be adversely affected from actions included in the SCF include: 1) injury or mortality from crushing, 2) temporarily reduced habitat suitability, 3) long-term habitat loss or degradation, and 4) temporarily reduced connectivity. These effects are described below.

Actions increasing the likelihood of a Woodland Crayfish introduction or facilitating the species spread, such as construction of new public river accesses, are outside the scope of the SCF. Actions that result in a long-term reduction in connectivity, such as construction of a dam, are also outside the scope of the SCF. For the purpose of the SCF, long-term is defined as more than 10 years.

Injury or Mortality

One of the primary ways in which crayfish may be adversely affected by actions included in the SCF is by injury or mortality from crushing during instream activities. Though crayfish can quickly move backwards when threatened, most individuals are sequestered under the substrate during the day when project activities typically occur (DiStefano 2021a, pers. comm.). Given this behavior, crayfish are vulnerable to crushing from heavy equipment or placement of heavy materials within the stream channel. Mortality may occur immediately or later if injuries are severe. We expect that injured individuals that do persist may forage less; refrain from breeding; experience reduced fitness, growth, or successful reproduction (due to impacts to egg or sperm development); or have a reduced ability to protect eggs or young.

The loss of individuals, whether during project activities or later due to injuries, may result in a temporary reduction in abundance within the impacted area. Disruption of breeding activities, reproduction, or care of young also may temporarily reduce abundance. We expect that these impacts will be realized immediately or if injured individuals persist, within one year, which encompasses one breeding season.

The threshold for when adverse effects in the form of injury or mortality are likely to occur is straightforward. We expect that adverse effects may occur whenever heavy equipment is used or heavy material is placed within areas of the stream occupied by one or both species (**Table 1**).

Temporarily Reduced Habitat Suitability

Another main way crayfish may be adversely affected by actions covered by the SCF is if the suitability of stream conditions is temporarily impacted. Suspended sediment can foul crayfish gills and reduce oxygen update, limiting the energy available for feeding, growth, and breeding (Rosewarne et al. 2014). If foraging is reduced enough, fitness, growth, reproduction, survivorship, or care of young could subsequently be lowered within the impacted area. These activities may also be impacted if spaces within gravel or under rocks are no longer available for sheltering and foraging. These spaces can be affected by

heavy equipment that temporarily compacts[1] the substrate or by sediment, either fine or coarse, that fills or covers the spaces. Impacts to stream velocity, water depth in pools, or water temperature can similarly impact crayfish when the conditions are no longer suitable.

Reduced survivorship or reproductive success may result in a temporary reduction in abundance within the impacted area, as could impacts to reproduction or the ability of females to care for young. We expect these impacts will occur within a year of modification to stream conditions, which encompasses one breeding season.

To determine at what level changes to stream conditions may meaningfully reduce crayfish health fitness, growth, reproduction, survivorship, or care of young, we queried species experts on appropriate thresholds for both the stream conditions and the duration in which the conditions are impacted. We also considered the size of an area with unsuitable conditions out of which crayfish could readily move to adjacent areas containing suitable conditions. Though movement data are not available for the Big Creek Crayfish and St. Francis River Crayfish, data are available for other stream-dwelling crayfish. In one study of the Noble Crayfish (*Astacus astacus*), adults moved an average of 3.2 ± 0.4 m within a 3-hour period, and juveniles moved 13.4 ± 3.4 m during the same time (Denek et al. 2019). The Spinycheek Crayfish (*Faxonius limosus*) has been documented moving a mean distance of 7.4 ± 15.6 m per day (Denek et al. 2019), and observations of the median daily movement by the White-clawed Crayfish (*Austropotamobius pallipes*) range from 0.23 to 2.1 m (McCreesh 2000, Robinson et al. 2000, Bubb et al. 2006, Bubb et al. 2008). Based on this information, we expect that the crayfishes can readily move at least 5 m within 24 hours to escape temporary changes in habitat suitability that may reduce crayfish fitness, growth, reproduction, survivorship, or care of young. Because crayfish may be unable to discern the direction of the nearest suitable habitat, we have selected a threshold of 25 m^2 so that suitable habitat will be no further than 5 m in any direction. However, because female crayfish tend to be less active when carrying eggs or young and because juveniles are vulnerable while molting (Pflieger 1996), we have selected a threshold of 4 m^2 when habitat suitability is reduced during April through June, the period when females either eggs or care for young (Pflieger 1996; Riggert et al. 1999).

Given the information above and considering input from species experts, we expect that adverse effects may occur if for more than 24 hours and in an area greater than 25 m^2 during July through March or in an area greater than 4 m^2 during April through June, turbidity exceeds 500 Nephelometric Turbidity Units (NTUs); sediment deposition exceeds 0.5 cm; stream flow velocity exceeds 0.6 m/s; stream depth in pools exceeds 1.8 m; water temperature exceeds 32.2 °C or water temperature is less than -6.7 °C (**Table 1**). Adverse effects may also occur if for any length of time and within an area greater than 25 m^2 during July through March or 4 m^2 during April through June, substrate is compacted such that spaces within gravel or under rocks cannot accommodate all life stages of crayfish (**Table 1**).

Long-Term Habitat Loss or Degradation

Crayfish also may be adversely affected by a long-term loss or degradation of suitable habitat, with long-term defined as more than 10 years for the purpose of this SA. Examples of habitat loss or degradation

[1] Substrate compaction from heavy equipment is likely to be temporary given substrate is a combination of sand and cobble/boulder because in the highly igneous areas of the Upper St. Francis River drainage, the (Westhoff 2022, pers. comm.), which does not typically compact. In the portion of the species' ranges in which substrate contains more chert, mild compaction of the gravel substrate may occur. However, the substrate is likely to loosen after one or two high water events (Westhoff 2022, pers. comm.). In some areas in the northern portion of the Upper St. Francis River watershed where fine sediment is more abundant, the Big Creek Crayfish and St. Francis River Crayfish are either absent or have much lower levels of abundance (Westhoff 2022, pers. comm.). Thus, it is very unlikely that the species would be impacted by compaction in these areas.

include, but are not limited to, deposition of sediment that fills spaces within gravel or under rocks, substrate compaction[1], and stream conditions that are outside of suitable ranges.

When long-term habitat loss or degradation occurs rapidly, such as during construction of a hardened stream crossing or a river access ramp, the primary impact to crayfish within the affected area may be injury or mortality if individuals are unable to escape the impacted area (see above for ***Injury and Mortality***). The loss or degradation of habitat would be a secondary impact resulting in reduced crayfish abundance within the affected area since crayfish would be unable to recolonize the area in previous densities. If long-term habitat loss occurs gradually, such as when depositional areas form due to changes in stream hydrology, crayfish are unlikely to experience injury or mortality or even reduced fitness, growth, survivorship, or reproductive success. Instead, crayfish abundance in the affected area likely gradually decreases as crayfish move to areas containing more suitable habitat. Whether long-term habitat loss or degradation occurs rapidly, the ultimate effect is a long-term reduction in crayfish abundance within the affected area, possibly eliminating crayfish presence entirely within the impacted area.

For actions resulting in a rapid degradation or loss of habitat, we expect abundance will be reduced within a year of modification to stream conditions. However, for some actions, it may take multiple years for depositional areas to form or for stream conditions to degrade outside the range of suitable conditions, such as an increase in stream depth due to scouring. Thus, it may be multiple years before effects are fully realized. Actions that cause long-term habitat loss or degradation extending across most of the stream width such that crayfish are unable to move through an area are outside the scope of the SCF. Thresholds at which crayfish movement among areas may be impeded are outlined below under **Temporarily Reduced Connectivity**.

We expect that adverse effects from long-term habitat loss or degradation may occur at the same thresholds as those that temporarily reduce habitat suitability when unsuitable conditions persist for more than 10 years. However, because crayfish will likely either be immediately injured and killed or gradually move from the affected area, the distance in which crayfish can readily move to escape changes in habitat suitability is less relevant than the size of an area that represents a meaningful loss or degradation of habitat. For the purpose of this SA, we consider 25 m^2 to represent a meaningful loss or degradation of habitat. Therefore, we consider adverse effects to occur if for more than 10 years and in an area greater than 25 m^2, turbidity exceeds 500 NTUs; sediment deposition exceeds 0.5 cm; stream flow velocity exceeds 0.6 m/s; stream depth in pools exceeds 1.8 m; water temperature exceeds 32.2 °C, water temperature is less than -6.7 °C, or if substrate is compacted such that spaces within gravel or under rocks cannot accommodate all life stages of crayfish. (**Table 1**).

Temporarily Reduced Connectivity

The last way in which the Big Creek Crayfish or St. Francis River Crayfish may be adversely affected by actions covered by the SCF is by a temporary reduction in connectivity among occupied sites. Examples of activities that could temporarily adversely affect connectivity include construction of work pads or coffer dams that increase stream flow velocity throughout much of the stream width such that crayfish are unable to move upstream or downstream of the area.

When connectivity among occupied sites is reduced, the ability of crayfish to breed with crayfish in other areas is affected, thus reducing gene flow. Gene flow is important in maintaining high genetic diversity, which allows species to adapt to future environmental changes and avoid inbreeding. Maintaining connectivity also helps facilitate recolonization of areas following local extirpations. Because reducing gene flow and recolonization potential over multiple areas could eventually reduce the crayfishes' overall

[1] Because bedrock within the crayfishes' ranges is composed of igneous rock (Westhoff 2011), which is very hard and made up of interlocking crystals, the bedrock crevices are unlikely to collapse from the weight of heavy equipment.

viability, actions reducing connectivity continuously for more than a year or intermittently[1] for more than 10 years are outside the scope of the SCF. Therefore, connectivity will be only temporarily affected by actions included in the SCF. We expect effects to connectivity from actions included in the SCF will occur immediately and persist until habitat suitability is restored and stream conditions return to suitable ranges, which may be up to one year after project activities are completed.

We are unable to determine the exact size or proportion of an area that temporarily reduces connectivity among occupied sites. However, we expect connectivity may be temporarily reduced if more than 75% of the stream width is impassable by crayfish. We consider crayfish passage to be impeded[2] when a physical barrier is present, high stream flow velocity prevents crayfish movement in either the upstream or downstream direction, or when stream conditions are unsuitable for a longitudinal stream distance greater than 10 m.

Based on the above considerations and input from species experts, we expect that adverse effects in the form of temporarily reduced connectivity may occur if for more than 30 days and across more than 75% of the stream width: 1) a physical barrier is present, 2) stream flow velocity exceeds 1.8 m/s (for any longitudinal stream distance), or 3) for a longitudinal stream distance greater than 10 m, stream depth exceeds 3.7 m, water temperature is less than -6.7 °C, or water temperature exceeds 35.0 °C (**Table 1**).

Big Creek Crayfish and St. Francis River Crayfish Critical Habitat

To evaluate effects to the crayfishes' critical habitat, we first considered the functions provided by critical habitat PBFs. These functions include:1) supporting occupancy and reproduction within an area, 2) supporting movement among occupied areas, and 3) preventing displacement of the crayfishes by nonnative species. Because actions increasing the likelihood of additional Woodland Crayfish introductions, increasing the likelihood of introductions of other nonnative species, or facilitating the Woodland Crayfish's expansion are outside the scope of the SCF, preventing displacement of the crayfishes by nonnative species is not discussed.

To evaluate effects to the crayfishes' critical habitat, we also considered the areas in which it is meaningful to evaluate effects since there are areas within the crayfishes' critical habitat boundaries that may contain one or more PBFs but have no reasonable potential to support any of the essential functions, either now or in the future. For example, some portions of lakes may contain suitable water temperature (PBF #3). But crayfishes cannot occupy these areas because other conditions within the lake, such as stream flow velocity (PBF #1), are unsuitable and will remain unsuitable since removal of the dams is unlikely. Evaluating impacts to water temperature within these areas would not be meaningful because an area cannot be essential to a species' conservation if it has no potential to support critical habitat functions. Similarly, it would not be meaningful to evaluate impacts to water temperature in areas with no spaces within gravel or under rocks or bedrock crevices for foraging and refugia, such as in stream side channels. To meaningfully evaluate impacts to the crayfishes' critical habitat PBFs from actions included in the SCF, we therefore evaluate impacts only in areas having a reasonable potential to support one or more critical habitat functions.

Described below are the functions provided by critical habitat PBFs and the thresholds at which we expect adverse effects may occur. For the purpose of this SA, sets of stream features with potential to support one or more critical habitat functions represent specific areas comprising the crayfishes' critical habitat, with a set of stream features consisting of a riffle, run, pool, and glide. We consider a PBF to be

[1] Such as increased stream temperature during summer months due to removal of canopy cover.
[2] Crayfish likely move in the downstream direction more easily than in the upstream direction, especially during flood events. However, for the purpose of this SA, we consider crayfish passage to be impeded if movement in either the upstream or downstream direction is affected.

adversely affected if the impacted area is large enough to appreciably reduce within a set stream features one or more of the critical habitat functions provided by the PBF.

Reduced Ability to Support Occupancy and Reproduction

Supporting occupancy and reproduction is a necessary function because without it, crayfish subpopulations could not persist. For a stream feature to support the function, stream conditions much be conducive for crayfish feeding, health, and breeding. The PBFs that provide conditions to support the crayfishes' occupancy and reproduction within an area include suitable stream flow velocity, stream depth, and water temperature; low stream embeddedness, and a healthy prey base (PBFs #1–5) (**Table 2**).

We are unable to determine the exact thresholds at which the ability of a stream feature to support occupancy and reproduction is appreciably reduced, especially given the size of the area likely depends on the size of the stream. However, we expect that a stream feature's ability to support occupancy and reproduction may be meaningfully reduced when stream conditions are unsuitable in more than 50% of a set of stream features. Under ***Temporarily Reduced Habitat Suitability***, we describe movement patterns of stream-dwelling crayfish and input from species experts to define thresholds at which unsuitable stream conditions may reduce crayfish health fitness, growth, reproduction, survivorship, or care of young. We consider these thresholds applicable also to an area's ability to support crayfish occupancy and reproduction. Therefore, we consider critical habitat to be adversely affected when for more than 24 hours and in an area greater than 25 m^2 during July through March or in an area greater than 4 m^2 during April through June, turbidity exceeds 500 NTUs; sediment deposition exceeds 0.5 cm; stream flow velocity exceeds 0.6 m/s; stream depth in pools exceeds 1.8 m; water temperature exceeds 32.2 °C, or water temperature is less than -6.7 °C (**Table 2**). Adverse effects may also occur if for any length of time and within an area greater than 25 m^2 during July through March or 4 m^2 during April through June, substrate is compacted such that spaces within gravel or under rocks cannot accommodate all life stages of crayfish (**Table 2**). We consider impacts to the ability of an area to support occupancy and reproduction to be long-term when adverse effect thresholds are exceeded for more than 10 years.

Temporarily Reduced Ability to Support Movement Among Occupied Areas

As noted previously, supporting connectivity is important because movement among occupied areas facilitates gene flow and recolonization in the event of a local extirpation. The critical habitat PBFs required to support the crayfishes' movement among occupied areas include suitable stream flow velocity, stream depth, and water temperature and connectivity (PBFs #1–3, 6) (**Table 2**).

We are unable to determine the exact thresholds at which the ability of a critical habitat area to support crayfish movement among occupied sites is appreciably reduced. However, as stated under ***Temporarily Reduced Connectivity***, we expect connectivity may be temporarily reduced if for more than 30 days, more than 75% of the stream width is impassable by crayfish. We assume that the ability of a critical habitat area to support movement among occupied areas is appreciably reduced at the same level and by the same factors. Therefore, we consider critical habitat to be adversely affected when for more than 30 days and across more than 75% of the stream width: 1) a physical barrier is present, 2) stream flow velocity exceeds 1.8 m/s (for any longitudinal stream distance), or 3) for a longitudinal stream distance greater than 10 m, stream depth exceeds 3.7 m, water temperature is less than -6.7 °C, or water temperature exceeds 35.0 °C (**Table 2**). Similar to ***Temporarily Reduced Connectivity***, actions are outside the scope of the SCF if they will reduce the ability of a critical habitat area to support crayfish movement among occupied areas, either continuously for more than a year or intermittently for more than 10 years.

Table 1. Estimated thresholds at which adverse effects to the Big Creek Crayfish and St. Francis River Crayfish may occur. Actions reducing connectivity continuously for more than one year or intermittently for more than 10 years are outside the scope of the SCF.

Type of Impact	Estimated Threshold for Adverse Effects
Injury or mortality	Whenever heavy equipment is used or heavy materials placed within occupied areas of the stream channel.
Temporarily reduced habitat suitability	For any length of time and within an area greater than 25 m^2 (29.9 yd^2) during July through March or in an area greater than 4 m^2 (4.8 yd^2) during April through June, substrate is compacted such that spaces within gravel or under rocks cannot accommodate all life stages of crayfish. OR For more than 24 hours and in an area greater than 25 m^2 (29.9 yd2) during July through March or in an area greater than 4 m^2 (4.8 yd^2) during April through June: • Turbidity exceeds 500 NTUs, • Short-term sediment deposition exceeds 0.5 cm (0.2 in), • Stream flow velocity exceeds 0.6 m/s (2 ft/s), • Stream depth in pools temporarily exceeds 1.8 m (6 ft), OR • Water temperature temporarily exceeds 32.2 °C (90 °F) or is less than -1.1 °C (30 °F).
Long-term habitat loss or degradation	For more than 10 years and in an area greater than 25 m^2 (29.9 yd^2): • Spaces within gravel or under rocks accommodating all life stages of crayfish are no longer available, OR • Adverse effect thresholds for temporarily reduced habitat suitability (see above) are exceeded.
Temporarily reduced connectivity	For more than 30 days (but not continuously for more than 1 year or intermittently for more than 10 years) and across more than 75% of the stream width: • A physical or biological impediment to movement is present for any longitudinal stream length, • Stream flow velocities exceed 1.8 m/s (4 ft/s) for any longitudinal stream length, • Stream depth exceeds 3.7 m (12 ft) for a longitudinal stream length greater than 10 m (33 ft), • Water temperature is less than -6.7 °C (20 °F) for a longitudinal stream length greater than 10 m (33 ft), OR • Water temperature is greater than 35.0 °C (95 °F) for a longitudinal stream length greater than 10 m (33 ft).

Table 2. The number, abbreviated name, and function of each critical habitat PBF and the estimated threshold at which adverse effects may occur. Actions reducing connectivity continuously for more than one year or intermittently for more than 10 years are outside the scope of the SCF.

PBF #	PBF Abbreviated Name	Function(s) Provided by PBF	Estimated Threshold for Adverse Effects
1	Stream flow velocity	Supports occupancy and reproduction	Stream flow velocity exceeds 0.6 m/s (2 ft/s) more than 50% of a set of stream features for more than 24 hours.
1	Stream flow velocity	Supports movement among areas	Stream flow velocity exceeds 1.8 m/s (4 ft/s) across more than 75% of the stream width for more than 30 days (but not more than 1 year).
2	Stream depth	Supports occupancy and reproduction	Stream depth in pools exceeds 1.8 m (6 ft) in more than 50% of a set of stream features for more than 24 hours.
2	Stream depth	Supports movement among areas	Stream depth in pools exceeds 3.7 m (12 ft) across more than 75% of the stream width for more than 30 days (but not more than 1 year) for a longitudinal stream distance more than 10 m (33 ft).
3	Water temperature	Supports occupancy and reproduction	Water temperatures is less than -1.1 °C (30 °F) or greater than 32.2 °C (90 °F) in more than 50% of a set of stream features for more than 24 hours.
3	Water temperature	Supports movement among areas	Water temperatures is less than -6.7 °C (20 °F) or greater than 35.0 °C (95 °F) across more than 75% of the stream width for more than 30 days (but not more than 1 year) for a longitudinal stream distance more than 10 m (33 ft).
4	Stream embeddedness	Supports occupancy and reproduction	In more than 50% of a set of stream features, turbidity exceeds 500 NTUs or sediment deposition exceeds 0.5 cm (0.2 in) for more than 24 hours.
5	Prey base	Supports occupancy and reproduction	In more than 50% of a set of stream features, turbidity exceeds 500 NTUs or sediment deposition exceeds 0.5 cm (0.2 in) for more than 24 hours.
6	Connectivity	Supports movement among areas	For more than 30 days (but not continuously for more than 1 year or intermittently for more than 10 years) and across more than 75% of the stream width: • A physical or biological impediment to movement is present for any longitudinal stream length, • Stream flow velocities exceed 1.8 m/s (4 ft/s) for any longitudinal stream length, • Stream depth exceeds 3.7 m (12 ft) for a longitudinal stream length greater than 10 m (33 ft), • Water temperature is less than -6.7 °C (20 °F) for a longitudinal stream length greater than 10 m (33 ft), OR • Water temperature is greater than 35.0 °C (95 °F) for a longitudinal stream length greater than 10 m (33 ft).

Anticipated Effects from Each Action

Based on considerations described above, we evaluated the ways in which the species and each critical habitat PBF may be affected by each action included in the SCF. As part of the evaluation, we estimated for each action the maximum spatial extent of effects, the maximum duration, and the maximum frequency within a 10-year period. To calculate the total spatial extent of effects from each action, we multiplied the spatial extent of effects by the frequency in which the action may occur.

Because each action included in the SCF may occur in a variety of stream orders with varying stream widths, it is difficult to estimate the total maximum area in which the species and their critical habitat may be adversely affected. Therefore, we estimated the maximum longitudinal stream distance in which adverse effects may occur. We then used these linear estimates to estimate the maximum percentage of each species' range and critical habitat that may be adversely affected. For project-level consultations resulting in adverse effects, however, we consider it more meaningful to identify the areal, rather than linear, extent of adverse effects to ensure the footprint of instream activities is minimized, a required conservation measure for projects using the SCF (see **Conservation Measures**). Therefore, we have also included the maximum width of the area in which adverse effects may occur to assist action agencies in completing the streamlined BA form.

As noted under **DESCRIPTION OF ACTIONS**, we have included within this SA a category for activities not explicitly identified but that are within the intent of the SCF. We are unable to predetermine the spatial extent of impacts from individual projects. However, because it is unlikely that we overlooked activities resulting in effects encompassing a large area, we assume that effects will be no more than 50% of actions explicitly described for each type of effect.

Lastly, given that temporarily reduced connectivity affects gene flow and recolonization potential of occupied crayfish areas both upstream and downstream of the temporary barrier to movement, we are unable to determine the spatial extent of impacts. However, actions are outside the scope of the SCF and require separate consultation if they will reduce connectivity either continuously for more than one year or intermittently for more than 10 years. In this way, we can ensure that actions included in the SCF are not likely to have a long-term effect on gene flow or recolonization potential.

Described in **Tables 3 and 4** are anticipated effects to the crayfishes and critical habitat PBFs from each action and the maximum spatial extent of adverse effects of individual projects. The maximum duration, maximum frequency within a 10-year period, and total maximum extent of adverse effects from each action are provided in **Tables 5 and 6.**

Table 3. Anticipated effects to the crayfishes from actions included in the in the SCF given the adverse effect thresholds outlined in Table 1. The maximum longitudinal stream distance in which adverse effects may occur are in bold.

Action	Anticipated Effects to the Crayfishes
Bridge construction	Injury or mortality from crushing: Injury and mortality will likely occur within instream areas traversed by heavy equipment or in which substrate is disturbed, which may include the area underneath the bridge, the area in which bridge supports are installed (encompassed by the area underneath the bridge), and areas immediately upstream and downstream of the bridge. The area underneath the bridge may be up to 25 m in length and span the entire stream width; whereas the areas upstream and downstream of the bridge may each extend up to 20 m in length and also span the entire stream width. **Distance of Adverse Effects = 65 m** Temporarily reduced habitat suitability: Heavy equipment use and substrate disturbance from installation of bridge supports will likely result in turbidity and sedimentation temporarily exceeding adverse effect thresholds throughout the project area (up to 65 m) and up to 200 m downstream with effects spanning the entire stream width. **Distance of Adverse Effects = 265 m** Long-term habitat loss or degradation: Changes in hydrology may result in long-term depositional areas upstream of bridge supports and further downstream. In addition, stream flow velocity and stream depth may exceed adverse effect thresholds immediately downstream of bridge supports. The depositional area in front of each bridge support may be up to 2 m in width and 2 m in length, the area downstream of each bridge support experiencing increased flow velocity and depth may also be 2 m in length and 2 m in width, and the depositional area further downstream may be up to 10 m in length and 4 m in width. **Distance of Adverse Effects = 14 m** Temporarily reduced connectivity: The area in which stream flow velocity and stream depth may increase beyond adverse effect thresholds is unlikely to span more than 75% of the stream width. However, crayfish movement may be temporarily impeded due to disturbance if instream work extends across more than 75% of the stream channel and exceeds 30 days. Long-term effects will likely be beneficial if connectivity improves due to improvement of stream conditions. **Distance of Adverse Effects (Temporary) = Indeterminable**
Bridge maintenance	Injury or mortality from crushing: Injury and mortality may occur in instream areas traversed by heavy equipment or in which substrate is disturbed, which may include the area underneath the bridge, areas immediately upstream and downstream of bridge, and areas further upstream and downstream requiring sand or gravel removal as part of maintenance. The area underneath the bridge may be up to 25 m in length and span the entire stream width, the areas immediately upstream and downstream of the bridge may each extend up to 20 m in length and span the entire stream width, and the areas further upstream and downstream with sand or gravel accumulation may extend up to 20 m upstream of the bridge and 100 m downstream of the bridge and span the entire stream width (encompassing the areas immediately upstream and downstream of the crossing). **Distance of Adverse Effects = 145 m** Temporarily reduced habitat suitability: Heavy equipment use, substrate disturbance around bridge supports, and substrate disturbance in areas requiring removal of sand and gravel for maintenance may result in turbidity and sedimentation temporarily exceeding adverse effect thresholds throughout the project area (up to 145 m) and up to 50 m downstream with effects spanning the entire stream width. **Distance of Adverse Effects = 195 m** Long-term habitat loss or degradation: Because no new structures will be installed within the stream channel, stream hydrology will not be affected and no new depositional areas will form.

Action	Anticipated Effects to the Crayfishes
	Temporarily reduced connectivity: Crayfish movement may be temporarily impeded across the stream width due to disturbance. However, instream work is unlikely to exceed 30 days.
Bridge removal	Injury or mortality from crushing: Injury and mortality will likely occur within instream areas traversed by heavy equipment or in which substrate is disturbed, which may include the area underneath the bridge, areas in which bridge supports are installed (encompassed by the area underneath the bridge), the areas immediately upstream and downstream of the bridge, and areas in which bridge debris is removed (encompassed by the area immediately upstream and downstream of the bridge). The area underneath the bridge may be up to 25 m in length and span the entire stream width, whereas the areas upstream and downstream of the bridge may each extend up to 20 m in length and also span the entire stream width. **Distance of Adverse Effects = 65 m** Temporarily reduced habitat suitability: Heavy equipment use and removal of bridge supports and bridge debris will likely result in turbidity and sedimentation temporarily exceeding adverse effect thresholds throughout the project area (up to 65 m) and up to 200 m downstream, with effects spanning the entire stream width. **Distance of Adverse Effects = 265 m** Long-term habitat loss or degradation: Removal of bridge supports may change hydrology around the area of the removed bridge, creating new depositional areas and displacing old ones. If there is a net decrease in suitable habitat, it is unlikely to exceed 25 m^2. Temporarily reduced connectivity: Crayfish movement may be impeded across the stream width due to disturbance. However, instream work is unlikely to exceed 30 days. Long-term effects may be beneficial if aquatic organism passage improves due to bridge removal. Beneficial effects: Though removal of bridge supports may change hydrology around the area of the removed bridge, there will likely be an overall increase in suitability of stream flow velocity and stream depth immediately downstream of the removed bridge supports. In addition, flood events may displace depositional areas immediately upstream of bridge supports and further downstream, increasing availability of spaces within gravel or under rocks.
Culvert installation, maintenance, replacement, and removal	Injury or mortality from crushing: Injury and mortality will likely occur within instream areas traversed by heavy equipment or in which substrate is disturbed, which may include the footprint of culverts, areas immediately upstream and downstream of culverts, and areas further upstream and downstream requiring sand or gravel removal as part of maintenance. The area underneath culverts may be up to 10 m in length and span the entire stream width, the areas immediately upstream and downstream of culverts may each extend up to 10 m in length and span the entire stream width, and the areas further upstream and downstream with sand or gravel accumulation may extend up to 20 m upstream of culverts and 50 m downstream of the culvert and span the entire stream width (encompassing the areas immediately upstream and downstream of culverts). **Distance of Adverse Effects = 80 m** Temporarily reduced habitat suitability: Heavy equipment use, substrate disturbance around culverts, and substrate disturbance in areas requiring removal of sand and gravel for maintenance will likely result in turbidity and sedimentation temporarily exceeding adverse effect thresholds throughout the project area (up to 80 m) and up to 100 m downstream with effects spanning the entire stream width. **Distance of Adverse Effects = 180 m**

Action	Anticipated Effects to the Crayfishes
	Long-term habitat loss or degradation: Unless an open bottom culvert is used, habitat within the footprint of new or larger culverts will be lost, and stream flow velocity immediately downstream of culverts may exceed the adverse effect threshold[1], even when culverts of sufficient size are used. In addition, after multiple flood events, changes in hydrology may result in long-term depositional areas immediately upstream of culverts and further downstream. The footprint of culverts may be up to 10 m in length and span the entire stream width, the upstream depositional area may extend up to 2 m in length and span the entire stream width, the area immediately downstream of culverts experiencing increased stream flow velocity may be up to 2 m in length and span the entire stream width, and the depositional area further downstream may be up to 3 m in length and 2 m in width. **Distance of Adverse Effects = 17 m** Temporarily reduced connectivity: The area in which stream flow velocity and stream depth may increase is unlikely to span more than 75% of the stream width. Though crayfish movement may be impeded across the stream width due to disturbance, instream work is unlikely to exceed 30 days. Beneficial effects: Culvert removal or replacement of undersized culverts with those of adequate size may improve suitability of stream flow velocity and stream depth immediately downstream of culverts and result in displacement of depositional areas immediately upstream of the culverts and further downstream, increasing availability of spaces within gravel or under rocks. Culvert removal or replacement of undersized culverts with those of adequate size may also improve aquatic organism passage.
Pipeline construction, repair, replacement, and removal	Injury and mortality from crushing: Unless horizontal directional drilling is used, injury and mortality will likely occur within instream areas traversed by heavy equipment or in which substrate is disturbed, which may include the footprint of the pipeline and areas immediately upstream and downstream of the pipeline. The footprint of the pipeline may be up to 2 m in length and span the entire stream width, whereas the areas immediately upstream and downstream of the pipeline may each extend up to 4 m in length and span the entire stream width. **Distance of Adverse Effects = 10 m** Temporarily reduced habitat suitability: Unless horizontal directional drilling is used, heavy equipment use and substrate disturbance will likely result in turbidity and sedimentation temporarily exceeding adverse effect thresholds throughout the project area (up to 10 m) and up to 100 m downstream, with effects spanning the entire stream width. **Distance of Adverse Effects = 110 m** Long-term habitat loss or degradation: Because new pipelines will be installed below the substrate, stream hydrology will not change and no new depositional areas will form. Temporarily reduced connectivity: Though instream activities may span the entire stream width, they are unlikely to exceed 30 days. Beneficial effects: If an exposed pipeline is removed or replaced, connectivity may improve if the exposed pipeline created a physical barrier to crayfish movement or if high stream flow velocity along the downstream side of the exposed pipeline impeded crayfish movement. Removal or replacement of an exposed pipeline may also result in displacement of depositional areas immediately upstream of the pipeline and further downstream, increasing availability of spaces within gravel or under rocks.
Construction, maintenance, replacement, and	Injury or mortality from crushing: Injury and mortality will likely occur within instream areas traversed by heavy equipment or in which substrate is disturbed, which may include the footprint of the access ramp and areas immediately upstream and downstream of the ramp. The footprint of the access ramp and the areas immediately upstream and downstream of the ramp may be up to 10 m in length and 10 m in width. **Distance of Adverse Effects = 10 m**

[1] If stream flow velocity or other stream conditions are expected to exceed the connectivity adverse effect thresholds for more than 1 year (**Table 1**), the action is outside the scope of the SCF and requires separate consultation.

Action	Anticipated Effects to the Crayfishes
removal of river accesses	Temporarily reduced habitat suitability: Heavy equipment use and substrate disturbance in and around the pipeline may result in turbidity and sedimentation temporarily exceeding adverse effect thresholds throughout the project area (up to 10 m) and up to 100 m downstream with effects spanning up to 10 m in width. **Distance of Adverse Effects = 110 m** Long-term habitat loss or degradation: Installation of a new or larger access ramp will result in long-term habitat loss due to a loss of spaces within gravel or under rocks within the footprint of the ramp. Changes in hydrology may result in increased stream flow velocity and stream depth immediately downstream of the ramp in an area up to 2 m in width and 2 m in length. Changes in hydrology may also result in long-term depositional areas immediately upstream of the ramp and further downstream, with the upstream depositional area up to 3 m in width and 3 m in length and the downstream depositional areas also up to 3 m in length and 3 m in width. **Distance of Adverse Effects = 8 m** Temporarily reduced connectivity: The area in which stream flow velocity and stream depth may increase is unlikely to span more than 75% of the stream width. Beneficial effects: The removal of an access ramp may improve suitability of stream flow velocity and stream depth immediately downstream of the ramp and result in displacement of depositional areas immediately upstream of the culverts and further downstream, increasing the availability of spaces within gravel or under rocks.
Construction, maintenance, use, and removal of hardened stream crossings	Injury or mortality from crushing: Injury and mortality will likely occur within instream areas traversed by heavy equipment or in which substrate is disturbed, which may include the footprint of the crossing, areas immediately upstream and downstream of the crossing, and areas further upstream and downstream requiring sand or gravel removal as part of maintenance. The footprint of the crossing may be up to 10 m in length and span the entire stream width, the areas immediately upstream and downstream of the culvert may each extend up to 10 m in length and span the entire stream width, and the areas further upstream and downstream with sand or gravel accumulation may extend up to 20 m upstream of the culvert and 50 m downstream of the culvert and span the entire stream width (encompassing the areas immediately upstream and downstream of the crossing). Because habitat will likely be unsuitable within the footprint of the crossing, injury or mortality is not anticipated when vehicles use the crossing to traverse the stream. **Distance of Adverse Effects = 80 m** Temporarily reduced habitat suitability: Heavy equipment use, substrate disturbance in and around the crossing, and substrate disturbance in areas requiring removal of sand and gravel for maintenance will likely result in turbidity and sedimentation temporarily exceeding adverse effect thresholds throughout the project area (up to 80 m) and up to 100 m downstream with effects spanning the entire stream width. When vehicles use the crossing to traverse the stream, turbidity and sedimentation may temporarily increase. However, they are unlikely to exceed the adverse effect threshold. **Distance of Adverse Effects = 180 m** Long-term habitat loss or degradation: Within the footprint of the stream crossing, habitat will likely be lost due to substrate compaction or from covering spaces within gravel or under rocks with crossing material. The footprint of the crossing may be up to 5 m in length and span the entire stream width. Immediately downstream of the crossing, stream flow velocity may increase, and the increased stream flow velocity may result in scour, increasing the stream depth. However, the increases are unlikely to exceed adverse effect thresholds. Changes in hydrology may result in long-term depositional areas immediately upstream of the crossing and further downstream of the crossing, with the upstream depositional area extending up to 2 m in length and spanning the entire stream width and area further downstream extending up to 5 m in length and 4 m in width. **Distance of Adverse Effects = 12 m**

Action	Anticipated Effects to the Crayfishes
	Temporarily reduced connectivity: Although stream flow velocity and stream depth may increase immediately downstream of the crossing, conditions unlikely to exceed either adverse effect threshold. Though crayfish movement may be impeded across the stream width due to disturbance from instream activities, instream work is unlikely to exceed 30 days. Beneficial effects: Installation of a hardened stream crossing may reduce the amount of turbidity and sedimentation within and downstream of the crossing footprint when vehicles cross. When a hardened stream crossing is removed, habitat suitability within the footprint of crossing will likely improve as the availability of spaces within gravel or under rocks increases, and stream flow velocity may improve immediately downstream of the crossing. Stream depth may also improve immediately downstream of the crossing due to scoured areas filling with gravel containing interstitial spaces, and connectivity may improve if an existing hardened stream crossing that impedes crayfish movement is removed or replaced with a new crossing with improved aquatic organism passage. When hardened stream crossings are removed, the availability of spaces within gravel or under rocks immediately upstream of the crossing and further downstream may increase if depositional areas are displaced during flood events.
Stream channel or streambed restoration	Injury or mortality from crushing: Injury and mortality will likely occur within instream areas traversed by heavy equipment or in which substrate is disturbed, which will likely include the entire footprint of the stream channel reconfigurations. The area in which heavy equipment is used or substrate disturbed may be up to 300 m in length and span the entire width of the stream. **Distance of Adverse Effects = 300 m** Temporarily reduced habitat suitability: Heavy equipment use and other substrate disturbance will likely result in turbidity and sedimentation temporarily exceeding adverse effect thresholds throughout the length of the project area (up to 300 m) and up to 200 m downstream with effects spanning the entire stream width. **Distance of Adverse Effects = 500 m** Long-term habitat loss or degradation: Modifying contours of the stream channel or stream bed may increase stream flow velocity and stream depth in some areas while decreasing it other areas. However, there will likely be a net increase in the area containing suitable stream flow velocity and stream depth. If there is a reduction in the overall area containing suitable stream flow velocity and stream depth, it is unlikely to exceed 25 m^2. Temporarily reduced connectivity: The area in which stream flow velocity and stream depth may increase is unlikely to span more than 75% of the stream width. However, crayfish movement may be temporarily impeded due to disturbance if instream work extends across more than 75% of the stream channel and exceeds 30 days. **Distance of Adverse Effects (Temporary) = Indeterminable** Beneficial effects: Stabilizing the stream channel will likely result in an overall improvement of stream conditions, including reduced turbidity and sedimentation within and downstream of the project footprint and increased availability of interstitial spaces. The improvement in stream conditions may also improve connectivity if previously unsuitable conditions extended across most of the stream width.
Streambank stabilization	Injury or mortality from crushing: Injury and mortality will likely occur within instream areas traversed by heavy equipment or in which substrate is disturbed, which may include the entire streambank being stabilized and areas immediately upstream and downstream of the streambank being stabilized. The streambank may be up to 200 m in length and span the entire stream width in small streams. The areas immediately upstream and downstream of the culvert may each extend up to 10 m in length and span the entire stream width. **Distance of Adverse Effects = 220 m** Temporarily reduced habitat suitability: Heavy equipment use and other substrate disturbance will likely result in turbidity and sedimentation temporarily exceeding adverse effect thresholds throughout the project (220 m) area and up to 100 m downstream with effects spanning the entire stream width. **Distance of Adverse Effects = 320 m**

Action	Anticipated Effects to the Crayfishes
	Long-term habitat loss or degradation: Long-term habitat loss and degradation are unlikely since there will likely be an overall increase in the amount of suitable habitat by reducing sedimentation and increasing availability of spaces within gravel or under rocks. Because stabilizing the streambank will likely result in an overall reduction in turbidity and sedimentation within the footprint and downstream of the footprint, availability of spaces within gravel or under rocks will increase. Temporarily reduced connectivity: Instream work may extend across more than 75% of the stream channel but is unlikely to exceed 30 days. Beneficial effects: Stabilizing the streambank and reducing erosion will likely in an overall reduction in turbidity and sedimentation within and downstream of the project footprint, increased the availability of spaces within gravel or under rocks.
Construction or modification of instream structures for streambank stabilization	Injury or mortality from crushing: Injury and mortality will likely occur within instream areas traversed by heavy equipment or in which substrate is disturbed, which may include the footprint of the structures and areas immediately upstream and downstream of the structures. The area encompassing the structures may be up to 150 m in length and span half of the stream width, and the areas immediately upstream and downstream of the structures may each extend up to 10 m in length and span up to half of the stream width. **Distance of Adverse Effects = 170 m** Temporarily reduced habitat suitability: Heavy equipment use and other substrate disturbance will likely result in turbidity and sedimentation temporarily exceeding adverse effect thresholds throughout the project area (up to 170 m) and up to 200 m downstream with effects spanning the entire stream width. **Distance of Adverse Effects = 370 m** Long-term habitat loss or degradation: Modifying the hydrology along a streambank may result in increased stream flow velocity and stream depth in some areas while decreasing stream flow velocity and stream depth in other areas. However, any reduction in the overall size of areas containing suitable stream flow velocity and stream depth is unlikely to exceed 25 m^2. Because stabilizing the streambank will likely result in an overall reduction in turbidity and sedimentation within the footprint and downstream of the footprint, availability of spaces within gravel or under rocks will increase. Temporarily reduced connectivity: If instream work extends across more than 75% of the stream channel and exceeds 30 days, crayfish movement may be temporarily reduced due to the disturbance and exceed the adverse effect threshold. **Distance of Adverse Effects (Temporary) = Indeterminable** Beneficial effects: Stabilizing the streambank will likely result in an overall reduction in turbidity and sedimentation within the footprint and downstream of the footprint, increased the availability of spaces within gravel or under rocks.
Instream heavy metal remediation and reduction	Injury or mortality from crushing: Injury and mortality will likely occur within instream areas traversed by heavy equipment or in which substrate is disturbed, which may include the footprint of the excavations, areas immediately upstream and downstream of excavations, and areas used to access excavation locations. The area of each excavation may be up to 100 m in length and span the entire stream width, the areas immediately upstream and downstream of each excavation may each extend up to 10 m in length and span the entire stream width, and the area used to access each excavation location may be up to 10 m in length and span the entire stream width. **Distance of Adverse Effects = 130 m** Temporarily reduced habitat suitability: Heavy equipment use and other substrate disturbance will likely result in turbidity and sedimentation temporarily exceeding adverse effect thresholds throughout the project area (up to 130 m), extending up to 100 m downstream of excavation locations with effects spanning the entire stream width. **Distance of Adverse Effects = 230 m** Long-term habitat loss or degradation: There will be an overall improvement in stream conditions due to removal of contaminated sediment. Any increases in stream depth from excavation is unlikely to exceed either adverse effect threshold.

Action	Anticipated Effects to the Crayfishes
	Temporarily reduced connectivity: Crayfish movement may be temporarily impeded due to disturbance if instream work extends across more than 75% of the stream channel. However, instream work is unlikely to exceed 30 days. Beneficial effects: The removal of contaminated sediment will likely result in an overall improvement in crayfish health as well as abundance of their prey.
Construction and removal of instream work pads	Injury or mortality from crushing: Injury and mortality will likely occur within instream areas traversed by heavy equipment or in which substrate is disturbed, which may include the footprint of the work pad and areas immediately upstream and downstream of the work pad. The footprint of the work pad may be up to 15 m in length and span up to 75% of the stream width in larger streams or the entire stream width in smaller streams, and the areas immediately upstream and downstream of the work pad may each extend up to 10 m in length and span the entire stream width. **Distance of Adverse Effects = 35 m** Temporarily reduced habitat suitability: Heavy equipment use and substrate disturbance in and around the work pad will likely result in turbidity and sedimentation temporarily exceeding adverse effect thresholds throughout the project area (up to 35 m) and up to 100 m downstream with effects spanning the entire stream width. If culverts are installed within the work pad, stream flow velocity may increase beyond adverse effect thresholds within and immediately downstream of culverts, even when culverts of appropriate size are used. The increased stream flow velocity may result in scour, increasing stream depth immediately downstream of the culverts. The area with increased stream flow velocity may include the length of the culverts (up to 15 m in length) and up to 2 m downstream of culverts, extending across the width of each culvert (up to 1 m each), and the area with increased stream depth may include up to 2 m downstream of culverts, extending across the width of each culvert (up to 1 m each). If culverts are not installed, stream flow velocity may still increase beyond adverse effect thresholds due to the reduced width in which water can flow. The area in which steam flow velocity may be increased includes the length of the work pad (up to 15 m) and extending across the width of the flowing portion of the stream. Under either scenario, the area in which stream flow velocity and stream depth may exceed adverse effect thresholds is encompassed by the area affected by turbidity and sedimentation. If changes in hydrology result in temporary depositional areas, sediment deposition may also temporarily exceed the adverse effect threshold immediately upstream of the work pad and further downstream. Both areas will likely be within the area affected by turbidity and sedimentation from heavy equipment use and substrate disturbance. **Distance of Adverse Effects = 135 m** Long-term habitat loss or degradation: No long-term habitat loss or degradation is anticipated since there will be no long-term to hydrology. Temporarily reduced connectivity: Even when culverts of appropriate size are used, crayfish movement may be impeded due to the combined effects of instream disturbance, presence of work pad material that physically impedes movement, and increased stream flow velocity within the culverts and portion of the stream outside the work pad. If crayfish movement is impeded for more than 30 days, the adverse effect threshold for temporarily reduced connectivity will be exceeded. If culverts are not installed, the adverse effect threshold may still be exceeded if crayfish movement is impeded for more than 30 days due to the combined effects of instream disturbance, presence of work pad material that physically impedes movement, and increased stream flow velocity within the portion of the stream outside the work pad. **Distance of Adverse Effects = Indeterminable**
Construction, removal, and use of temporary stream crossings	Injury or mortality from crushing: Injury and mortality will likely occur within instream areas traversed by heavy equipment or in which substrate is disturbed, which may include the footprint of the stream crossing and areas immediately upstream and downstream of the crossing. The footprint of the crossing may be up to 10 m in length and span the entire stream width, and the areas immediately upstream and downstream of the crossing may each extend up to 10 m in length and span the entire stream width. **Total Stream distance = 30 m**

Action	Anticipated Effects to the Crayfishes
	Temporarily reduced habitat suitability: Heavy equipment use and substrate disturbance in and around the crossing will likely result in turbidity and sedimentation temporarily exceeding the adverse effect threshold throughout the project area (up to 30 m) and up to 100 m downstream with effects spanning the entire stream width. If culverts are installed within the crossing (as opposed to a crossing spanning the stream channel), stream flow velocity may increase beyond adverse effect thresholds within and immediately downstream of culverts, even when culverts of appropriate size are used. The increased stream flow velocity may result in scour, increasing stream depth immediately downstream of the culverts. The area with increased stream flow velocity may include the length of the culverts (up to 10 m in length) and up to 2 m downstream of culverts, extending across the width of each culvert (up to 1 m each), and the area with increased stream depth may include up to 2 m downstream of culverts, extending across the width of each culvert (up to 1 m each). The area in which stream flow velocity and stream depth may exceed adverse effect thresholds is encompassed by the area affected by turbidity and sedimentation. If changes in hydrology result in temporary depositional areas, sediment deposition may temporarily exceed the adverse effect threshold immediately upstream of the crossing and further downstream. Both areas will likely be within the area affected by turbidity and sedimentation from heavy equipment use and substrate disturbance. When existing fords are used as temporary crossings, sedimentation may occur downstream of the crossing. However, turbidity and sedimentation are not expected to exceed the adverse effect threshold. **Distance of Adverse Effects = 130 m** Long-term habitat loss or degradation: No long-term habitat loss or degradation is anticipated since there will be no long-term to hydrology. Temporarily reduced connectivity: Even when culverts of appropriate size are used, crayfish movement may be impeded due to the combined effects of instream disturbance, presence of work pad material that physically impedes movement, and increased stream flow velocity within the culverts and portion of the stream outside the work pad. If crayfish movement is impeded for more than 30 days, the adverse effect threshold will be exceeded. If the crossing consists of a bridge spanning the entire stream channel, no effects are anticipated. **Distance of Adverse Effects = Indeterminable**
Installation and removal of coffer dams and dewatering	Injury or mortality from crushing: Injury and mortality will likely occur within instream areas traversed by heavy equipment or in which substrate is disturbed, which may include the footprint of the coffer dam and areas immediately adjacent to the coffer dam. Though heavy equipment may not be used within the entire footprint of the coffer dam, any crayfish located within the dam will likely also be injured or killed if they emerge. The footprint of the coffer dam may be up to 15 m in length and span up to half of the stream width and the areas adjacent to the coffer dam may each extend up to 10 m in length and span the entire stream width. **Distance of Adverse Effects = 35 m** Temporarily reduced habitat suitability: Heavy equipment use and substrate disturbance in and around the coffer dam will likely result in turbidity and sedimentation temporarily exceeding adverse effect thresholds throughout the project area (up to 25 m) and up to 100 m downstream with effects spanning the entire stream width. Stream flow velocity may increase beyond adverse effect thresholds due to the reduced width in which water can flow. The area in which steam flow velocity may be increased includes the length of the coffer dam (up to 15 m), extending across the flowing portion of the stream and is encompassed by the area affected by turbidity and sedimentation. If changes in hydrology result in temporary depositional areas, sediment deposition may temporarily exceed the adverse effect threshold immediately upstream of the coffer dam and further downstream. Both areas will likely be within the area affected by turbidity and sedimentation from heavy equipment use and substrate disturbance. **Distance of Adverse Effects = 135 m** Long-term habitat loss or degradation: No long-term habitat loss or degradation is anticipated since there will be no long-term to hydrology. Temporarily reduced connectivity: Crayfish movement may be impeded due to the combined effects of instream disturbance, presence of work the coffer dam that physically impedes movement, and increased stream flow velocity within the portion of the stream outside the coffer dam. If crayfish movement is impeded for more than 30 days, the adverse effect threshold will be exceeded. **Distance of Adverse Effects = Indeterminable**

Action	Anticipated Effects to the Crayfishes
Geotechnical investigations (borings)	Injury or mortality from crushing: Injury and mortality will likely occur within instream areas traversed by heavy equipment or in which substrate is disturbed, which may include the footprint of the borings, areas immediately upstream and downstream of the borings, and the path taken to access boring locations. The footprint of the borings themselves may be up to 2 m in length and 2 m in width, the areas immediately upstream and downstream of the borings may each be 7 m in length and 7 m in width, and the path taken to access the borings may be 5 m in length and span most of the stream width. **Distance of Adverse Effects = 16 m** Temporarily reduced habitat suitability: Heavy equipment use and other substrate disturbance may result in turbidity and sedimentation temporarily exceeding adverse effect thresholds throughout the project area (up to 16 m) and up to 20 m downstream with effects spanning the entire stream width. **Distance of Adverse Effects = 36 m** Long-term habitat loss or degradation: No long-term habitat loss or degradation is anticipated since there will be no long-term to hydrology. Temporarily reduced connectivity: No impact to connectivity is expected since instream activities are unlikely to extend across more than 75% of the stream channel or exceed 30 days.
Streambank grading	Injury or mortality: No injury or mortality is expected since heavy equipment will not be used within the stream channel. Temporarily reduced habitat suitability: Though heavy equipment will likely not be used within the stream channel, soil may be released into the stream and result in turbidity and sedimentation temporarily exceeding adverse effect thresholds throughout the project area (up to 50 m) and up to 50 m downstream with effects spanning the entire stream width. **Distance of Adverse Effects = 100 m** Long-term habitat loss or degradation: No long-term habitat loss or degradation is anticipated since there will be no long-term to hydrology. Temporarily reduced connectivity: No impact to connectivity is expected since there will be no instream activities, and turbidity and sedimentation are unlikely to extend across more than 75% of the stream channel or exceed 30 days. Beneficial effects: When the purpose of the grading is to reduce erosion, there will likely be an overall reduction in sedimentation, which will increase habitat suitability in previous depositional areas.
Vegetation or tree removal required for other actions	Injury or mortality: No injury or mortality is expected since heavy equipment will not be used within the stream channel. Temporarily reduced habitat suitability: If vegetation removal is extensive, or if heavy rains occur before the streambank is revegetated, turbidity and sedimentation may temporarily exceed adverse effect thresholds throughout the project area (up to 30 m) and up to 50 m downstream with effects spanning the entire stream width. In addition, if tree canopy over the stream is reduced, water temperature may increase and exceed the adverse effect threshold until new trees are tall enough to provide canopy cover. The impacted area may be up to 20 m in length and span the entire stream width. Actions are outside the scope of the SCF if they will increase water temperature beyond the adverse effect threshold for temporarily reduced connectivity, either continuously for more than a year or intermittently for more than 10 years. **Distance of Adverse Effects = 80 m** Long-term habitat loss or degradation: If tree canopy over the stream is reduced and it takes more than 10 years for trees are to grow tall enough to provide canopy cover, water temperature may increase and exceed the adverse effect threshold. The impacted area may be up to 20 m in length and span the entire stream width. Note that actions are outside the scope of the SCF if they will increase water temperature beyond the adverse effect

Action	Anticipated Effects to the Crayfishes
	threshold for temporarily reduced connectivity, either continuously for more than a year or intermittently for more than 10 years. **Distance of Adverse Effects = 20 m** Temporarily reduced connectivity: If tree canopy over the stream is reduced, water temperature may increase and exceed the adverse effect threshold in up to 20 m in length and span the entire stream width. Actions are outside the scope of the SCF if they will increase water temperature beyond the adverse effect threshold for temporarily reduced connectivity, either continuously for more than a year or intermittently for more than 10 years. **Distance of Adverse Effects = Indeterminable**
Other terrestrial actions	Adverse effects not anticipated if turbidity and temperature do not exceed adverse effect thresholds and if stream conditions are not otherwise impacted.
Activities not explicitly described	Injury or mortality from crushing: If heavy equipment is used within the stream channel, injury and mortality will likely occur within instream areas traversed by the equipment or in which substrate is disturbed. The area in which injury or mortality may occur may include up to 150 m in length and span the entire stream width. **Distance of Adverse Effects = 150 m** Temporarily reduced habitat suitability: If heavy equipment is used within the stream channel or the substrate is disturbed from other activities, turbidity and sedimentation temporarily may temporarily exceed adverse effect thresholds throughout the project area and downstream with effects spanning the entire stream width. **Distance of Adverse Effects = 250 m** Long-term habitat loss or degradation: If a structure is constructed or placed within the stream channel, habitat within the footprint of the structure may be lost as long as the structure is in place. In addition, changes in hydrology may result in long-term depositional areas immediately upstream of the structure and further downstream of the structure. **Distance of Adverse Effects = 10 m** Temporarily reduced connectivity: If instream work extends across more than 75% of the stream width and exceeds 30 days, connectivity may be temporarily reduced due to the disturbance and exceed the adverse effect threshold. **Distance of Adverse Effects = Indeterminable** Beneficial effects: There may be an overall improvement in habitat suitability within and downstream of the project footprint.

Table 4. Anticipated effects to each critical habitat PBF from actions included in the SCF given the adverse effect thresholds outlined in Table 2. The maximum longitudinal stream distance in which adverse effects may occur are in bold. Because adverse effect thresholds for stream embeddedness and prey base are the same, effects to these PBFs are not discussed separately. Temporary increases in stream flow velocity immediately downstream of heavy equipment are not anticipated to exceed adverse effect thresholds beyond 24 hours and thus, are not discussed.

Action	Anticipated Effects to Critical Habitat
Bridge construction	Stream flow velocity: Bridges that span the entire stream channel are unlikely to affect stream flow velocity since stream hydrology is unlikely to change. For larger streams in which bridge supports are used to support the bridge, stream flow velocity immediately downstream of bridge supports will likely increase, However, size of the area impacted is unlikely to encompass more than 50% of a set of stream features or extend across more than 75% of the stream width. Stream depth: For bridges with bridge supports, increased stream flow velocity immediately below bridge supports will likely result in scour, increasing stream depth. However, size of the area impacted is unlikely to encompass more than 50% of a set of stream features or extend across more than 75% of the stream width. Water temperature: No effects anticipated. Stream embeddedness/Prey base: Heavy equipment use and substrate disturbance from installation of bridge supports will likely result in sedimentation temporarily exceeding the adverse effect threshold throughout the project area (up to 65 m) and up to 200 m downstream with effects spanning the entire stream width. After multiple flood events, changes in hydrology may result in long-term depositional areas immediately upstream of bridge supports and further downstream of the bridge. However, size of the depositional areas is unlikely to encompass more than 50% of a set of stream features. **Distance of Adverse Effects = 265 m (Temporary)** Connectivity: The area in which stream flow velocity and stream depth may increase is unlikely to span more than 75% of the stream width. However, crayfish movement may be temporarily impeded due to disturbance if instream work extends across more than 75% of the stream channel and exceeds 30 days, thereby exceeding the adverse effect threshold. **Distance of Adverse Effects = Indeterminable (Temporary)**
Bridge maintenance	Stream flow velocity: Because no new structures will be installed or constructed within the stream channel, stream flow velocity will not increase within any areas. Thus, no effects are anticipated. Stream depth: Because no new structures will be installed or constructed within the stream channel, stream depth will not increase within any areas due to scouring from increased stream flow velocity. Thus, no effects are anticipated. Water temperature: No effects anticipated. Stream embeddedness/Prey base: If heavy equipment is not used within the stream channel, the size of areas experiencing sedimentation from substrate disturbance in and around bridge supports is unlikely to encompass more than 50% of a set of stream features. However, if heavy equipment is used within the stream channel, sedimentation downstream of substrate disturbance is expected to temporarily exceed the adverse effect threshold throughout the project area (up to 45 m) and up to 100 m downstream, with effects spanning the entire stream width. Because no new structures will be installed within the stream channel, stream hydrology will not be affected and no new depositional areas will form. **Distance of Adverse Effects = 145 m (Temporary)** Connectivity: Crayfish movement may be temporarily impeded across the stream width due to disturbance. However, instream work is unlikely to exceed 30 days.

Action	Anticipated Effects to Critical Habitat
Bridge removal	Stream flow velocity: Because no new structures will be installed or constructed within the stream channel, stream flow velocity will not increase within any areas. Effects may be beneficial if removal of bridge supports improves stream flow velocity immediately downstream. Stream depth: Because no new structures will be installed or constructed within the stream channel, stream depth will not increase within any areas due to scouring from increased stream flow velocity. Effects may be beneficial if removal of bridge supports improves stream depth immediately downstream due to scoured areas filling with gravel containing interstitial spaces. Water temperature: No effects anticipated. Stream embeddedness/Prey base: Heavy equipment use and removal of bridge supports and bridge debris will likely result in sedimentation temporarily exceeding the adverse effect threshold for occupancy and reproduction throughout the project area (up to 65 m) and up to 200 m downstream with effects spanning the entire stream width. However, long-term effects may be beneficial if flood events displace depositional areas immediately upstream of bridge supports and further downstream, increasing availability of spaces within gravel or under rocks and thus, improving stream embeddedness and the prey base. **Distance of Adverse Effects (Temporary) = 265 m (Temporary)** Connectivity: Crayfish movement may be impeded across the stream width due to disturbance. However, instream work is unlikely to exceed 30 days and thus, not exceed the adverse effect threshold. Long-term effects may be beneficial if aquatic organism passage improves due to removal of the bridge.
Culvert installation, maintenance, replacement, and removal	Stream flow velocity: Within culverts and the areas immediately downstream, stream flow velocity may increase, but size of the area impacted is unlikely to encompass more than 50% of a set of stream features or extend across more than 75% of the stream width. Effects may be beneficial if removal of culverts or replacement of undersized culverts with those of adequate size improves stream flow velocity immediately downstream. Stream depth: Within areas immediately downstream of culverts, increased stream flow velocity may result in scour, increasing stream depth. However, size of the area impacted is unlikely to encompass more than 50% of a set of stream features or extend across more than 75% of the stream width. Long-term effects may be beneficial if removal of culverts or replacement of undersized culverts with those of adequate size improves stream depth immediately downstream due to scoured areas filling with gravel containing interstitial spaces. Water temperature: No effects anticipated. Stream embeddedness/Prey base: Heavy equipment use, substrate disturbance in and around culverts, and substrate disturbance in areas requiring removal of sand and gravel for maintenance will likely result in sedimentation temporarily exceeding the adverse effect threshold throughout the project area (up to 80 m) and up to 100 m downstream with effects spanning the entire stream width. Unless an open bottom culvert is used, installation of new or larger culverts will also reduce spaces within gravel or under rocks within the footprint of culverts long-term, thereby reducing stream embeddedness and the prey base. In addition, after multiple flood events, changes in hydrology may result in long-term depositional areas immediately upstream of culverts and further downstream. However, the combined size of the area encompassed by culverts and depositional areas is unlikely to exceed 50% of a set of stream features. Long-term effects may be beneficial if removal of culverts or replacement of undersized culverts with those of adequate size results in displacement of depositional areas immediately upstream of culverts and further downstream, increasing availability of spaces within gravel or under rocks and thus, improving stream embeddedness and the prey base. **Distance of Adverse Effects = 180 m (Temporary)** Connectivity: The area in which stream flow velocity and stream depth may increase is unlikely to span more than 75% of the stream width. Though crayfish movement may be impeded across the stream width due to disturbance, instream work is unlikely to exceed 30 days. Long-term effects may be beneficial if aquatic organism passage improves due to culvert removal or replacement of undersized culverts with those of adequate size.

Action	Anticipated Effects to Critical Habitat
Pipeline construction, repair, replacement, and removal	Stream flow velocity: Because all new pipelines will be buried under the substrate, stream flow velocity will not increase within any areas. Effects may be beneficial if removal or replacement of an exposed pipeline improves stream flow velocity immediately downstream. Stream depth: Because all new pipelines will be buried under the substrate, stream flow velocity will not increase within any areas. Effects may be beneficial if removal or replacement of an exposed pipeline improves stream depth immediately downstream due to scoured areas filling with gravel containing interstitial spaces. Water temperature: No effects anticipated. Stream embeddedness/Prey base: Unless horizontal directional drilling is used, heavy equipment use and substrate disturbance will likely result in sedimentation temporarily exceeding the adverse effect threshold throughout the project area (up to 10 m) and up to 100 m downstream with effects spanning the entire stream width. Long-term effects may be beneficial if removal or replacement of an exposed pipeline results in displacement of depositional areas immediately upstream of the pipeline and further downstream, increasing availability of spaces within gravel or under rocks and thus, improving stream embeddedness and the prey base. **Distance of Adverse Effects = 110 m (Temporary)** Connectivity: Though instream activities may span the entire stream width, they are unlikely to exceed 30 days. Removal or replacement of an exposed pipeline may be beneficial if the exposed pipeline created a physical barrier to crayfish movement or if high stream flow velocity along the downstream side of the exposed pipeline impeded crayfish movement.
Construction, maintenance, replacement, and removal of river accesses	Stream flow velocity: Stream flow velocity may increase immediately downstream of new access ramps, but size of the area impacted is unlikely to encompass more than 50% of a set of stream features or extend across more than 75% of the stream width. Effects may be beneficial if removal or replacement of an existing access ramp improves stream flow velocity immediately downstream. Stream depth: Suitability of stream depth may decrease immediately downstream of new access ramps due to scour from increased stream flow velocity, but size of the area impacted is unlikely to encompass more than 50% of a set of stream features or extend across more than 75% of the stream width. Effects may be beneficial if removal or replacement of an existing ramp improves stream depth immediately downstream due to the scoured area filling with gravel containing interstitial spaces. Water temperature: No effects anticipated. Stream embeddedness/Prey base: If heavy equipment is not used within the stream channel, the size of areas experiencing sedimentation from substrate disturbance in and around the access ramp is unlikely to encompass more than 50% of a set of stream features. However, if heavy equipment is used within the stream channel, sedimentation downstream of substrate disturbance is expected to temporarily exceed the adverse effect threshold throughout the project area (up to 10 m) and up to 100 m downstream, with effects spanning the entire stream width. Installation of a new or larger access ramp will also reduce spaces within gravel or under rocks within the footprint of the ramp long-term, thereby reducing stream embeddedness and the prey base. After multiple flood events, changes in hydrology may result in long-term depositional areas immediately upstream of the ramp and further downstream. However, the combined size of the area encompassed by the access ramp and depositional areas is unlikely to exceed 50% of a set of stream features (initial sedimentation will no longer be present after multiple flood events). **Distance of Adverse Effects = 110 m (Temporary)** Connectivity: The area in which stream flow velocity and stream depth may increase is unlikely to span more than 75% of the stream width.

Action	Anticipated Effects to Critical Habitat
Construction, maintenance, use, and removal of hardened stream crossings	Stream flow velocity: Immediately downstream of the crossing, stream flow velocity may increase, but the velocity is unlikely to exceed either adverse effect threshold. Long-term effects may be beneficial if removal or replacement of a hardened stream crossing improves stream flow velocity immediately downstream. Stream depth: Within the area immediately downstream of the crossing, increased stream flow velocity may result in scour, increasing stream depth. However, stream depth is not anticipated to exceed either adverse effect threshold. Long-term effects may be beneficial if removal or replacement of a hardened stream crossing improves stream depth immediately downstream due to scoured areas filling with gravel containing interstitial spaces. Water temperature: No effects anticipated. Stream embeddedness/Prey base: Heavy equipment use, substrate disturbance in and around the crossing, and substrate disturbance in areas requiring removal of sand and gravel for maintenance will likely result in sedimentation temporarily exceeding the adverse effect threshold throughout the project area (up to 80 m) and up to 100 m downstream with effects spanning the entire stream width. Installation of a new hardened stream crossing will likely also reduce spaces within gravel or under rocks within the footprint of crossing long-term, thereby reducing stream embeddedness and the prey base. After multiple flood events, changes in hydrology may result in long-term depositional areas immediately upstream of the crossing and further downstream. However, the combined size of the area encompassed by the crossing and depositional areas is unlikely to exceed 50% of a set of stream features (initial sedimentation will no longer be present after multiple flood events). When vehicles use the crossing to traverse the stream, turbidity and sedimentation may temporarily increase. However, they are unlikely to exceed the adverse effect threshold. Long-term effects may be beneficial if removal or replacement of a hardened stream crossing results in displacement of depositional areas immediately upstream of the crossing and further downstream, increasing availability of spaces within gravel or under rocks and thus, improving stream embeddedness and the prey base. **Distance of Adverse Effects = 180 m (Temporary)** Connectivity: Stream flow velocity and stream depth may increase immediately downstream of the crossing. However, conditions are not anticipated to exceed either adverse effect threshold. Crayfish movement may be impeded across the stream width due to disturbance from instream activities, but instream work is unlikely to exceed 30 days. Long-term effects may be beneficial if an existing hardened stream crossing that impedes crayfish movement is removed or replaced with a new crossing with improved aquatic organism passage.
Stream channel or streambed restoration	Stream flow velocity: Modifying contours of the stream channel or stream bed may increase stream flow velocity in some areas while decreasing it other areas. However, long-term effects of stabilizing the stream channel will likely be beneficial and result in an overall improvement in stream conditions for the crayfishes, including stream flow velocity. If there is a reduction in the overall area containing suitable stream flow velocity, unsuitable areas are unlikely to encompass more than 50% of a set of stream features or extend across more than 75% of the stream width. Stream depth: Modifying contours of the stream channel or stream bed may increase stream depth in some areas while decreasing it other areas. However, effects of stabilizing the stream channel will likely be beneficial and result in an overall improvement in stream conditions for the crayfishes, including stream depth in scoured areas. If there is a reduction in the overall area containing suitable stream depth, unsuitable areas are unlikely to encompass more than 50% of a set of stream features or extend across more than 75% of the stream width. Water temperature: No effects anticipated. Stream embeddedness/Prey base: Heavy equipment use and substrate disturbance will likely result in sedimentation temporarily exceeding the adverse effect threshold throughout the project area (up to 300 m) and up to 200 m downstream with effects spanning the entire stream width. However, long-term effects will likely be beneficial since stabilizing the stream channel will likely result in an overall reduction in sedimentation within and downstream of the

Action	Anticipated Effects to Critical Habitat
	project footprint, increasing availability of spaces within gravel or under rocks and thus, improving stream embeddedness and the prey base. **Distance of Adverse Effects (Temporary) = 500 m (Temporary)** Connectivity: The area in which stream flow velocity and stream depth may increase is unlikely to span more than 75% of the stream width. However, crayfish movement may be temporarily impeded due to disturbance if instream work extends across more than 75% of the stream width and exceeds 30 days. Long-term effects will likely be beneficial if connectivity improves due to improvement of stream conditions. **Distance of Adverse Effects (Temporary) = Indeterminable (Temporary)**
Streambank stabilization	Stream flow velocity: No effects anticipated. Stream depth: No effects anticipated. Water temperature: No effects anticipated. Stream embeddedness/Prey base: Heavy equipment use and substrate disturbance will likely result in sedimentation temporarily exceeding the adverse effect threshold throughout the project area (up to 220 m) and up to 100 m downstream with effects spanning the entire stream width. However, long-term effects will likely be beneficial since stabilizing the streambank will likely result in an overall reduction in sedimentation within and downstream of the project footprint, increasing availability of spaces within gravel or under rocks and thus, improving stream embeddedness and the prey base. **Distance of Adverse Effects (Temporary) = 320 m (Temporary)** Connectivity: Instream work may extend across more than 75% of the stream channel but is unlikely to exceed 30 days.
Construction or modification of instream structures for streambank stabilization	Stream flow velocity: Modifying the hydrology along a streambank may result in increased stream flow velocity in some areas while decreasing stream flow velocity in other areas. However, any reduction in the overall size of areas containing suitable stream flow velocity is not anticipated to encompass more than 50% of a set of stream features or extend across more than 75% of the stream width. Stream depth: Modifying the hydrology along a streambank may increase stream depth in some areas while decreasing it other areas. However, any reduction in the overall size of areas containing suitable stream depth is not anticipated to encompass more than 50% of a set of stream features or extend across more than 75% of the stream width. Water temperature: No effects anticipated. Stream embeddedness/Prey base: Heavy equipment use and substrate disturbance will likely result in sedimentation temporarily exceeding the adverse effect threshold throughout the project area (up to 170 m) and up to 200 m downstream with effects spanning the entire stream width. However, long-term effects will likely be beneficial since stabilizing the streambank will likely result in an overall reduction in sedimentation within and downstream of the project footprint, increasing availability of spaces within gravel or under rocks and thus, improving stream embeddedness and the prey base. **Distance of Adverse Effects (Temporary) = 370 m (Temporary)** Connectivity: If instream work extends across more than 75% of the stream width and exceeds 30 days, crayfish movement may be temporarily reduced due to the disturbance and exceed the adverse effect threshold. **Distance of Adverse Effects = Indeterminable (Temporary)**

Action	Anticipated Effects to Critical Habitat
Instream heavy metal remediation and reduction	Stream flow velocity: No effects anticipated. Stream depth: Excavating portions of the streambed will likely increase stream depth in excavated areas. However, increased stream depth is unlikely to exceed either adverse effect threshold. Water temperature: No effects anticipated. Stream embeddedness/Prey base: Heavy equipment use and substrate disturbance will likely result in sedimentation temporarily exceeding the adverse effect threshold throughout each project area (up to 130 m) and up to 100 m downstream with effects spanning the entire stream width. **Distance of Adverse Effects (Temporary) = 230 m (Temporary)** Connectivity: Crayfish movement may be temporarily impeded due to disturbance if instream work extends across more than 75% of the stream width. However, instream work is unlikely to exceed 30 days.
Construction and removal of instream work pads	Stream flow velocity: If culverts are installed within the work pad, stream flow velocity may increase immediately downstream of and within culverts, even when culverts of appropriate size are used. However, size of the area impacted is unlikely to encompass more than 50% of a set of stream features or extend across more than 75% of the stream width. If culverts are not installed, stream flow velocity will likely also increase due to the reduced width in which water can flow. However, size of the area impacted is unlikely to encompass more than 50% of a set of stream features or extend across more than 75% of the stream width, and stream flow velocity will return to baseline after removal of the work pad. Stream depth: Within areas immediately downstream of culverts, increased stream flow velocity may result in scour, increasing stream depth. However, size of the area impacted is unlikely to encompass more than 50% of a set of stream features or extend across more than 75% of the stream width, and stream depth will return to baseline after removal of the work pad. Water temperature: No effects anticipated. Stream embeddedness/Prey base: Heavy equipment use and substrate disturbance in and around the work pad will likely result in sedimentation temporarily exceeding the adverse effect threshold throughout the project area (up to 35 m) and up to 100 m downstream, with effects spanning the entire stream width. If changes in hydrology result in temporary depositional areas, sediment deposition may temporarily exceed the adverse effect threshold immediately upstream of the work pad and further downstream. Both areas will likely be within the area affected by sedimentation from heavy equipment use and substrate disturbance. **Distance of Adverse Effects = 135 m (Temporary)** Connectivity: Even when culverts of appropriate size are used, crayfish movement may be impeded due to the combined effects of instream disturbance, presence of work pad material that physically impedes movement, and increased stream flow velocity within the culverts and portion of the stream outside the work pad. If crayfish movement is impeded for more than 30 days, the adverse effect threshold will be exceeded. If culverts are not installed, the adverse effect threshold may still be exceeded if crayfish movement is impeded for more than 30 days due to the combined effects of instream disturbance, presence of work pad material that physically impedes movement, and increased stream flow velocity within the portion of the stream outside the work pad. **Distance of Adverse Effects = Indeterminable (Temporary)**
Construction, removal, and use of	Stream flow velocity: If the crossing consists of a bridge spanning the entire stream channel, no effects are anticipated. If culverts are installed within the stream crossing, stream flow velocity may increase immediately downstream of and within culverts even when culverts of appropriate size are used.

Action	Anticipated Effects to Critical Habitat
temporary stream crossings	However, size of the area impacted is unlikely to encompass more than 50% of a set of stream features or extend across more than 75% of the stream width, and stream flow velocity will return to baseline after removal of the crossing. Stream depth: If culverts are installed within the stream crossing, increased stream flow velocity immediately downstream of culverts may result in scour, increasing stream depth. However, size of the area impacted is unlikely to encompass more than 50% of a set of stream features or extend across more than 75% of the stream width, and stream depth will return to baseline after removal of the crossing Water temperature: No effects anticipated. Stream embeddedness/Prey base: Heavy equipment use and substrate disturbance in and around the crossing will likely result in sedimentation temporarily exceeding adverse effect thresholds throughout the project area (up to 30 m) and up to 100 m downstream with effects spanning the entire stream width. If changes in hydrology result in temporary depositional areas, sediment deposition may temporarily exceed the adverse effect threshold immediately upstream of the crossing and further downstream. Both areas will likely be within the area affected by sedimentation from heavy equipment use and substrate disturbance. When existing fords are used as temporary crossings, sedimentation may occur downstream of the crossing. However, sedimentation is not expected to exceed the adverse effect threshold. **Distance of Adverse Effects = 135 m (Temporary)** Connectivity: Even when culverts of appropriate size are used, crayfish movement may be impeded due to the combined effects of instream disturbance, presence of crossing material that physically impedes movement, and increased stream flow velocity within the culverts. If crayfish movement is impeded for more than 30 days, the adverse effect threshold will be exceeded. If the crossing consists of a bridge spanning the entire stream channel, no effects are anticipated. **Distance of Adverse Effects = Indeterminable (Temporary)**
Installation and removal of coffer dams and dewatering	Stream flow velocity: Stream flow velocity will likely increase due to the reduced width in which water can flow. However, size of the area impacted is unlikely to encompass more than 50% of a set of stream features or extend across more than 75% of the stream width, and stream flow velocity will return to baseline after removal of the work pad. Stream depth: No effects anticipated. Water temperature: No effects anticipated. Stream embeddedness/Prey base: Heavy equipment use and substrate disturbance in and around the coffer dam will likely result in sedimentation temporarily exceeding adverse effect thresholds throughout the project area (up to 25 m) and up to 100 m downstream with effects spanning the entire stream width. If changes in hydrology result in temporary depositional areas, sediment deposition may temporarily exceed the adverse effect threshold immediately upstream of the coffer dam and further downstream. Both areas will likely be within the area affected by sedimentation from heavy equipment use and substrate disturbance. **Distance of Adverse Effects = 135 m (Temporary)** Connectivity: Crayfish movement may be impeded due to the combined effects of instream disturbance, presence of work the coffer dam that physically impedes movement, and increased stream flow velocity within the portion of the stream outside the coffer dam. If crayfish movement is impeded for more than 30 days, the adverse effect threshold will be exceeded. **Distance of Adverse Effects = Indeterminable (Temporary)**
Geotechnical investigations (borings)	Stream flow velocity: No effects anticipated. Stream depth: No effects anticipated.

Action	Anticipated Effects to Critical Habitat
	Water temperature: No effects anticipated. Stream embeddedness/Prey base: Heavy equipment use and other substrate disturbance may result in sedimentation temporarily exceeding adverse effect thresholds throughout the project area (up to 16 m) and up to 20 m downstream with effects spanning the entire stream width. **Distance of Adverse Effects = 36 m (Temporary)** Connectivity: No effects anticipated.
Streambank grading	Stream flow velocity: No effects anticipated. Stream depth: No effects anticipated. Water temperature: No effects anticipated. Stream embeddedness/Prey base: Though heavy equipment will likely not be used within the stream channel, soil may be released into the stream and result in turbidity and sedimentation temporarily exceeding adverse effect thresholds throughout the work area (up to 50 m) and up to 50 m downstream, with effects spanning the entire stream width. When the purpose of the grading is to reduce erosion, there will likely be an overall reduction in sedimentation, which will increase habitat suitability in previous depositional areas. **Distance of Adverse Effects = 100 m (Temporary)** Connectivity: No effect to connectivity is expected since there will be no instream activities, and turbidity and sedimentation are unlikely to extend across more than 75% of the stream width or exceed 30 days.
Vegetation or tree removal required for other actions	Stream flow velocity: No effects anticipated. Stream depth: No effects anticipated. Water temperature: If tree canopy over the stream is reduced, water temperature may increase and exceed adverse effect thresholds for both critical habitat functions until new trees are tall enough to provide canopy cover. The impacted area may be up to 20 m in length and span the entire stream width either temporarily or long-term, depending on the length of time for trees to grow tall enough to provide canopy cover. Note that actions are outside the scope of the SCF if they will increase water temperature beyond the adverse effect threshold for temporarily reduced connectivity, either continuously for more than a year or intermittently for more than 10 years. **Distance of Adverse Effects = 20 m (Long-term)** Stream embeddedness/Prey base: If vegetation removal is extensive, or if heavy rains occur before the streambank is revegetated, sedimentation may temporarily exceed adverse effect thresholds throughout the work area (up to 30 m) and up to 50 m downstream, with effects spanning the entire stream width. **Distance of Adverse Effects = 80 m (Temporary)** Connectivity: If tree canopy over the stream is reduced, water temperature may increase and exceed the adverse effect threshold during summer months in up to 20 m and span the entire stream width. Actions are outside the scope of the SCF if they will increase water temperature beyond the adverse effect threshold for temporarily reduced connectivity, either continuously for more than a year or intermittently for more than 10 years. **Distance of Adverse Effects = Indeterminable (Temporary)**

Action	Anticipated Effects to Critical Habitat
Other terrestrial actions	Stream flow velocity: No adverse effects anticipated. Stream depth: No adverse effects anticipated. Water temperature: No adverse effects anticipated, provided effects to temperature do not exceed the adverse effect threshold. Stream embeddedness/Prey base: No adverse effects anticipated if turbidity and temperature do not exceed adverse effect thresholds and if stream conditions are not otherwise impacted Connectivity: No adverse effects anticipated.
Activities not explicitly described	Stream flow velocity: No adverse effects anticipated. Stream depth: No adverse effects anticipated. Water temperature: If tree canopy over the stream is reduced, water temperature may increase and exceed adverse effect threshold for both critical habitat functions until new trees are tall enough to provide canopy cover. The impacted area may be up to 10 m in length and span the entire stream width either temporarily or long-term, depending on the length of time for trees to grow tall enough to provide canopy cover. Actions are outside the scope of the SCF if they will increase water temperature beyond the adverse effect threshold for temporarily reduced connectivity, either continuously for more than a year or intermittently for more than 10 years. **Distance of Adverse Effects = 10 m (Long-term)** Stream embeddedness/Prey base: If heavy equipment is used within the stream channel or the substrate is disturbed from other activities, turbidity and sedimentation temporarily may temporarily exceed the adverse effect threshold throughout the project area and downstream with effects spanning the entire stream width. If a structure is constructed or placed within the stream channel, habitat within the footprint of the structure may be lost as long as the structure is in place. In addition, changes in hydrology may result in long-term depositional areas immediately upstream of the structure and further downstream of the structure. However, the combined size of the area encompassed by the structure and depositional areas is unlikely to exceed 50% of a set of stream features. **Distance of Adverse Effects = 250 m (Temporary)** Connectivity: If instream work extends across more than 75% of the stream width and exceeds 30 days, connectivity may be temporarily reduced due to the disturbance and exceed the adverse effect threshold. **Distance of Adverse Effects = Indeterminable (Temporary)**

Table 5. The maximum extent of anticipated adverse effects to the Big Creek Crayfish and St. Francis River Crayfish from actions included in the SCF. The duration of action refers to the duration of activities, and the frequency of the action refers to the number of times an action may occur within a 10-year period. Longitudinal stream distance in which adverse effects may occur is calculated in Table 3.

Action	Type of Adverse Effect	Maximum Stream Distance Adversely Affected by Individual Projects (m)	Duration of Action (months)	Frequency of Action (occurrences in 10-year period)	Maximum Total Stream Distance Adversely Affected (m)
Bridge construction	Injury or mortality	65	3	5	325
Bridge construction	Temporarily reduced habitat suitability	265	3	5	1325
Bridge construction	Long-term habitat loss or degradation	14	3	5	70
Bridge construction	Temporarily reduced connectivity	Indeterminable	3	5	Indeterminable
Bridge maintenance	Injury or mortality	145	4	10	1,450
Bridge maintenance	Temporarily reduced habitat suitability	195	4	10	1,950
Bridge removal	Injury or mortality	65	3	5	325
Bridge removal	Temporarily reduced habitat suitability	265	3	5	1,325
Culvert installation, maintenance, replacement, and removal	Injury or mortality	80	1	8	640
Culvert installation, maintenance, replacement, and removal	Temporarily reduced habitat suitability	180	1	8	1,440
Culvert installation, maintenance, replacement, and removal	Long-term habitat loss or degradation	17	1	8	136
Pipeline construction, repair, replacement, and removal	Injury or mortality	10	1	5	50
Pipeline construction, repair, replacement, and removal	Temporarily reduced habitat suitability	110	1	5	550
Construction, maintenance, replacement, and removal of river accesses	Injury or mortality	10	1	6	60
Construction, maintenance, replacement, and removal of river accesses	Temporarily reduced habitat suitability	110	1	6	660
Construction, maintenance, replacement, and removal of river accesses	Long-term habitat loss or degradation	8	1	6	48
Construction, maintenance, use, and removal of hardened stream crossings	Injury or mortality	80	1	4	320
Construction, maintenance, use, and removal of hardened stream crossings	Temporarily reduced habitat suitability	180	1	4	720

Action	Type of Adverse Effect	Maximum Stream Distance Adversely Affected by Individual Projects (m)	Duration of Action (months)	Frequency of Action (occurrences in 10-year period)	Maximum Total Stream Distance Adversely Affected (m)
Construction, maintenance, use, and removal of hardened stream crossings	Long-term habitat loss or degradation	12	1	4	48
Stream channel or streambed restoration	Injury or mortality	300	4	3	900
Stream channel or streambed restoration	Temporarily reduced habitat suitability	500	4	3	1,500
Stream channel or streambed restoration	Temporarily reduced connectivity	Indeterminable	4	3	Indeterminable
Streambank stabilization	Injury or mortality	220	1	4	880
Streambank stabilization	Temporarily reduced habitat suitability	320	1	4	1,280
Construction or modification of instream structures for streambank stabilization	Injury or mortality	170	1	3	510
Construction or modification of instream structures for streambank stabilization	Temporarily reduced habitat suitability	370	1	3	1,110
Construction or modification of instream structures for streambank stabilization	Temporarily reduced connectivity	Indeterminable	1	3	Indeterminable
Instream heavy metal remediation and reduction	Injury or mortality	130	1	10	1300
Instream heavy metal remediation and reduction	Temporarily reduced habitat suitability	230	1	10	2300
Construction and removal of instream work pads	Injury or mortality	35	2	6	210
Construction and removal of instream work pads	Temporarily reduced habitat suitability	135	2	6	810
Construction and removal of instream work pads	Temporarily reduced connectivity	Indeterminable	2	6	Indeterminable
Construction, removal, and use of temporary stream crossings	Injury or mortality	30	1	5	150
Construction, removal, and use of temporary stream crossings	Temporarily reduced habitat suitability	130	1	5	650
Construction, removal, and use of temporary stream crossings	Temporarily reduced connectivity	Indeterminable		5	Indeterminable

Action	Type of Adverse Effect	Maximum Stream Distance Adversely Affected by Individual Projects (m)	Duration of Action (months)	Frequency of Action (occurrences in 10-year period)	Maximum Total Stream Distance Adversely Affected (m)
Installation and removal of coffer dams and dewatering	Injury or mortality	35	1	6	210
Installation and removal of coffer dams and dewatering	Temporarily reduced habitat suitability	135	1	6	810
Installation and removal of coffer dams and dewatering	Temporarily reduced connectivity	Indeterminable	1	6	Indeterminable
Geotechnical investigations (borings)	Injury or mortality	16	1	10	160
Geotechnical investigations (borings)	Temporarily reduced habitat suitability	36	1	10	360
Streambank grading	Temporarily reduced habitat suitability	100	1	20	2,000
Vegetation or tree removal required for other actions	Temporarily reduced habitat suitability	80	1	20	1,600
Vegetation or tree removal required for other actions	Long-term habitat loss or degradation	20	1	20	400
Vegetation or tree removal required for other actions	Temporarily reduced connectivity	Indeterminable	1	20	Indeterminable
Other terrestrial actions	None (provided effects do not exceed adverse effect thresholds)	NA	NA	NA	Indeterminable
Activities not explicitly described	Injury or mortality	150	4	10	1,500
Activities not explicitly described	Temporarily reduced habitat suitability	250	4	10	2,500
Activities not explicitly described	Long-term habitat loss or degradation	10	4	10	100
Activities not explicitly described	Temporarily reduced connectivity	Indeterminable	4	10	Indeterminable
Total Spatial Extent of Adverse Effects				**Injury or mortality**	**8,990**
				Temporarily reduced habitat suitability	**21,015**
				Long-term habitat loss or degradation	**802**
				Temporarily reduced connectivity	**Indeterminable**
				TOTAL	**30,807 (Excluding temporarily reduced connectivity)**

Table 6. The maximum extent of anticipated adverse effects Big Creek Crayfish (BCC) and St. Francis River Crayfish (SFRC) critical habitat PBFs from actions included in the SCF. The duration of action refers to the duration of activities, and the frequency of the action refers to the number of times an action may occur within a 10-year period. Longitudinal stream distance in which PBFs may be adversely affected is calculated in Table 4.

Action	PBF(s) Adversely Affected	Function Affected	Duration of Adverse Effect	Maximum Stream Distance Adversely Affected by Individual Projects (m)	Duration of Action (months)	Frequency of Action (occurrences in 10-year period)	Maximum Total Stream Distance Adversely Affected (m)
Bridge construction	Stream embeddedness/ Prey base	Supporting occupancy and reproduction	Temporary	265	3	5	1,325
Bridge construction	Stream embeddedness/ Prey base	Supporting movement among occupied areas	Temporary	Indeterminable	3	5	Indeterminable
Bridge maintenance	Stream embeddedness/ Prey base	Supporting occupancy and reproduction	Temporary	145	4	10	1,450
Bridge removal	Stream embeddedness/ Prey base	Supporting occupancy and reproduction	Temporary	265	3	5	1,325
Culvert installation, maintenance, replacement, and removal	Stream embeddedness/ Prey base	Supporting occupancy and reproduction	Temporary	180	1	8	1,440
Pipeline construction, repair, replacement, and removal	Stream embeddedness/ Prey base	Supporting occupancy and reproduction	Temporary	110	1	5	550
Construction, maintenance, replacement, and removal of river accesses	Stream embeddedness/ Prey base	Supporting occupancy and reproduction	Temporary	110	1	6	660
Construction, maintenance, use, and removal of hardened stream crossings	Stream embeddedness/ Prey base	Supporting occupancy and reproduction	Temporary	180	1	4	720
Stream channel and streambed restoration	Stream embeddedness/ Prey base	Supporting occupancy and reproduction	Temporary	500	4	3	1,500
Stream channel and streambed restoration	Connectivity	Supporting movement among areas	Temporary	Indeterminable	4	3	Indeterminable
Streambank stabilization	Stream embeddedness/ Prey base	Supporting occupancy and reproduction	Temporary	320	1	4	1,280

Action	PBF(s) Adversely Affected	Function Affected	Duration of Adverse Effect	Maximum Stream Distance Adversely Affected by Individual Projects (m)	Duration of Action (months)	Frequency of Action (occurrences in 10-year period)	Maximum Total Stream Distance Adversely Affected (m)
Construction or modification of instream structures for streambank stabilization	Stream embeddedness/ Prey base	Supporting occupancy and reproduction	Temporary	370	1	3	1,110
Construction or modification of instream structures for streambank stabilization	Connectivity	Supporting movement among occupied areas	Temporary	Indeterminable	1	3	Indeterminable
Instream heavy metal remediation and reduction	Stream embeddedness/ Prey base	Supporting occupancy and reproduction	Temporary	230	1	10	2,300
Construction and removal of instream work pads	Stream embeddedness/ Prey base	Supporting occupancy and reproduction	Temporary	135	2	6	810
Construction and removal of instream work pads	Connectivity	Supporting movement among occupied areas	Temporary	Indeterminable	2	6	Indeterminable
Construction, removal, and use of temporary stream crossings	Stream embeddedness/ Prey base	Supporting occupancy and reproduction	Temporary	130	1	5	650
Construction, removal, and use of temporary stream crossings	Connectivity	Supporting movement among occupied areas	Temporary	Indeterminable	1	5	Indeterminable
Installation and removal of coffer dams and dewatering	Stream embeddedness/ Prey base	Supporting occupancy and reproduction	Temporary	135	1	6	810
Installation and removal of coffer dams and dewatering	Connectivity	Supporting movement among occupied areas	Temporary	Indeterminable	1	6	Indeterminable
Geotechnical investigations (borings)	Stream embeddedness/ Prey base	Supporting occupancy and reproduction	Temporary	36	1	10	360

Action	PBF(s) Adversely Affected	Function Affected	Duration of Adverse Effect	Maximum Stream Distance Adversely Affected by Individual Projects (m)	Duration of Action (months)	Frequency of Action (occurrences in 10-year period)	Maximum Total Stream Distance Adversely Affected (m)
Streambank grading	Stream embeddedness/ Prey base	Supporting occupancy and reproduction	Temporary	100	1	20	2,000
Vegetation or tree removal required for other actions	Stream embeddedness/ Prey base	Supporting occupancy and reproduction	Temporary	80	1	20	1,600
Vegetation or tree removal required for other actions	Water temperature	Supporting occupancy and reproduction	Long-term	20	1	20	400
Vegetation or tree removal required for other actions	Connectivity	Supporting movement among occupied areas	Temporary	Indeterminable	1	20	Indeterminable
Other terrestrial actions	None (provided effects do not exceed adverse effect thresholds)	NA	NA	NA	NA	NA	NA
Activities not explicitly described	Water temperature	Supporting occupancy and reproduction	Long-term	10	4	10	100
Activities not explicitly described	Stream embeddedness/ Prey base	Supporting occupancy and reproduction	Temporary	250	4	10	2,500
Activities not explicitly described	Connectivity	Supporting movement among occupied areas	Temporary	Indeterminable	4	10	Indeterminable
Total Spatial Extent of Adverse Effects						**Stream flow velocity**	**NA**
						Stream depth	**NA**
						Water temperature	**500**
						Stream embeddedness/Prey base	**22,390**
						Connectivity	**Indeterminable**
						TOTAL	**22,890 (Excluding temporarily reduced connectivity)**

Cumulative Effects

In a biological opinion, the Service must predict the consequences to species caused by future non-Federal activities within the action area, i.e., cumulative effects. Cumulative effects are those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR §402.02). Additional regulations at 50 CFR §402.17(a) identify factors to consider when determining whether activities are reasonably certain to occur. These factors include, but are not limited to: existing plans for the activity; and any remaining economic, administrative, and legal requirements necessary for the activity to go forward.

State, local, and private actions not associated with the actions evaluated in this SA (e.g., development, agriculture, etc.) are likely to continue throughout the action area. These State, local, and private actions are likely to result in varying degrees of adverse effects to the Big Creek Crayfish, St. Francis River Crayfish, and the species' critical habitat. Therefore, cumulative effects are likely to occur.

Within Missouri, numerous cumulative effects that can have long-term, continuous impacts on Big Creek Crayfish and St. Francis River Crayfish populations and in-stream habitat in the future are related, but not limited, to: local municipalities' maintenance procedures for unpaved roads, activities related to timber harvest, agriculture and livestock production, recreational activities, and the State of Missouri's management and enforcement of laws that affect water quality. While impacts of these activities are likely occurring to individuals, we do not consider these impacts to affect the overall persistence or reproductive potential of the Big Creek Crayfish or the St. Francis River Crayfish because the species are abundant in areas not impacted by the Woodland Crayfish. We also do not anticipate that the overall value of critical habitat features will be affected by cumulative effects, though one or more PBFs could be affected in localized areas.

There also are future actions of the State, research centers, and municipalities that can aid in the recovery of species or preserve the baseline status of the species. These actions include, but are not limited, to: 1) the MDC Comprehensive Wildlife Conservation Strategy; 2) efforts to improve in-stream water and habitat quality by State agencies, Federal agencies, and non-profit, conservation organizations; 3) implementation of BMPs developed for aquatic species, and 4) research aimed at recovery of the Big Creek Crayfish and St. Francis River Crayfish. While we are unable to determine the extent to which these efforts may benefit the two crayfishes and their critical habitat, the intent is that they will aid in recovery of the species and improve or maintain the quality of critical habitat.

In addition to the effects described above, climate changes are likely affecting the Big Creek Crayfish within the action area because flood events in Missouri have become more frequent and severe. These flood events can increase streambank erosion, thereby increasing sediment deposition, and can also injure or kill crayfish due to high stream flow velocities and mobilization of the substrate. Because climate changes are projected to increase in the future, we expect that within the action area, the Big Creek Crayfish will continue to be impacted into the future by climate changes.

While the effects described above are likely affecting individuals within the action area, we do not consider these impacts to affect the overall persistence or reproductive potential of the Big Creek Crayfish because the species is abundant in areas not impacted by the Woodland Crayfish.

CONCLUSION

The actions anticipated to result in adverse effects to the Big Creek Crayfish, St. Francis River Crayfish are the same as those expected to result in adverse effects to critical habitat and include: 1) bridge construction; 2) bridge maintenance; 3) bridge removal; 4), culvert construction, maintenance, and replacement; 5) pipeline construction, maintenance, repair, replacement, and removal; 6) stream restoration; 7) construction, maintenance, replacement, and removal of river accesses; 8) construction, maintenance, replacement, use, and removal of hardened stream crossings; 9) stream channel or streambed restoration; 10) streambank stabilization; 11) construction or modification of instream structures for streambank stabilization; 12) instream heavy metal remediation and reduction; 13) construction and removal of instream work pads; 14) construction, removal, and use of temporary stream crossings, 15) installation and removal of coffer dams and dewatering; 16) geotechnical investigations (borings); 17) streambank grading; 18) vegetation or tree removal required for other actions; and 19) activities not explicitly described.

Summarized below are effects of these activities and our determination on the overall impact to the crayfishes' viability and value of their critical habitat.

Big Creek Crayfish and St. Francis River Crayfish

The Big Creek Crayfish and St. Francis River Crayfish may be adversely affected by actions included in the SCF in the form of injury or mortality, temporarily reduced habitat suitability, long-term habitat loss or degradation, and temporarily reduced connectivity. Injury or mortality and temporarily reduced habitat suitability may reduce crayfish abundance temporarily in affected areas; whereas long-term habitat loss or degradation may result in a long-term decrease in abundance in affected areas. In areas in which connectivity is temporarily reduced, gene flow and recolonization potential may be temporarily reduced.

After reviewing the current status of the two crayfishes, the environmental baseline for the action area, effects of the proposed actions, and cumulative effects; it is the Service's biological opinion that completion of the actions is not likely to jeopardize the continued existence of either species. This determination is based on the following considerations which indicate that the crayfishes' overall resiliency, redundancy, and representation will not be affected:

1) Though we are unable to quantify the area in which connectivity will be temporarily reduced, actions resulting in a long-term reduction in connectivity are outside the scope of the SCF. Therefore, the crayfishes will maintain genetic diversity and the potential for recolonization in the instance of local extirpations.

2) Areas in which injury or mortality may occur are encompassed by those in which habitat suitability may be temporarily reduced. Thus, the total area in which the crayfishes may experience adverse effects other than temporarily reduced connectivity constitutes only a small amount of each species' range (a maximum of 0.7% for each species) (**Table 7**).

3) Crayfish are thought to quickly rebound from disturbance if habitat conditions are suitable.

4) Many of the impacts will be temporary, with long-term impacts to habitat suitability constituting a maximum of only 0.03% of each species' range (**Table 7**).

5) Many actions will result in an overall improvement of habitat conditions due to reducing sedimentation, with some actions increasing connectivity.

6) The Big Creek Crayfish and St. Francis River Crayfish are abundant in areas not invaded by the Woodland Crayfish or impacted by heavy metal contamination.

7) Because our analysis considers the ability of crayfish to quickly rebound from disturbance, we will track the location of projects likely to adversely affect the species. If projects are located near each other, we will assess the proximity and level of impacts to determine if the ability of crayfish to recolonize impacted areas will be reduced.

8) Additional conservation measures will be implemented in areas within the crayfishes' ranges that contribute a greater amount to the species' viability than the rest of the range. These areas include those that may function as refugia from the Woodland Crayfish, areas containing unique genetic diversity that may help the species adapt to changing environmental conditions over time, and areas containing high levels of abundance that may provide resiliency to withstand environmental and demographic stochasticity.

Big Creek Crayfish and St. Francis River Crayfish Critical Habitat

Critical habitat for the Big Creek Crayfish and St. Francis River Crayfish may be adversely affected by actions included in the SCF in the form of reduced ability to support occupancy or reproduction and temporarily reduced ability to support movement among occupied areas.

After reviewing the current status of the Big Creek Crayfish's and St. Francis River Crayfish's critical habitat, environmental baseline for the action area, effects of the proposed actions, and the cumulative effects; it is the Service's biological opinion that completion of the actions is not likely to destroy or adversely modify critical habitat for the two crayfishes. This determination is based on the following considerations:

1) Though we are unable to quantify the area in which connectivity will be temporarily reduced, actions resulting in a long-term reduction in connectivity are outside the scope of the SCF. Therefore, critical habitat areas will continue to support crayfish movement among occupied areas.

2) The area in which the crayfishes' critical habitat may be adversely affected constitutes a small percentage of each species' total critical habitat (a maximum of 1.3% and 1.4% of the total critical habitat for the Big Creek Crayfish and St. Francis River Crayfish, respectively) (**Table 7**).

3) Many of the impacts will be temporary with long-term effects to critical habitat constituting a maximum of 0.03% of each species' total critical habitat (**Table 7**).

4) Many actions will result in an overall improvement in stream embeddedness and the crayfishes' prey base due to reducing sedimentation, with some actions also improving connectivity.

Table 7. The size of the Big Creek Crayfish and St. Francis Crayfish ranges and critical habitat, the total stream distance impacted by actions included in the SCF, and the maximum percentage of each that may be impacted by actions.

Species or Critical Habitat	Maximum Percent with Adverse Effects	Maximum Percent of Range with Long-term Adverse Effects
Big Creek Crayfish Range	1.0%	0.03%
St. Francis River Crayfish Range	1.0%	0.03%
Big Creek Crayfish Critical Habitat	1.3%	0.03%
St. Francis River Crayfish Critical Habitat	1.4%	0.03%

REFERENCES CITED

Allert, A.L., R.J. DiStefano, J.F. Fairchild, C.J. Schmitt, M.J. McKee, J.A. Girondo, W.G. Brumbaugh, and T.W. May. 2013. Effects of historical lead-zinc mining on riffle-dwelling benthic fish and crayfish in the Big River of southeastern Missouri, USA. Ecotoxicology 22(3): 506-521.

Allert, A.L., R.J. DiStefano, C.J. Schmitt, J.F. Fairchild, and W.G. Brumbaugh. 2012. Effects of mining-derived metals on riffle-dwelling crayfish in southwestern Missouri and southeastern Kansas, USA. Archives of Environmental Contamination and Toxicology 64:563-572.

Allert, A.L., J.F. Fairchild, R.J. DiStefano, C.J. Schmitt, J.M. Besser, W.G. Brumbaugh, and B.C. Poulton. 2008. Effects of lead–zinc mining on crayfish (*Orconectes hylas*) in the Black River watershed. Freshwater Crayfish 16: 97–111.

Allert, A.L. J.F. Fairchild, R.J. DiStefano, C.J. Schmitt, and W.G. Brumbaugh. 2009. Ecological effects of lead mining on Ozark streams—in-situ toxicity to woodland crayfish (*Orconectes hylas*). Ecotoxicology and Environmental Safety 72:1207–1219.

Boone, M. 2001. St. Francis River Watershed Inventory and Assessment. Resource Document, Missouri Department of Conservation. 80 pp.

Bubb, D.H., T.J. Thom, and M.C. Lucas. 2006. Movement, dispersal and refuge use of co-occurring introduced and native crayfish. Freshwater Biology 51: 1359–1368.

Bubb, D.H., T.J. Thom, and M.C. Lucas. 2008. Spatial ecology of the white-clawed crayfish in an upland stream and implications for the conservation of this endangered species. Aquatic Conservation: Marine and Freshwater Ecosystems 18: 647-657.

Buřič, M., A. Kouba, and P. Kozák. 2009. Spring mating period in *Orconectes limosus*: the reason for movement. Aquatic Sciences 71: 473-477.

Creaser, E.P. 1931. Three New Crayfishes (*Cambarus*) from Puebla and Missouri. The University of Michigan Press: pp. 7-10. Ann Arbor, Michigan.

Czarneski, J. 1985. Accumulation of lead in fish from Missouri streams affected by lead mining. Bulletin of Environmental Contamination and Toxicology 34: 736–745.

DiStefano, R.J. 2008a. Conservation of imperiled crayfish—*Orconectes* (Procericambarus) *peruncus* (Creaser, 1931) (Decapoda: Cambaridae). Journal of Crustacean Biology 28(1):189–192.

DiStefano, R.J. 2008b. Conservation of imperiled crayfish—Orconectes (Procericambarus) *quadruncus* (Creaser, 1933) (Decapoda: Cambaridae). Journal of Crustacean Biology 28(2):417–421.

DiStefano, R.J. 2021. Personal Communication. Information provided by Bob DiStefano (Resource Scientist/Crayfish Ecologist, Missouri Department of Conservation) during a telephone call on March 18, 2021, to discuss potential impacts to the Big Creek Crayfish from instream disturbance.

DiStefano, R.J. and J.T. Westhoff. 2011. Range expansion by an invasive crayfish and subsequent range contraction of imperiled endemic crayfish in Missouri (USA) Ozark streams. Freshwater Crayfish 18(1): 37-44.

DiStefano, R.J., J. Young, and D.B. Noltie. 2002. A study of the life history of Orconectes hylas with comparisons to *Orconectes peruncus* and *Orconectes quadruncus* in Ozark streams, Missouri, USA. Freshwater Crayfish, 13: 439-456.

Fetzner Jr., J.W. and R.J. DiStefano. 2008. Population genetic analysis of two threatened (and one introduced) crayfish from the St. Francis River Drainage of Missouri. Final Project Report to the Missouri Department of Conservation, Columbia, Missouri. 14-15 pp.

Fetzner Jr., J.W., R.J. DiStefano, and J.T. Westhoff. 2016. Development and screening of novel microsatellite loci in freshwater crayfish from the upper St. Francis River basin of Missouri: Testing for hybridization as a possible mechanism for the decline of two imperiled endemic crayfish species. Final project report to the Missouri Department of Conservation and U.S. Fish and Wildlife Service. Cooperative Agreement 70. iii+66 pp.

Loughman, Z.J., S.A. Welsh, N.M. Sadecky, Z.W. Dillard, and R.K. Scott. 2017. Environmental covariates associated with *Cambarus veteranus* (Decapoda: Cambaridae), an imperiled Appalachian crayfish endemic to West Virginia, USA. Journal of Crustacean Biology 5: 642-648.

Loughman, Z.J., S.A. Welsh, N.M. Sadecky, Z.W. Dillard, and R.K. Scott. 2017. Evaluation of physiochemical and physical habitat associations for *Cambarus callainus* (Big Sandy Crayfish), an imperiled crayfish endemic to the Central Appalachians. Aquatic Conservation: Marine and Freshwater Ecosystems 2017:1–9.

McCreesh, P.A. 2000. Effects of a fisheries restoration scheme on the biological communities of the Rye Water, an Irish lowland river. PhD thesis, University College Dublin.

[MDC] Missouri Department of Conservation. 2017. Unpublished data on locations of the Big Creek Crayfish (*Faxonius peruncus*) and St. Francis River Crayfish (*Faxonius quadruncus*) in Missouri. Provided by Robert DiStefano (Resource Scientist/Crayfish Ecologist, Missouri Department of Conservation) on January 30, 2017.

[MDC] Missouri Department of Conservation. 2018. Unpublished data on locations of the Woodland Crayfish (*Faxonius hylas*) in Missouri. Provided by Robert DiStefano (Resource

Scientist/Crayfish Ecologist, Missouri Department of Conservation) and Drew White (Crayfish Crew Leader, Missouri Department of Conservation) on January 30, 2018.

Missouri Natural Resource Trustee Council. 2014. Southeast Missouri Ozarks Regional Restoration Plan and Environmental Assessment. Accessed on April 5, 2018, at https://www.fws.gov/midwest/es/ec/nrda/SEMONRDA/pdf/FinalSEMORRP25April2016WithErrata.pdf.

Pflieger, W.L. 1996. The crayfishes of Missouri. Missouri Department of Conservation, Jefferson City, MO.

Riggert, C.F., R.J. DiStefano, and D. Noltie. 1999. Distributions and selected ecological aspects of the crayfishes *Orconectes peruncus* (Creaser, 1931) and *Orconectes quadruncus* (Creaser, 1933) in Missouri. American Midland Naturalist 142: 348–362.

Robinson CA, Thom TJ, Lucas MC. 2000. Ranging behaviour of a large freshwater invertebrate, the white-clawed crayfish *Austropotamobius pallipes*. Freshwater Biology 44: 509–521.

Rosewarne, P.J., J.C. Svendsen, R.J.G. Mortimer, and A.M. Dunn. 2014. Muddied waters: suspended sediment impacts on gill structure and aerobic scope in an endangered native and an invasive freshwater crayfish. Hydrobiologia 722: 61-74.

Schmitt, C.J., M.L. Wildhaber, J.B. Hunn, T. Nash, M.N. Tieger, and B.L. Steadman. 1993, Biomonitoring of lead-contaminated Missouri streams with an assay for erythrocyte (d)-aminolevulinic acid dehydratase activity in fish blood: Archives of Environmental Contamination and Toxicology 25: 464–475.

Strahler, A.N. 1952. Hypsometric (area-altitude) analysis of erosional topology. Geological Society of America Bulletin 63(11): 1117–1142.

Westhoff, J.T. 2011. Investigation of an invasive crayfish and its relation to two imperiled native crayfishes: anthropogenic influences, multi-scale habitat associations, and conservation options. Ph. D. Dissertation, University of Missouri, Columbia, Missouri, USA, 55; 57; 95; 254 pp.

Westhoff, J.T. 2022. Personal Communication. Information provided by Dr. Jacob Westhoff (Assistant Leader and Cooperative Assistant Professor/Crayfish Expert, U.S. Geological Survey, Missouri Cooperative Fish and Wildlife Research Unit) in an email on June 15, 2022, pertaining to potential impacts to Big Creek Crayfish and St. Francis River Crayfish habitat from the use of heavy equipment within the stream.

Westhoff, J.T., C.F. Rabeni, and S.P. Sowa. 2011. The distributions of one invasive and two native crayfishes in relation to coarse-scale natural and anthropogenic factors. Freshwater Biology 56:2415-2431.

Williams, A.B. 1954. Speciation and distribution of the crayfishes of the Ozark Plateaus and Ouachita Provinces. University of Kansas Science Bulletin, 36: 803–918.

[USFWS] U.S. Fish and Wildlife Service. 1983a. Endangered and threatened species listing and recovery priority guidance. Federal Register 48: 43098-43105.

[USFWS] U.S. Fish and Wildlife Service. 1983b. Endangered and threatened species listing and recovery priority guidelines correction. Federal Register 48: 51985.

[USFWS] U.S. Fish and Wildlife Service. 2022. Species status assessment report for the Big Creek Crayfish (*Faxonius peruncus*) and St. Francis River Crayfish (*Faxonius quadruncus*). Version 2.0, January 2022. Midwest Region, Bloomington, Minnesota. 51 pp. + app.

[USFWS] U.S. Fish and Wildlife Service. 2023. Endangered and threatened wildlife and plants; threatened species status with section 4(d) rule for Big Creek Crayfish and St. Francis River Crayfish and designation of critical habitat. Federal Register 88: 25512.

[USFWS/NMFS]. U.S. Fish and Wildlife Service and National Marine Fisheries Service. 1998. Endangered Species Act Consultation Handbook: Procedures for Conducting Section 7 Consultations and Conferences. March 1998.