Estimating costs of using foul-release type coatings to mitigate *Dreissena* sp. mussel macrofouling at a FCRPS facility

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Estimating costs of using foul-release type coatings to mitigate *Dreissena* sp. mussel macrofouling at a FCRPS facility

Abstract

The costs to apply a foul-release type coating to components of a Federal Columbia River Power System (FCRPS) facility are estimated in this document to aid cost/ benefit analyses regarding the different control options to mitigate the potential effects of zebra (*Dreissena polymorpha*) and quagga mussels (*D. rostriformis bugensis*) macrofouling in the Columbia River Basin. It is estimated to cost $1,111,855 to apply the Sher-Release/ Duplex foul-release coating system, manufactured by FUJIFILM Smart Surfaces LLC, to the 1,300 diffuser gratings and the 156 flat steel bars that are part of the auxiliary water system (AWS) in the adult fish passage facilities located at The Dalles Dam Project. The total surface area of the AWS diffuser gratings and bars is 10,390-m^2 (111,832-ft^2), meaning the total costs for application including labor, equipment/ supplies and other direct costs is \$107/ m^2 (\$9.94/ ft^2). The work to remove the gratings and bars, apply and cure paint and reinstall is done during the in-water work period, which is December to mid-January for the East ladder and mid-January through February for the North ladder.

Background

Context

Zebra mussels (*Dreissena polymorpha*) and quagga mussels (*D. rostriformis bugensis*) are invasive freshwater mussels that cause extensive economic and ecological impacts in areas outside their native range (Dermott and Kerec 1997; Mann, Radtke, Huppert, Hamilton, Hanna, Duffield and Netusil 2010; Ricciardi, Neves and Rasmussen 1998). Zebra and quagga mussels, hereafter referred to as *Dreissena*, attach to hard submerged surfaces such as concrete, steel and rock using byssal threads and this biofouling can create operational problems for hydroelectric and irrigation facilities, e.g., clogging screens and pipes (Boelman, Neilson, Dardeau and Cross 1997; Claudi and Mackie 1994; Jenner, Whitehouse, Taylor and Khalanski 1998; Neitzel, Johnson, Page, Young and Daling 1984). *Dreissena* can form large dense populations and through their collective filter feeding and deposition of feces and pseudofeces, they change the physical and chemical characteristics of submerged substrates, and this increases corrosion, siltation, material loadings and frictional resistance (Venkatesan and Murphy 2009). *Dreissena* mussels have led to millions of dollars in additional maintenance costs for munical water districts in Nevada, Arizona and California as well as instigating several lake closures (DeLeon 2012; Willett 2012), and if they become established in the Columbia River Basin (CRB), management costs at hydropower facilities are expected to exceed $24 million/ year (Phillips, Darland and Sytsma 2005).

The risk of *Dreissena* mussel infestation in the CRB is increasing. In 2007, *Dreissena* mussels were found to have established populations west of the Rocky Mountains. Trailered watercraft with attached *Dreissena* mussels are regularly intercepted by watercraft inspection stations operated by the States of Idaho, Montana, Washington and Oregon (Begley 2013; Boatner 2013; Knight 2013; Pleus 2013). The risk posed to the Pacific Northwest by the proximity of these new infestations is significant and increases the likelihood of the successful transport and introduction of these species into the CRB.

Federal Columbia River Power System (FCRPS) hydropower facilities in the CRB are particularly vulnerable to macrofouling impacts by *Dreissena* due to the requirements for fish passage of threatened and endangered species and the dependence on once-through river water for raw-water cooled heat exchangers that are fed by concrete-embedded piping. In facilities located in infested waterways, *Dreissena* macrofouling impacts are most problematic on fixed screens and grates, grates used to regulate flow, smaller diameter intake conduits operated at capacity and small diameter piping with flow velocities less than 1.8 m/s (5.9 ft/s) (Claudi and Mackie 1994).

Planning is critical to minimizing and mitigating the costs of an invasion of the CRB by *Dreissena*, and Bonneville Power Administration (BPA), Pacific States Marine Fisheries Commission (PSMFC), US Army Corps of Engineers (USACE), US Bureau of Reclamation (USBR) and other stakeholders have recognized the need to develop long-term management measures. Combating the impacts of these fouling mussels will require an integrated management plan that may include specialized coatings to reduce mussel settlement and growth on vulnerable FCRPS facility components. There are reactive and preventative methods available for controlling *Dreissena* macrofouling including treating water with chemicals and heat, manual cleaning, replacing equipment, modifying open-loop cooling systems to closed-loop, mechanical filtration, etc. (Boelman et al. 1997; Daling and Johnson 1984; Jenner et al. 1998; Miller, Payne, Nelson and McMahon 1992). This document, however, pertains to anti-fouling coatings and specifically, to the foul-release type coatings that lack biocides and provide fouling protection by minimizing the initial attachment and strength of attachment through the properties of the coating surface.

This type of foul-release coatings, hereafter referenced as foul-release, can develop fouling but the strength of the bond is weak and can be broken by the force of flowing water or by light cleaning (Chambers, Stokes, Walsh and Wood 2006). Most commercially available foul-release coatings employ multiple layers to improve adhesion and corrosion protection. The topcoats typically have properties like low surface energy, non-polarity and elasticity and they are slippery and rubbery. A tie coat is used to bond this slippery and rubbery topcoat to a tough, water-resistant anticorrosive bottom layer, e.g., epoxy.

Foul-release coatings are environmentally friendly and effective against macrofouling, but these coatings are mechanically weak and are expensive. The efficacy of foul-release coatings against macrofouling varies by product (Wells and Sytsma 2009), but several coating systems have shown excellent performance in panel and trial applications against fouling mussels (Drooks 2009; EPRI 1992; Matsui, Nagaya, Funahashi, Goto, Yuasa, Yamamoto, Ohkawa and Magara 2002; Poulton 2009; Skaja 2012). The resistance of foul-release coatings to abrasion and gouging by flotsam and facility operations, as well as the resistance to adhesion failure (e.g., peeling and blistering), however, are major concerns (Drooks 2009; Skaja 2012). Additionally, foul-release coatings are expensive, and were estimated in 1999 to range between \$108/m^2 (\$10.03/ft^2) and \$127/m^2 (\$11.80/ft^2) including installation, materials and labor (Gross 1997; Jones-Meehan, Cella, Montemarano, Swain, Wiebe, Meyer and Baier 1999). EPRI (1992) estimated the application costs, including material and labor, to be \$44/m^2 (\$4.09/ft^2) for concrete and \$55/m^2 (\$5.11/ft^2) for steel, and recoating was half the initial application costs.

An effective *Dreissena* treatment and control program in the CRB will include proven technologies, maintains operational flexibility, can be rapidly implemented, and is cost effective and dependable. BPA funded this effort to develop a detailed cost estimate for applying a foul-release type coating that has demonstrated effectiveness against *Dreissena* to selected component(s) at a FCRPS facility.

Study area

This cost estimate is focused on U.S. FCRPS facilities located in the CRB. The CRB refers to the drainage basin of the Columbia River and covers an area of approximately 670,000 square kilometers (256,688 square miles) in the Pacific Northwest region of North America. The CRB encompasses areas in seven U.S. states and Canadian province of British Columbia (Figure 1).

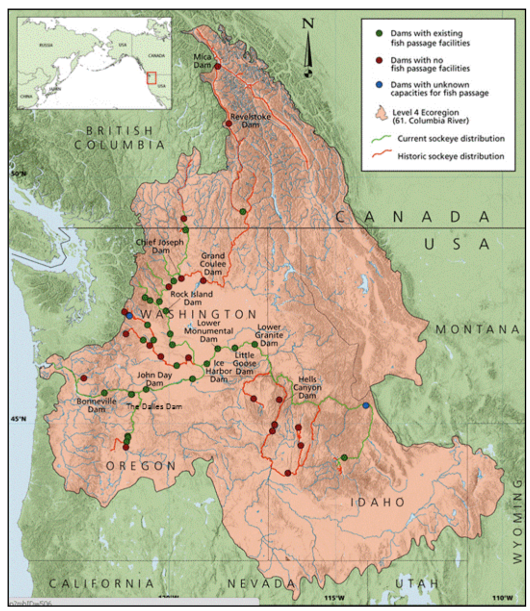

Figure 1: The Columbia River Basin. [Photo credit: Wild Salmon Center and Ecotrust 2005].

The FCRPS consists of 31 multiuse dams located in the CRB owned by USACE and USBR. The objectives of the FCRPS include generating power, protecting fish and wildlife, controlling flooding, providing irrigation and navigation and sustaining cultural resources (FCRPS 2003). There are numerous juvenile and adult life stages of salmon and steelhead fish located in the CRB that are protected under the Endangered Species Act of 1978 including but not limited to, the Upper Columbia River spring-run Chinook ESU (*Oncorhynchus tschawytscha),* Snake River Sockeye ESU (*O. nerka),* Snake River fall-run Chinook ESU, Snake River spring/ summer-run Chinook ESU, Columbia River Chum ESU *(O. keta)*, Middle Columbia River Steelhead ESU *(O. mykiss)*, Snake River Basin Steelhead ESU, and Upper Columbia River Steelhead ESU (Good, Waples and Adams 2005).

History of macrofouling in study area

Dreissena are not currently found in the CRB (Benson 2013; Wells 2013). *Limnoperna fortunei* (Golden lake mussel), is another prolific freshwater mussel capable of attaching to hard submerged surfaces via byssal threads and developing encrusting colonies, but *L. fortunei* has not been detected in North America (Magara, Matsui, Goto and Yuasa 2001; Sylvester, Dorado, Boltovskoy, Juárez and Cataldo 2005). Foul-release coatings have also demonstrated effectiveness against *Limnoperna fortunei* macrofouling (Matsui et al. 2002).

Corbicula fluminea (Asian clam) is a freshwater bivalve that was introduced to the CRB in the 1930s (Burch 1944), and is causing macrofouling problems in FCRPS facilities on the main stem Columbia River, e.g., *Corbicula* are removed from cooling condenser tubes during main unit overhauls every five years (Athearn and Darland 2007; Kovalchuk 2007). *Corbicula* adults do not attach to hard surfaces using byssal threads, but these clams do accumulate in collection channels, fishways, under diffuser gratings, behind and lodged in valves, screens and on separator bars (Kovalchuk 2007). In addition to the macrofouling problems associated with blockage, *Corbicula* can cause physical injury to fish (Kovalchuk 2007).

Previous studies

This project builds upon prior (Wells and Sytsma 2009) and ongoing TI-funded projects (Sytsma 2013), as well as research being conducted by USBR and Metropolitan Water District (MWD). USBR is currently conducting steel panel and grate experiments to assess the feasibility of using coatings on its facilities on the lower Colorado River because they are having problems with *Dreissena* macrofouling on external structures such as trash racks and screens, e.g., untreated track racks at Parker Dam were almost completely occluded by *Dreissena* after seven months immersion (Skaja 2012; Willett 2012). This coating research is led by Dr. Allen Skaja, and is currently focused on non-toxic coatings because of the concern over drinking water and endangered species. The foul-release coatings that have been evaluated by USBR and have been effective for a period over 36 months include Sher-Release and Intersleek 970 systems (Skaja 2012). MWD is also currently involved with steel panel and grate experiments in the lower Colorado River using the Intersleek 970 and Sher-Release systems (Drooks 2009; De Leon 2009).

In 2009, BPA funded PSMFC and PSU to explore the feasibility of using foul-release type coatings to mitigate *Dreissena* impacts at FCRPS facilities, and in 2010, BPA funded PSMFC and PSU to evaluate the effective service life of the three most promising foul-release coatings coming out of the MWD and USBR research under Columbia River field conditions on both steel and concrete panels and comparing to protective coatings used by USACE to protect submerged steel and concrete as well as bare concrete. The PSU test panels are deployed in the Columbia River from the breakwater dock at the Port of Camas-Washougal as well as from a moored buoy structure in San Justo Reservoir, CA, which is infested with zebra mussels.

This project also builds upon older coating technology research and the experiences of other North American facilities. Foul-release coatings were evaluated in panel and trial applications by USACE (Beitelman 2009; Kelly 1998; Miller and Freitag 1992; Race 1992; Race 1992b; Race and Miller 1992; Race and Kelly 1994; Race and Miller 1994), Ontario Hydro (Leitch and Puzzuoli 1992; Poulton 2009), Pacific Gas and Electric (Innis 2009), The Electric Power Research Institute (EPRI 1989; EPRI 1992), The Long Island Lighting Company (Gross 1997), and Consolidated Edison Company (Kovalak, Lonton and Smithee 1993). These findings have historical relevance, but it is important to note that coating manufacturers have changed coating formulations, and to the authors' knowledge, foul-release coatings have never been evaluated in the Columbia River.

Regulatory criteria or standards

Foul-release coatings are classified as pesticides and are subject to the provisions of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). The foul-release coatings in question do not contain biocides in the active and inactive ingredients of the topcoats; however, these coatings are not exempt from FIFRA because the coatings make use of specific working on their product labels, datasheets and/ or websites that make pesticidal claims, e.g., "to prevent, repel, or mitigate fouling" (Schulze 2009; Steinwand 2009). Other exemptions to FIFRA are also not applicable to foul-release coatings including 152.10(c) for products that provide a physical barrier and 152.25(f) for minimal risk pesticides (Wells 2013). To the authors' knowledge, none of the commercially available foul-release coatings have been registered under FIFRA for freshwater use by the coating manufacturers. FIFRA registration or exemption will be required before any large scale foul-release coating application at a FCRPS facility.

Work conducted in USACE fishways is under USACE safety clearance, and Hazard Energy Control Procedure (HECP) training is required as well as adherence to safety standards specified in the 385-1-1 manual (USACE 2008).

Surface preparation for painted surfaces follows standards specified by the Society for Protective Coatings including solvent cleaning, near white blasting and sweep blasting as listed below.

SSPC	The Society for Protective Coatings - Painting and Surface Preparation Standards
SSPC-SP1	Steel Structures Painting Council - Solvent Cleaning
SSPC-SP2	Steel Structures Painting Council - Hand Tool Cleaning
SSPC-SP7	Steel Structures Painting Council - Brush Off Blast Cleaning
SSPC-SP10	Steel Structures Painting Council - Near White Blast Cleaning

Project Description

Goals

The goal of this project is to assist BPA, USACE and other stakeholders to develop accurate cost/ benefit analyses regarding the different *Dreissena* control options in FCRPS facilities. If *Dreissena* become established in the CRB and cause macrofouling problems, an integrated management plan will be required to mitigate impacts to FCRPS facilities. Foul-release coatings are environmentally friendly, effective against macrofouling and may be used on particular components to reduce mussel settlement and growth. Foul-release coatings, however, are mechanically weak and expensive, and it is important to develop accurate cost/ benefit analyses to determine the cost effectiveness and feasibility of their use.

Objectives

The project objective is to develop a detailed cost estimate for applying a foul-release coating to candidate component(s) of a FCRPS facility. The specific project objectives are:

- Identify the foul-release coatings system to apply,
- Identify a FCRPS facility to develop cost estimate for,
- Identify candidate component(s) to coat,
- Develop work plan to remove, clean, paint and re-install candidate components within the in-water work window, and to
- Develop a detailed budget including materials, equipment and labor.

Information needed and sources

The foul-release coating system to be used in this cost estimate was identified using the following parameters: 1) commercially available products, 2) effective against bivalve macrofouling, empirically and independently demonstrated, and 3) the availability of customer service by coating manufacturer. Coating technology is dynamic and existing coating systems are being improved and novel systems developed, but this effort focused on commercially available products. The USBR research initially explored numerous types of coatings and products, including many foul-release systems, and they eliminated many coating systems that did not provide adequate protection from *Dreissena* in the lower Colorado River (Skaja 2009). The early successful coatings were evaluated over longer periods on steel panels and steel trash racks and the testing was expanded to evaluate measures of durability (Drooks 2009; Skaja 2010) In 2010, PSU identified the two best performing foul-release coatings from the USBR and MWD research (i.e. Sher-Release/ Duplex and Intersleek 970), and initiated a panel experiment using both concrete and steel to compare the effective service life and durability against the protective coatings used by USACE on submerged steel and concrete under Columbia River field conditions (Wells 2013). The PSU experiment also included HempasilX3, a promising foul-release system that had not been evaluated by USBR and MWD. Preliminary data from the PSU research indicated that the efficacy and durability of the Sher-Release/ Duplex, Intersleek 970 and HempasilX3 foul-release systems were relatively similar for the period evaluated to date, i.e. up to15 month immersion. Each of the manufacturers and/ or service representatives was contacted for assistance in developing the cost estimate. The Sher-Release/ Duplex foul-release coatings system was selected for this cost estimate because FUJIFILM Smart Surfaces, LLC responded to the request for information and provided estimates for material costs as well as information on painter contractors, project timelines, modifications needed to accommodate inclement weather, and other general knowledge regarding large scale application (Hampton 2013).

The FCRPS facility to be used in this cost estimate was identified from USACE hydropower facilities on the main stem Columbia River with fish passage facilities that provided the information needed to develop the cost estimate. USACE hydropower facilities within the FCRPS were chosen over the USBR facilities because they represent the largest stakeholder in terms of number of facilities operated and megawatts produced. The list was narrowed to USACE hydropower facilities on the main stem Columbia River with fish passage facilities (Bonneville, The Dalles, John Day and McNary) because these facilities presented the most challenges for paint application (i.e. size, representative components, and exposure to the greatest number of threatened and endangered salmonid fish runs, which determines the in-water work period). Bonneville and John Day were ideal candidate facilities because the USACE

Corrosion Prevention Crew is located at Bonneville and *Dreissena* vulnerability assessments have been done for both of these facilities (Athearn and Darland 2007; Kovalchuk 2007). The Dalles Dam Project was selected for this cost estimate because they responded to the request for information (Cordie 2013).

Candidate components for foul-release coatings were limited to those structures that 1) are at high- to medium risk for *Dreissena* macrofouling; 2) if fouled by *Dreissena*, would pose a serious problem to fish passage and/ or operations; 3) have limited other *Dreissena* control options available such as mechanical and chemical cleaning; 4) can be dried and cleaned for paint application; 5) are accessible and an appropriate material for paint application via conventional or airless spray; 6) and are protected from gouging from large woody debris, rocks, etc. A general list of candidate components for foul-release coatings at FCRPS hydroelectric facility includes screens, drains, diffuser gratings, trash racks, diffuser plates, vertical barrier screens and fish passage facilities (Claudi 2008; Claudi and Prescott 2011; Darland 2013; Phillips et al. 2005).

Risk for *Dreissena* macrofouling on components was assessed according to *Dreissena* biology (Wells 2013), existing literature on macrofouling in hydropower facilities (Abdul Azis, Al-Tisan, Al-Daili, Green, Ba-Mardouf, Al-Qahtani and Al-Sabai 2003; Boleman et al. 1997; Claudi and Mackie 1994; Claudi 1995; Claudi 2009; Jenner et al. 1998; Miller et al. 1992; Neitzel et al. 1984) and criteria presented by Kovalchuk (2007) that considered the time period a component was submerged in raw water, the accessibility of the component during operation as well as during seasonal maintenance in-water work periods, component redundancy and the level of interaction between the component and fish. Risk consideration was also given for the importance of components to operations and/ or fish passage, and this was assessed using vulnerability assessments (Athearn and Darland 2007; Kovalchuk 2007), facility design and fish passage criteria (NMFS 2011), cost estimates for *Dreissena* impacts on CRB hydropower (Phillips et al. 2005), prior experiences with macrofouling that resulted in unscheduled facility outages for cleaning or maintenance, e.g., *Corbicula fluminea* (Athearn and Darland 2007; Kovalchuk 2007) and personal communications (Darland 2013). The control options available for the various components that were identified as at-risk were evaluated using vulnerability assessments (Athearn and Darland 2007; Claudi and Prescott 2011; Kovalchuk 2007; USBR 2012) and *Dreissena* control and management documents (Boelman et al. 1997; Daling and Johnson 1984; Jenner et al. 1998; Miller et al. 1992).

The candidate components that were identified as at-risk for macrofouling, and would result in deleterious impacts to operations and/ or fish passage if fouled, and had limited control options available included the following:

- submersible traveling screens (STS) (Juvenile ByPass System)
- vertical barrier screens (VBS) (Juvenile ByPass System)
- adult drain recesses in elevated chute of primary dewatering structure (Juvenile ByPass System)
- perforated plates in sample holding tank (Laboratory/ Smolt Monitoring Facility)
- crowder panels in the smolt monitoring facility (Laboratory/ Smolt Monitoring Facility)
- intake gratings on main raw water supply line to generator air cooler (Powerhouse and Other)
- intake gratings on lines pulling from scroll case for thrust bearing coolers and duplex strainers (Powerhouse and Other)
- pressure gauges on automatic strainers in generator air coolers and thrust bearing coolers (Powerhouse and Other)
- duplex strainers for fire suppression and deck wash pumps (Powerhouse and Other)
- sensor wells in forebay and tailwater (Powerhouse and Other)
- pressure sensitive transducers (Adult Fishways)
- adult ladders and weirs (Adult Fishways)
- picketed leads (Adult Fishways)
- gratings over diffuser pools in collection channel, fishways and fishway entrances (Adult Fishways).

The aforementioned list was further refined by the component accessibility, materials, redundancy and exposure to debris that would result in gouging damage. This information was obtained through personal communication with USACE personnel (Cordie 2013). Information was only obtained for The Dalles Dam Project, and this facility does not have juvenile bypass system nor a laboratory/ smolt monitoring facility (Cordie 2013), thus eliminating these components from consideration in this estimate. Intake gratings on the main raw water header cannot be removed, but there are steel mesh strainers in the cooling water supply that are removed during routine maintenance (Cordie 213), and other more cost effective control options are available, e.g., manual cleaning. Intake gratings on lines pulling from the scroll case cannot be removed (Cordie 2013). Duplex strainers for fire suppression cannot be removed (Cordie 2013), and other more cost effective control options are available, e.g., operated to create unfavorable anoxic conditions with periodic flushing. Acoustic sensors are used in forebay and tailwater and thus not exposed to raw water (Cordie 2013). Pressure sensitive transducers are exposed to raw water and are removable, but it is unknown if applying foul-release coating would impact sensor operation. Concrete and steel adult ladders and weirs can be dewatered and are accessible for painting; however, lamprey attach to the floors of fishways and weir orifices (Cordie 2013), and foul-release coatings may interfere with lamprey attachment during passage and/ or lamprey attachment could damage coatings. The gratings over the diffuser pools are galvanized steel flat bar stock with a maximum 1-inch clear spacing (NMFS 2011). The diffuser gratings are only de-watered during the in-water work period, but are accessible and can be removed although the process is labor intensive (Cordie 2013).

A work plan was needed to identify the tasks, timeline, the required equipment and personnel, and ultimately the costs needed to remove, clean, paint and re-install the candidate components within the in-water work window. Information about how the candidate component is installed and handled as well as other USACE scheduled maintenance activities occurring during the in-water work period is important information to determine how the component is removed from The Dalles Dam, the availability of USACE labor, and requirements for communication and coordination with USACE. This information was provided by USACE personnel (Cordie 2013). A construction and electrical contractor with experience contracting with USACE Portland District provided information about subcontractor availability and limitations, HECP training and general insight about contracting with USACE (Hage Electric and Construction Services Inc.) (Hage 2013). Information needed for paint application includes exposure to the weather during the in-water work period, component handling, turnaround time, surface preparation, component material and size, quality control and quality assurance procedures, requirements for space, power and compressed air. This information was obtained through personal communication with the manufacturer of the Sher-Release/ Duplex coating system (FUJIFILM Smart Surfaces, LLC) (Hampton 2013) and through personal communication with an industrial painter (HCI Inc.) (Cornelius 2013). A commercial real estate broker was contacted to determine availability, costs and terms, restrictions on use and general information regarding a short-term lease on an industrial warehouse for painting during inclement weather (John L. Bowman Real Estate) (Bowman 2013). Information about purchasing large tents was obtained from website for All Seasons Tent Sales at www.tent4sale.com. Information about grate handling and transportation, e.g., forklift and flatbed truck rental, and rigging equipment, was obtained through personal communication with Norlift of Oregon, Inc. (Lemons 2013), FreightCenter.com (Broome 2013), and West Coast Wire Rope (Saxton 2013). Quotes for materials to make paint racks were obtained from Metal Supermarkets and Oregon Bolt Inc. and labor was estimated from previous experiences making steel frames for an experiment (Wells 2013).

Target population

Foul-release coatings are being considered for application to FCRPS facility components to mitigate the potential macrofouling impacts of invasive epifaunal freshwater mussels that attach to hard submerged surfaces using byssal threads. Most adult freshwater mussels do not attach to hard surfaces but instead bury into the sediment using their foot (e.g., *Corbicula fluminea* and *Anodonta* sp.) (McMahon1991). There are three species of freshwater mussels, however, that attach to and live on the surface of submerged rock, concrete, steel, etc. using byssal threads (i.e.

Dreissena polymorpha, *D. rostriformis bugensis* and *Limnoperna fortunei).* Similar to many marine and brackish water bivalves, these three freshwater species are planktotrophic, meaning that fertilization and larval development is indirect and occurs in the water column (Raven 1958). Larval development for other freshwater bivalves is either direct (i.e. larvae develop within egg capsules or brood-pouch of adults) or indirect, involving a parasitic glochidium that attaches to a host such as fish (Raven 1958). This document deals specifically with *Dreissena* due to their proximity to the CRB, and because *L. fortunei* is not known to be established in North America (Benson 2013; Magara et al. 2001; Sylvester et al. 2005); however, the efficacy of foul-release coatings against *L. fortunei* and hence the applicability of this document, is expected to be comparable for *Dreissena* and *L. fortunei (*Matsui et al. 2002).

Dreissena produce planktonic larvae (veligers) that disperse throughout hydrologic connected waterways and facility components. The peak of *Dreissena* spawning in North America typically occurs between July and August (Adrian, Ferro and Keppner 1994; Garton and Haag 1993; Keppner, Adrian and Ferro 1996; Kraft, Garton, Johnson and Hieb 1996) when water temperatures are between 16^{o} and 19^{o}C (McMahon 1996). Spawning can begin at water temperatures at 9^{o}C and 12^{o}C, and veligers are present in the water column in North America for 8 to 10 months (McMahon and Bogan 2001).

Larval settlement out of the water column is an active process that involves initial settlement, metamorphosis and translocation to a preferred location. Larval settlement typically parallels temporal spawning patterns, and *Dreissena* juveniles are generally found in the Midwest of North America between August and September (Thorp, Alexander, Greenwood, Casper, Kessler, Black, Fang, Westin and Lewis 1994). *Dreissena* do not appear to discriminate surfaces on which they initially settle (Sprung 1993). Once metamorphosis is complete, *Dreissena* move to a preferred location such as the backside of a screen where flow is baffled and there is constant influx of food and oxygen (Ackerman, Sim, Nichols and Claudi 1994; Sprung 1993).

Dreissena attach to solid substrates using byssal threads. The byssal apparatus is a bundle of proteinaceous threads attached to the retractor muscle of the foot, and threads attach to the substrate using adhesive plaques (Eckroat, Masteller, Shaffer and Steele 1993; Rzepecki and Waite 1993). *Dreissena* recruitment is reduced in oxygen concentrations less than 2.0 mg/ L (DeLeon 2009), water velocities greater than 1.8 m/s (5.9 ft./s) (Claudi and Mackie 1994), and in areas of unsuitable substrates and large amounts of sediment (Sprung 1993). *Dreissena* juveniles and adults translocate year-round (Claudi and Mackie 1994), and adults tolerate wide fluctuations in flow patterns, ranging between 0.05 cm/s to 1.8 m/s (0.002 ft./s to 5.9 ft./s) (Claudi and Mackie 1994; Jenner et al. 1998).

Dreissena are small, short-lived mussels that are highly fecund and quickly reach sexual maturity. Adult *Dreissena* are typically 10 to 30-mm (0.4 to 1.2-in.) in shell length (Mills, Dermitt, Roseman, Dustin, Mellina, Conn and Spidle 1993; Karatayev et al. 2007). *Dreissena* in the Great Lakes live 1.5 to 7 years with most living two years (Mackie 1993; Mackie and Schloesser 1996; McMahon 1991). The annual growth rate was 15 to 21-mm (0.6 to 0.8-in.), and the mean growth rate was 0.12 and 0.13-mm/day for small *Dreissena* and 0.4 to 0.5-mm/day for 15-mm mussels (MacIsaac 1994; Mackie 1993; Wells 2013). *Dreissena* reach sexual maturity when shell lengths are 5 to 10-mm (0.2 to 0.4-in.) (Mackie 1993; Mackie and Schloesser 1996; Nichols 1996). *Dreissena* females release 275,000 to 1.5 million eggs/ year (Karatayev, Boltovskoy, Padilla and Burlakova 2007; Nichols 1996), and the density of newly settled *Dreissena* can be as high as 700,000 individuals/ m^2 in one growing season; adult bed densities can be greater than 200,000 individuals/ m^2 (Jenner et al. 1998).

Selected foul-release coating system

Sher-Release/ Duplex is the foul-release coating system that was selected for this cost estimate. The Sher-Release/ Duplex coating system is a silicone-based foul-release coating manufactured by FUJIFILM Smart Surfaces LLC and marketed by Sherwin Williams. The system includes three basic layers: an epoxy primer, a tie coat and a room temperature vulcanized silicone topcoat that contains proprietary free silicone oil.

The application of Sher-Release/ Duplex system involves four coats. The dry film thickness per coat generally ranges from 0.152 to 0.305-mm (6 to 12-mil) although the tie coat and topcoat thickness can vary depending on substrate depth profile (Hampton 2011). The first coat onto bare substrate is an immersion grade epoxy primer. The second cost is another immersion grade epoxy primer that has a tethering agent added to promote adhesion. The third coat is the tie coat, and the silicone topcoat is the fourth and final coat (Hampton 2011). Naphtha is used to thin the topcoat and clean equipment (Music 2011).

The Sher-Release/ Duplex coating is effective against *Dreissena* macrofouling. Steel panels and grates deployed in the lower Colorado River have shown excellent performance against *Dreissena* for over 36 months, and have remained essentially free of mussels (Skaja 2012). The concrete and steel panels deployed in the Columbia River and San Justo Reservoir, CA have been effective against algae, bryozoans and *Dreissena* for a period of up to 15 months, and any attached organisms were easily removed (Wells 2013). Sher-Release/ Duplex was the only coating system that was specifically mentioned by Ontario Hydro staff when asked about their long-term experiences with foul-release coatings (Poulton 2009).

The Sher-Release/ Duplex coating is soft and there are concerns regarding long-term durability. According to Ontario Hydro, this coating system lasted 8 to 10 years in experimental applications before blistering (Poulton 2009). This coating had fair durability in short-term USBR, MWD and PSU field experiments (Drooks 2009; Skaja 2012; Wells 2013). Foul-release coatings in general, however, are soft and can be gouged with a fingernail.

Selected FCRPS facility

The Dalles Dam Project, owned and operated by the USACE, was selected as the FCRPS facility to develop the cost estimate for applying the foul-release coating. The Dalles Dam Project is located on the Columbia River in north-central Oregon and south-central Washington (Figure 2). The Dam is located at river mile (RM) 191.5, and the upstream reservoir is called Lake Celilo while the downstream reservoir is called Lake Bonneville. The Dalles Dam Project operates two adult fish ladders, the East ladder located along the Oregon shoreline and the North fish ladder located along the Washington shoreline (Figure 2).

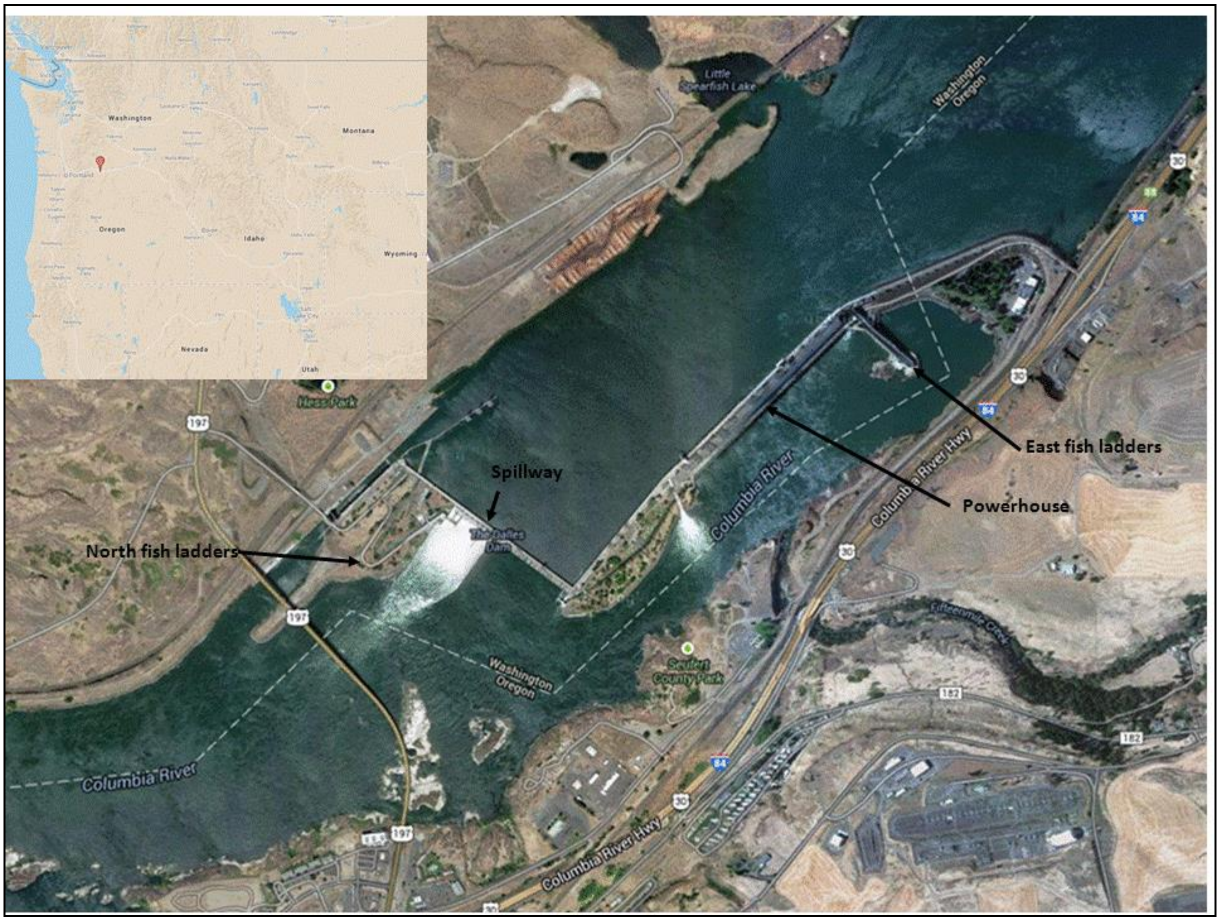

Figure 2: The Dalles Dam Project.

Selected facility component

The gratings over the diffuser pools in the adult collection channel, fishway and entrances were the FCRPS facility component selected for foul-release application in this cost estimate. There are approximately 1,000 gratings in the East ladder and 300 gratings in the North ladder (Figure 2) (Cordie 2013). Each grating is approximately 0.6 x 2.1-m (2 x 7-ft) and weighs approximately 91-kg (200-lbs) (Cordie 2013). The gratings are non-corrosive galvanized flat bar stock with a maximum of 1-in. (2.5-cm) clear spacing (Figures 3 and 4) (NMFS 2011). All edges and surfaces of diffuser gratings that are exposed to fish must be rounded or ground smooth to reduce the likelihood of fish injury (NMFS 2011). The gratings are secured to metal studs with washers and nuts, and this area is then covered with flat metal bars (Cordie 2013). The gratings are submerged for most of the year, but are dewatered during the in-water work period and can be accessed (Cordie 2013; NMFS 2011).

These gratings are diffusers in the auxiliary water system (AWS), and are part of upstream adult fish passage systems. The AWS is used to divert water from the project forebay or tailrace into the adult fish ladder to meet specified attraction flows in the fishway, the entrance pool through the fishway entrance, in areas between fishway weirs that may become back-watered, and to provide additional flows to transition pools, trap pools, exit control sections and counting station pools (NMFS 2011). Water typically flows through an intake screen or fine trash rack, through a control gate and then through the diffuser gratings before entering the fishway (NMFS 2011). The diffuser gratings function as an energy dissipation zone, and consist of either vertically-oriented or horizontally-oriented bars (NMFS 2011) (Figures 3 and 4). The maximum water velocity through a horizontally-oriented AWS diffuser grating is less than 0.15 m/s (0.5 ft./s) (based on total diffuser grating area), and water velocities are nearly uniform (NMFS 2011).

Figure 3: Diffuser gratings in stacks. [Photo credit: Robert Cordie, US Army Corps of Engineers]

Figure 4: Diffuser gratings and flat bars being installed at The Dalles Dam. [Photo credit: Robert Cordie, US Army Corps of Engineers]

Tasks required

Developing a detailed cost estimate for applying the Sher-Release/ Duplex foul-release coating system to the 1,300 diffuser gratings located in the adult fishways at The Dalles Dam Project will involve coordinating and communicating the project plan with USACE personnel and the construction and painter contractors; obtaining security and safety clearance; making paint racks; removing gratings from fishways and transporting to paint locations; cleaning, prepping, painting, drying and curing gratings; transporting gratings back to The Dalles Dam and re-installing in fishways; and implementing quality control and quality assurance measures.

- Project coordination and communication will be conducted during pre-project and planning meetings before the start of the project with USACE personnel including Project Manager, Fish Biologists GS12 and contractor supervisors to evaluate study designs, develop schedules and identify issues. A representative from FUJIFILM Smart Surfaces LLC will train paint contractors regarding the application of the Sher-Release system. During the December to February period there will be daily meetings at the start of each work day to review daily tasks, safety information and other pertinent information.
- A total of 240 paint racks will be made prior to the start of the in-water work period. Paint racks will be assembled in the leased warehouse used for paint application. Gratings will be hung from paint racks, and paint racks will be wheeled so that gratings can be easily moved between stations for cleaning, applying the primer, tie coat and topcoat and drying and curing.
- A USACE safety and security officer ENG GS-11 will be present when any work is done at The Dalles Dam Project to ensure security and safety compliance. All work inside fishway is under Corps safety clearance and personnel must receive HECP training and adhere to all safety standards specified in the 385-1-1 manual (USACE 2008). The painting supervisor will function as the safety and security officer at the paint location. Access cards will be issued to contractors working at The Dalles Dam after security clearance.
- The 1,000 gratings will be removed from East fishway in December using construction contractors in crews of 14 people with one supervisor. The 300 gratings will be removed from the North fishway in January using construction contractors in crews of seven people with one supervisor. Construction contractors will remove and stack flat bar, unbolt gratings and stack gratings in staging location. Gratings custom-made for unusual deployment locations will be mapped and all gratings will be tagged for tracking. The stacks of grating and bars will be rigged for the crane and lifted deck side; crane is operated by USACE structural crew with two USACE riggers. Stacks of grating and bars will be strapped to skids and loaded onto flatbed truck using a rented electric forklift.

Grating and bars will be transported to a leased warehouse for paint application. A rented forklift at the paint warehouse will unload grates and bars from the flatbed trucks.

- Construction contractors will load gratings onto paint racks for paint application in the paint warehouse. Two gratings are hung from each paint rack so that paint application can be continuous on all surfaces except the small area covered by the hooks used for hanging gratings. Tags on gratings are transferred to the paint rack at the paint warehouse. Flat bars are placed on raised two by fours on the points of nails for coating application, and are manually flipped over for application to both sides.
- Grates are cleaned and surfaces prepared for coating application by solvent cleaning per SSPC-SP1, corrosion is blasted to near white according to SSPC-SP-10, and solid galvanized surfaces are swept blasted according to SSPC-SP-7.
- Macropoxy 646-100, Seaguard tie coat and Sher-Release topcoat are applied according to specifications detailed in product datasheets and by a representative from FUJIFILM Smart Surfaces LLC. Painting contractors measure wet film thickness during application and record ambient conditions and application details on tags located on paint rack. Paint is dried and cured while gratings hang on paint racks.
- The cured gratings and flat bars are stacked onto skids with foam shims, loaded onto flatbed trucks using forklift and transported back to The Dalles Dam. Stacked gratings and bars are moved into the fishway using the crane operated by USACE structural crew and riggers. The construction contractors re-install gratings and bars. USACE Fish Biologist GS12 inspects installation.

Practical and logistical constraints

Candidate components for foul-release coatings must be dewatered, cleaned and completely dried for paint application. The work area must be large enough for a man to access the candidate component with conventional or airless spray, or the component must be able to be removed.

Maintenance on structures associated with fish passage is generally limited to periods when no fish runs are occurring, and these in-water work periods limit the total number of days available to work as well as the time of year. The in-water work window for the East fish ladder at The Dalles Dam is December 1 through mid-January, and the in-water work window for the North fish ladder is mid-January through February 28 (Cordie 2013). The in-water work period for the East ladder also coincides with several holidays, e.g., Christmas, Hanukkah and New Year’s. USACE structural crew personnel typically work 40 hours per week, Monday through Thursday. Therefore, approximately 18 work days are available for working in the East fishway and approximately 28 days for working in the North fishway.

The expected weather during the in-water work period is inclement for painting and requires painting indoors where temperature and humidity can be more controlled. The monthly normals for the period between 1981 to 2010 for The Dalles, OR are in Table 1. Paint adhesion, drying and curing are affected by moisture and low temperatures, and although certain formulations can be used to expedite drying and curing, e.g., Macropoxy 646-100, ambient conditions will need to be mitigated using covered structures, dehumidifiers and heaters (Hampton 2013).

Table 1: Monthly normals for The Dalles, OR (Western Regional Climate Center 2013).

	December	January	February
Mean temperature	1.89ºC (35.4ºF)	2.33ºC (36.2ºF)	4.11ºC (39.4ºF)
Mean minimum temperature	-1.83ºC (28.7ºF)	-1.67ºC (29.0ºF)	-1.39ºC (29.5ºF)
Mean precipitation	7.87-cm (3.10-in.)	6.53-cm (2.57-in.)	4.65-cm (1.83-in.)

The availability of USACE personnel and equipment during the in-water work period is a practical constraint. USACE personnel and equipment are being used for routine maintenance and other scheduled activities that must also happen in the in-water work period. Contractors can complete many of this project's tasks, but there are certain tasks that must be done by USACE personnel, e.g., crane operation.

Approximately 40% of the gratings deployed at The Dalles Dam Project are custom made for specific deployment locations, meaning these gratings are not interchangeable and must be mapped and re-installed in their original position. A majority of the gratings, however, are a standard size and are interchangeable (Cordie 2013).

Hazardous materials are used during paint application and require safety precautions, e.g., naphtha. Safety precautions include the use of respirators, tyvec suits, chemical gloves, head socks and plastic tarping (Cornelius 2013; Music 2010).

Each coat of the Sher-Release/ Duplex coatings system is continuously applied to the entire surface of the component at one time. This means all surfaces of the component must be accessible during painting. Components such as trash racks are often hung on racks for painting (Cornelius 2013; Hampton 2013). The small surface area of the grating covered by the wire or hooks used for hanging the gratings will not be painted.

The application of the different layers of the Sher-Release/ Duplex system requires physical and/ or temporal separation to avoid cross-contamination. The Sher-Release/ Duplex silicone topcoat can contaminate the epoxy primer coat and this will deleteriously affect adhesion (Music 2011). Silicone contamination is indicated by the presence of fish-eyes (Music 2011). Debris from abrasive blasting can contaminate other coats during drying.

The large number of gratings to be coating in the short turn-around time of this project means a large number of gratings will need to be processed each day. Gratings are heavy and need to be hung for painting, drying and curing. Gratings will be hung from wheeled racks designed to hold two gratings each to maximize efficiency of the painting stations while minimizing risks of cross-contamination. Racks will be wheeled into each station for the appropriate coat and then returned to the drying and curing area. The time and date for application of each coat will be recorded on tags attached to the racks.

It was difficult to obtain accurate cost estimates. It takes time to develop accurate bids, and yet this serves the companies' interest when responding to a request for bids. This project sent out requests for information and these were not requests for bids. We relied on those companies willing to donate their time and expertise, and used the best available information.

Organization and Schedule

Key individuals and responsibilities

Table 2: Proposed USACE and contractor staff involved in the application of the Sher-Release/ Duplex coating system to diffuser gratings at The Dalles Dam Project.

Agency	Title	Responsibilities
USACE	Chief, Planning, Environmental Resources and Fish Policy and Support Division	Approves scope of project and spending authority
USACE	Environmental Stewardship and Compliance Program Manager	Reviews and clarifies scope of project and budget
USACE	Project Manager, The Dalles Dam Project	Overall project supervision and direction
USACE	Fish Biologist GS12	Primary point of contact for project. Writes plan, schedule and reports. Oversees subcontractors, timeline and QA/QC plan. Inspects design for compliance with Fish Passage Plan
USACE	Fish Biologist GS12	Quality assurance and quality control officer. Inspects installation to ensure compliance with FPP and project plan
USACE	Engineer GS11	Safety and security officer. Ensures compliance with all safety and security standards at The Dalles Dam.
USACE	Structural crew	Operates cranes and rigging
Construction contractor	Supervisor	Oversees construction contractors. Point of contact for construction contractors.
Construction contractor	Journeyman	Grating removal, loading, hanging on racks and installation.
Industrial paint contractor	Supervisor	Oversees paint contractors. Point of contact for painters. QA/QC officer for painting
Industrial painter contractor	Journeyman	Clean, dry and paint. Records ambient conditions and time of application. Complies with scope of work
FUJIFILM Smart Surfaces LLC.	VP Marine Marketing and Technical Support	Trains paint contractors how to apply Sher-Release/ Duplex system and addresses project specific problems.

Project schedule

Table 3: Project schedule by tasks for East ladder containing approximately 1,000 gratings.

Agency	Task	un- known	December, 2013																		January, 2014					
			2	3	4	5	9	10	11	12	16	17	18	19	23	24	25	26	30	31	1	2	6	7	8	9
			M	T	W	R	M	T	W	R	M	T	W	R	M	T	W	R	M	T	W	R	M	T	W	R
USACE	Pre- & planning meeting	■																								
General laborers	Paint rack assembly	■																								
USACE, Constrct	Meeting @ The Dalles		■	■	■	■	■	■	■	■	■	■	■	■					■			■	■	■	■	■
USACE	Safety and security		■	■	■	■	■	■	■	■	■	■	■	■					■			■	■	■	■	■
Constrct	Unbolt grates		■	■	■	■	■	■																		
USACE	Map/ tag grates		■	■	■	■	■	■	■																	
Constrct	Stack grates & flat bars		■	■	■	■	■	■	■																	
USACE	Rigging & crane		■	■	■	■	■	■	■																	
Constrct	Forklift/ tie down/ unload				■		■	■	■																	
Constrct	Hang grates				■	■	■	■	■	■	■	■														
Paint	Meeting @ paint			■	■	■	■	■	■	■	■	■	■	■					■			■	■			
Paint	Clean, dry and prime				■	■	■	■	■	■	■	■	■	■												
Paint	Tie coat					■	■	■	■	■	■	■	■	■					■			■				
Paint	Topcoat						■	■	■	■	■	■	■	■					■			■				
Constrct	Stack grates							■	■	■	■	■	■	■					■			■	■			
Constrct	Forklift/ tie down									■	■	■	■						■				■			
USACE	Rigging & crane									■			■						■			■	■			
USACE	Map/ tag tracking		■	■	■	■	■	■	■	■	■	■	■	■					■			■	■	■	■	■
Constrct	Position & bolt grates/ bars									■	■	■	■	■					■			■	■	■		
USACE	Inspection									■	■	■	■	■					■			■	■	■	■	■
Constrct, Paint	Cleanup/ Breakdown																							■	■	

Table 4: Project schedule by tasks for North ladder containing approximately 300 gratings.

Agency	Task	Un-known	January												February															
			13	14	15	16	20	21	22	23	27	28	29	30	3	4	5	6	10	11	12	13	17	18	19	20	24	25	26	27
			M	T	W	R	M	T	W	R	M	T	W	R	M	T	W	R	M	T	W	R	M	T	W	R	M	T	W	R
USACE	Pre & plan meeting	■																												
G. laborers	Paint rack assembly	■																												
USACE, Constrct	Meeting @ TheDalles		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
USACE	Safety and security		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Constrct	Unbolt grates		■	■																										
USACE	Map/ tag grates		■	■																										
Constrct	Stack grates & bars		■	■	■																									
USACE	Rigging & crane				■	■																								
Constrct	Forklift/ unload				■	■																								
Constrct	Hang grates					■	■																							
Paint	Meeting @ paint				■	■	■	■	■	■	■	■	■	■																
Paint	Clean, dry, prime					■	■	■																						
Paint	Tie coat						■	■	■																					
Paint	Topcoat							■	■	■																				
Constrct	Stack grates							■	■	■	■																			
Constrct	Forklift/ tie down							■	■	■	■																			
USACE	Rigging & crane										■	■	■																	
USACE	Map/ tag tracking										■	■	■	■																
Constrct	Position/bolt grates										■	■	■	■																
USACE	Inspection										■	■	■	■	■	■														
Constrct, Paint	Cleanup/ breakdown														■	■														

Limitations on schedule

The work schedule for the East ladder spans the entire in-water work period (Table 3), and this limits the flexibility of the schedule. There are more gratings on the East fishway compared to the North, and the in-water work period for the East is truncated by several holidays. The schedule, however, represents a conservative estimate, e.g., labor estimates to complete each task were augmented by 40%. The additional built-in labor scheduled each day, especially for construction and painter contractors was done to build-in flexibility for problems and delays in lieu of additional days.

Project Design

Location of activities

AWS diffuser gratings will be removed from the adult fish passage systems located at the East and North fish ladders at The Dalles Dam Project, loaded onto flatbed trucks and transported to a leased warehouse in the Portland, OR area for paint application. Warehouse location may vary depending on availability and cost. An area of approximately 22,000 square foot of industrial warehouse is required to clean, paint, dry and cure the 1,300 grates within the in-water work period. This area can hold approximately 240 paint racks (Figure 5), which means a total of 480 gratings can be hung for cleaning, painting, drying and curing at one time. The paint warehouse will have five general work areas physically separated using plastic tarps to avoid cross-contamination (Figure 5). The largest area (approximately 18,800 square foot) will be used for drying and curing and additional space heaters will be focused in this area, if needed to augment warehouse heating system. Four areas of approximately 720 square foot each will be used for cleaning and application of primer, tie coat and topcoat. Dehumidifiers will be used primarily in the painting areas, as needed.

Paint racks are wheeled metal racks used to hang grating for cleaning and paint application (Figure 6). Paint racks are assembled in the painting warehouse by general laborers in the month preceding the in-water work period and the start of painting. Two gratings are hung from each rack so that paint application can be continuous on all surfaces except the small area covered by the hooks used for hanging the gratings. Paint racks are wheeled so that the gratings can be easily pushed to different areas. A total of 240 paint racks will be used for this project.

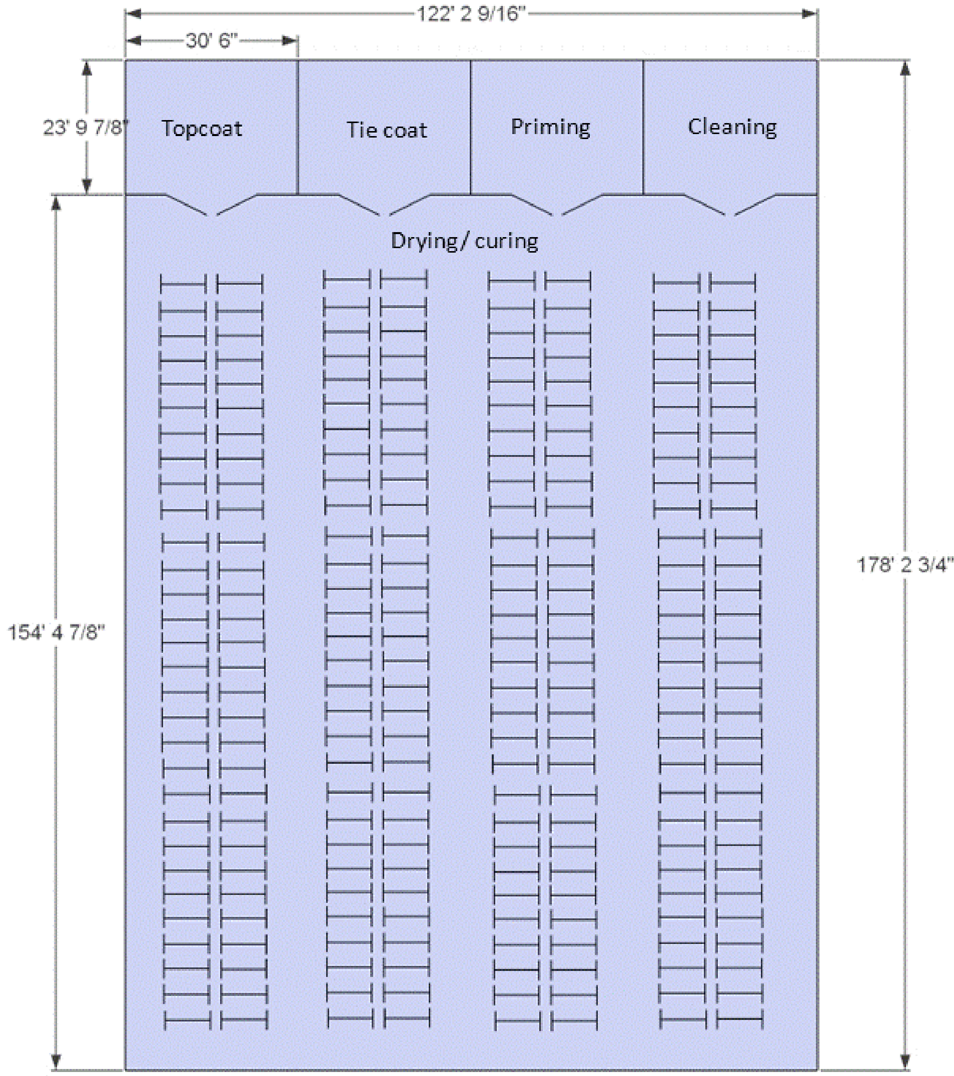

Figure 5: Plan view of schematic drawing of warehouse used for paint application showing the different areas for cleaning, drying and curing as well as applying the primer, tie coat and topcoat. Paint racks are shown as |---|. Paint racks will be assembled in the warehouse.

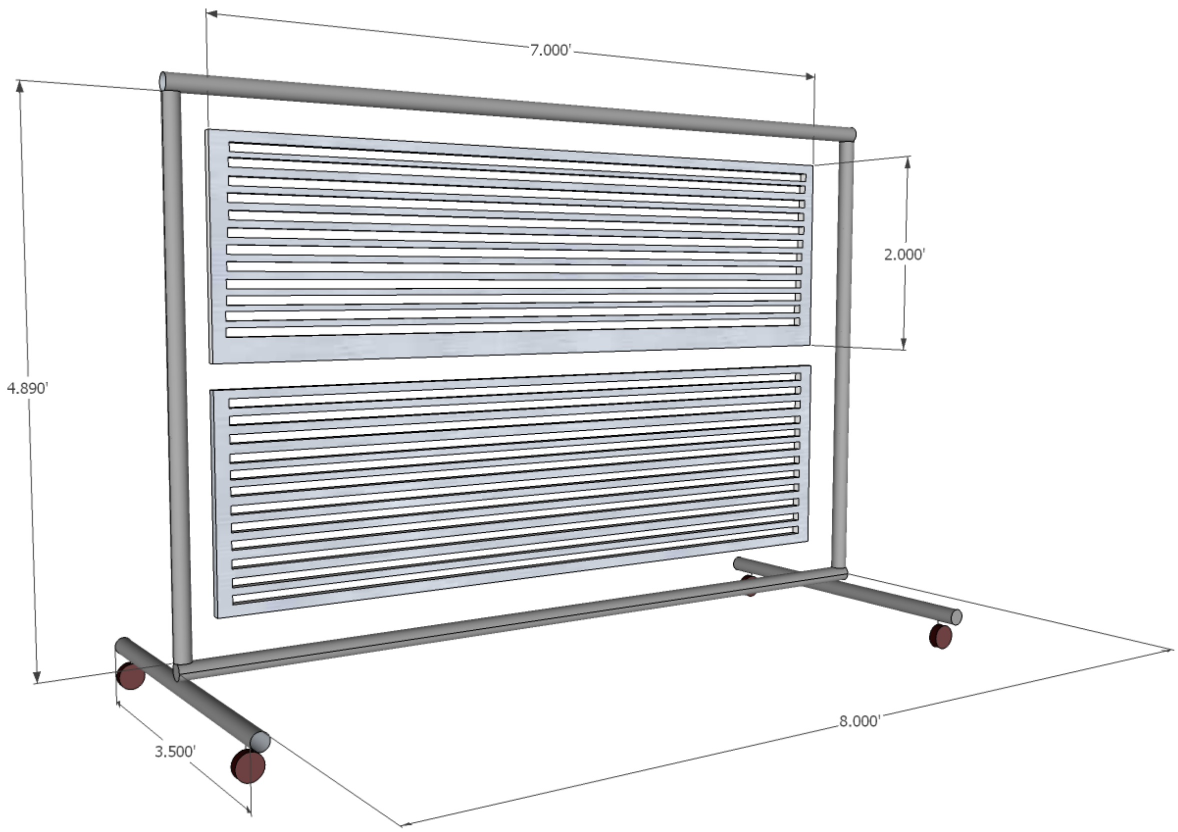

Figure 6: Schematic drawing of paint rack used to hang two gratings for cleaning and paint application. A total of 240 paint racks will be used for this project.

Assumptions of plan

Silicone-based foul-release coatings are considered non-toxic (Fendinger, Lehmann and Mihaich 1997; Jarvie 1986; Lawson 1986; Nendza 2007; Stevens, Powell, Mäkelä and Karman 2001), but more work is needed to explore potential impacts on salmonids as well as potential toxic and/ or mechanical effects. The Sher-Release/ Duplex topcoat contains a silicone resin matrix primarily composed of polydimethylsiloxane (PDMS). The PDMS materials bound within the coating matrix are biologically inert, insoluble, show no toxic effects, do not react with body fluids, and are not released to environment under normal conditions (Lawson 1986; Nendza 2007). Mechanical damage to the coating matrix can release bound PDMS materials to the environment, but these silicones become particulate litter (Nendza 2007). There are PDMS oils, however, that are not bound within the coating matrix, and these migrate to the coating surface and are released to the environment. These PDMS oils are largely inert and no toxic effects have been reported (Annelin and Frye 1989; Aubert, Aubert, Augier and Guillemaut 1985; Carpenter, Cella and Dorn 1995; Craig and Caunter 1990; Henry, Wieland, Powell and Giesy 2001; Nendza 2007;

Opperhuizen, Velde, Gobas, Liem, Steen and Hutzinger 1985; Powell, Annelin and Gallavan 1999; Stevens et al. 2001; Watermann, Daehne, Sievers, Dannenberg, Overbeke, Klijnstra and Heemken 2005). PDMS oils, however, could be toxic under certain conditions (Chapman 2001), and PDMS oils could be sensed by salmonids and affect swimming behavior. Further evaluations are warranted.

Permitting the application of a foul-release type coating to FCRPS facility components is complex, and the costs for permitting are not addressed in this document. Due to the presence of threatened and endangered species in the Columbia River, an Endangered Species Act (ESA) consultation with the National Marine Fisheries Service (NMFS) and the US Fish and Wildlife Service (USFWS) will be required. The USACE would be the lead agency developing the documents for the consultation. The National Environmental Protection Act (NEPA) process, e.g., Environmental Impact Statement through the public review process and agency review, will be informed by the ESA consultation being either formal or informal. Although, foul-release coatings like Sher-Release/ Duplex do not contain biocides, these coatings make pesticidal claims on their product labels, datasheets and/or websites, and are therefore classified as pesticides and are subject to the provisions of FIFRA (Schulze 2009; Steinwand 2009). The Sher-Release/ Duplex system is not currently registered under FIFRA for application to a static hydroelectric facility located in freshwater; this product was originally developed to prevent fouling on the hulls of ocean-going ships. There are several unknowns at this time regarding the FIFRA registration process. Can the paint manufacturers avoid FIFRA registration requirements by removing the pesticidal claims, e.g., chemicals used in ponds to change water color that also control growth of unwanted algae? If coating manufacturers registered their products under FIFRA for use on federal hydroelectric projects, would a full FIFRA registration be required? There are also some uncertainties associated with the Clean Water Act (CWA). It appears that the CWA would be administered by the USEPA in Region 10 instead of by the States of Oregon and Washington because a federal agency would be conducting the actions at federal facilities with federal monies. CWA may not come into play, however, because the components are removed from the water, and the application of the product is done out of the water. Additionally, there may be unique requirements with the Facility Permit that need to be addressed. A Section 10 or 404 permit from the USACE will also be required. Lastly, any actions that may impact fish passage would need approval from the Fish Passage Operation and Maintenance Team, which has already identified the need to conduct a salmonid avoidance test (Wells 2013).

The USACE labor costs are rough estimates. It was difficult to determine all the appropriate USACE personnel that would contribute to this project and how many hours would be billed to the project. This cost estimate identifies the following personnel: Chief, Planning, Environmental Resources and Fish Policy and Support Division; Environmental Stewardship and Compliance

Program Manager; Project Manager for The Dalles Dam Project; two Fish Biologists GS12; Engineer GS11; and three Structural Crew. Estimates of USACE labor distribution during the project period are provided in Tables 5 and 6. Assumptions of labor estimates include daily meetings for thirty minutes with all those working that day present. It is assumed that one person requires 20 minutes to rig a stack of flat bars or gratings for the crane with a total of 20 stacks of bars and 67 stacks of gratings for the East ladder and 6 stacks of bars and 20 stacks of gratings for the North ladder. Another assumption was that hoisting the stacks of gratings and bars with the crane requires three people and 15 minutes per stack. All of these labor estimates were then augmented by 40 to account for unforeseen problems and delays.

The labor costs for the contractors are estimated based on the best available information and were aimed to be representative of the current market. Contractor costs are based on estimates from one to two companies, and these estimates were not provided as a formal bid and may change. The construction contractor cost estimate reflects a crew of 15 with one supervisor for the East ladder and a crew of seven and one supervisor for the North ladder. The construction contractor labor distribution for the East and North ladders is provided in Tables 7 and 8, respectively. Construction contractor labor estimates assume daily meetings for thirty minutes with all personnel present; two people taking seven minutes to move each flat bar into a stack; one person taking 10 minutes to unbolt each grating; two people taking seven minutes to move each grating into a stack; two people taking seven minutes to load each stack onto a flatbed trailer using a forklift; one person taking 10 minutes to tie down each stack to the flatbed trailer; one person taking seven minutes to unload each stack using a forklift at the paint warehouse; and three people taking five minutes to hang each grating on paint racks. Painting contractor labor estimates reflect a crew of nine with one supervisor, and the labor distribution for the East and North ladders is provided in Tables 9 and 10, respectively. It is assumed that one painter can apply a coat to a grating, check the wet film thickness and record the time and date in 10 minutes. It is also assumed that the painting contractors have the equipment and compressed air capacity to simultaneously operate six spray guns and one blasting station. All of these labor estimates were augmented by 40% to account for unforeseen problems and delays.

Table 5: USACE personnel labor estimates (hours) for applying the Sher-Release/ Duplex coating to the gratings in East ladder at The Dalles Dam during the in-water work period (i.e. December through mid-January).

		December																		**January**					
Task	unknown	2	3	4	5	9	10	11	12	16	17	18	19	23	24	25	26	30	31	1	2	6	7	8	9
	date	M	T	W	R	M	T	W	R	M	T	W	R	M	T	W	R	M	T	W	R	M	T	W	R
Pre-planning meetings	46																								
Planning	98																								
Project meeting	15																								
Meeting @ The Dalles		5	5	5	5	5	5	5	6	6	6	6	6					6			6	6	6	6	6
Safety and security		10	10	10	10	10	10	10	10	10	10	10	10					10			10	10	10	10	10
Map/ tag grates		10	10	10	10	10	10	10	10	10	10	10	10					10			10	10	10	10	10
Rigging		8	6	15	6	4	1		4			11						7			8	10			
Crane direction		3	3	10	13	21	8	4	3			9						5			6	7			
Crane		1	1	5	6	10	4	2	3			9						5			6	7			
Inspection									10	10	10	10	10					10			10	10	10	10	10
Personnel (hrs./ day)																									
Chief	2																								
ESPM	6																								
PM	11																								
GS12	95	11	11	11	12	12	12	12	22	22	22	23	22					22			23	22	22	22	22
ENG11	30	11	11	11	11	11	11	11	11	11	11	11	11					11			11	11	11	11	11
SC	15	15	13	33	27	37	15	8	13	3	3	31	3					20			22	27	3	3	3
Daily Total (hours)	159	37	35	55	50	60	38	31	46	36	36	64	36	0	0	0	0	53	0	0	56	60	36	36	36

Table 6: USACE personnel labor estimates (hours) for applying the Sher-Release coating to the gratings in North ladder at The Dalles Dam during the in-water work period (i.e. mid-January through February).

		January												February															
Task	unknown date	13 M	14 T	15 W	16 R	20 M	21 T	22 W	23 R	27 M	28 T	29 W	30 R	3 M	4 T	5 W	6 R	10 M	11 T	12 W	13 R	17 M	18 T	19 W	20 R	24 M	25 T	26 W	27 R
Pre-planning meeting	14																												
Planning	30																												
Project meeting	5																												
Meeting @ The Dalles		2	2	4	4	2	2	2	2	5	4	4	2	2															
Safety and security		10	10	10	10	10	10	10	10	10	10	10	10	10															
Map/ tag grates		10	10	10	10	10	10	10	10	10	10	10	10	10															
Rigging				13						13																			
Crane direction				21	15					14	11	11																	
Crane				5	4					3	3	3																	
Inspection										10	10	10	10	10															
Personnel (hrs./ day)																													
Chief	1																												
ESPM	2																												
PM	3																												
GS12	28	11	11	11	11	11	11	11	11	22	21	21	21	21															
ENG11	9	11	11	11	11	11	11	11	11	11	11	11	11	11															
SC	6			41	21					32	16	16																	
Daily Total (hours)	49	22	22	63	43	22	22	22	22	65	48	48	32	32															

Table 7: Construction contractor labor estimates (hours) for applying Sher-Release/ Duplex to the gratings in the East ladder at The Dalles Dam during the in-water work period (i.e. December through mid-January).

		December																		**January**					
Task	un-known date	2 M	3 T	4 W	5 R	9 M	10 T	11 W	12 R	16 M	17 T	18 W	19 R	23 M	24 T	25 W	26 R	30 M	31 T	1 W	2 R	6 M	7 T	8 W	9 R
Project meeting	4																								
Meeting @ The Dalles		8	8	8	8	8	8	8	8	8	8	8	8					8			8	8	8	8	
Supervise		10	10	10	10	10	10	10	10	10	10	10	10					10			10	10	10	10	
Stack grates & bars		55	69	65	99	49	30																		
Unbolt grates		87	81	31	14	11	10																		
Forklift/ tie down/ unload				9		28	20	6																	
Hang grates				14	14	13	62	126	36	43	42														
Unload racks/stack							14	14	56	56	42	42	42					42			28	14			
Forklift/ tie down									8	8	6	4						4				4			
Position & bolt grates									40	55	71	79	116					72			53	57	56		
Cleanup/ breakdown																							50	4	
Personnel (hrs./day)																									
Supervisor	4	11	11	11	11	11	11	11	11	11	11	11	11					11			11	11	11	11	
Journeyman	0	149	157	126	134	108	143	153	147	169	168	132	165					125			88	82	113	11	
Daily Total (hours)	4	160	168	137	145	119	154	164	158	180	179	143	176	0	0	0	0	136	0	0	99	93	124	22	0

Table 8: Construction contractor labor estimates (hours) for applying the Sher-Release/ Duplex coating to the gratings in the North ladder at The Dalles Dam during the in-water work period (i.e. mid-January through February).

		January												February															
Task	un-known date	13	14	15	16	20	21	22	23	27	28	29	30	3	4	5	6	10	11	12	13	17	18	19	20	24	25	26	27
		M	T	W	R	M	T	W	R	M	T	W	R	M	T	W	R	M	T	W	R	M	T	W	R	M	T	W	R
Project meeting	1																												
Meeting @ The Dalles		6	6	6	6	6	6	6	6	6	6	6	6	6															
Supervise		10	10	10	10	10	10	10	10	10	10	10	10	5															
Stack grates & bars		12	64	34																									
Unbolt grates		61	9																										
Forklift/ tie down/ unload				6	13																								
Hang grates					39	67																							
Unload racks/stack							21	28	28	28																			
Forklift/ tie down							2	2	2	2																			
Position & bolt grates										15	62	62	40																
Cleanup/ breakdown													14	2															
Personnel (hrs./day)																													
Supervisor	1	11	11	11	11	11	11	11	11	11	11	11	11	6															
Journeyman		78	78	45	57	72	28	35	35	50	67	67	59	7															
Daily Total (hours)	1	89	89	56	68	83	39	46	46	61	78	78	70	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 9: Industrial painter contractor labor estimates (hours) for applying the Sher-Release/ Duplex coatings to the gratings in the East ladder at The Dalles Dam during the in-water work period (i.e. December through mid-January).

		December																		January					
Task	un-known date	2 M	3 T	4 W	5 R	9 M	10 T	11 W	12 R	16 M	17 T	18 W	19 R	23 M	24 T	25 W	26 R	30 M	31 T	1 W	2 R	6 M	7 T	8 W	9 R
Project meeting	14																								
Meeting @ warehouse		7	46	7	7	7	7	7	7	7	7	7	7	7				7				7			
Supervise		10	5	10	10	10	10	10	10	10	10	10	10	10				10				10	10		
Clean, dry and prime				56	56	56	56	56	56	56	56	56	56												
Tie coat					28	22	22	22	22	22	22	22	22	50				22							
Topcoat						22	22	22	22	22	22	22	22	50				50							
Cleanup/ Breakdown				2	2	3	3	3	3	3	3	3	3	2				2				2			
Personnel (hrs./day)																									
Supervisor	14	11	10	11	11	11	11	11	11	11	11	11	11	11				11				11			
Journeyman	0	6	41	64	92	109	109	109	109	109	109	109	109	108				80				8	10		
Daily Total (hours)	14	17	51	75	103	120	120	120	120	120	120	120	120	119	0	0	0	91	0	0	0	19	10	0	0

Table 10: Industrial painter contractor labor estimates (hours) for applying Sher-Release/ Duplex coating to the gratings in the North ladder at The Dalles Dam during the in-water work period (i.e. mid-January through February).

		January												February															
Task	un-known date	13	14	15	16	20	21	22	23	27	28	29	30	3	4	5	6	10	11	12	13	17	18	19	20	24	25	26	27
		M	T	W	R	M	T	W	R	M	T	W	R	M	T	W	R	M	T	W	R	M	T	W	R	M	T	W	R
Project meeting	1																												
Meeting @ warehouse				7	7	7	7	7	7	7																			
Supervise				10	10	10	10	10	10	10	10																		
Clean, dry and prime					95	64	10																						
Tie coat						31	31	22																					
Topcoat							22	31	31																				
Cleanup/ Breakdown					2	2	3	3	2	80																			
Personnel (hrs./day)																													
Supervisor	1			11	11	11	11	11	11	11	10																		
Journeyman	0			6	103	103	72	62	39	86																			
Daily Total (hours)	**1**	**0**	**0**	**17**	**114**	**114**	**83**	**73**	**50**	**97**	**10**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Estimating costs of using foul-release type coatings to mitigate *Dreissena* sp. macrofouling at a FCRPS facility

For purposes of this cost estimate, the paint materials are listed separately in the budget. The painting contractor, however, would typically provide all labor, materials, tools and equipment necessary to complete the coating system in accordance with the provided specifications. This means that the paint material costs would be included in the bid from the painting contractor. The painting contractor will handle, store, transport and dispose of hazardous waste materials in compliance with Federal and State Government Hazardous Waste Regulations. Painting contractor will fully protect all equipment, walls, floors, ceilings, and other surfaces of leased warehouse from damage by paint drippings, paint mist, and other contaminants. USACE maintains ownership of gratings and flat bars and is responsible for shipment to and from paint facilities. Construction contractor shall provide all the labor, materials, tools and equipment to remove gratings and load onto flatbed trucks, except for the forklifts and the operation of the crane and rigging equipment. Forklifts, crane and rigging equipment are the responsibility of USACE.

Paint materials costs were estimated using the total area of grating and flat bar to be coated plus an additional 20% to 40% for overspray and loss. One 5-gallon kit can cover an area of approximately 93-m^2 (1,000-ft^2) and this kit includes the epoxy primers, tie coat and topcoat. The approximate costs for a 5-gallon kit are provided in Table 11 (Hampton 2013). The total surface area of the gratings was calculated for a 61-cm (24-in.) x 213-cm (84-in.) x 3.8-cm (1.5-in.) grating. The thickness of the flat bar stock was estimated based on photographs to be 1-cm (0.4-in.) wide and the space between the stock to be 2.54-cm (1-in.) wide. The surface area of each grating was calculated to be 53,837-cm^2 (8,344.8-in^2). There are a total of 1,300 gratings and 40% was added to the area calculations to account for overspray and loss. Therefore, the total surface area of grating to be coated was 9,798-m^2 (105,469-ft^2). The flat bar area was calculated for a 610-cm (240-in.) x 25.4-cm (10-in.) x 0.5-cm (0.188-in.) flat bar. The total surface area per bar was calculated to be 31,574-cm^2 (4,894-$in.^2$) and there were estimated to be 156 bars. A twenty percent loss factor was used for overspray and loss associated with painting flat bars. Therefore, the total surface for flat bars was 591-m^2 (6,363-ft^2). The total surface area of the 1,300 gratings and the 156 flat bars to be coated was 10,390-m^2 (111,832-ft^2). These calculations indicate that 112 5-gallon kits are needed for coating the 1,300 gratings and 156 flat bars.

Table 11: Estimated price for a 5-gallon kit of the Sher-Release/ Duplex foul-release coating system.

QTY	Product	Unit	Price/ unit	Total
5	Epoxy 1	gallon	40.25	201.25
5	Epoxy 2 with tethering agent	gallon	40.30	201.50
5	Tie coat	gallon	267.50	1,337.50
5	Top coat	gallon	355.00	1,775.00
			Total	**$3,515.25**

Paint equipment and supplies costs are calculated for paint consumables, safety and blasting based on rates provided by an industrial painter. Paint consumables, e.g., plastic, tape, masking supplies, tarps, spray tips, buckets, measuring cups, etc., are billed at $4/ hr. painting time (Cornelius 2013). A total of 1,013 painting hrs. was estimated for this project. Safety sundries, e.g., respirator cartridges, tyvec suits, chemical gloves, head socks, coveralls, etc. are billed at $4/ hr. for painting, blasting and cleaning activities (Cornelius 2013). A total of 1,419 painting, blasting and cleaning hrs. was estimated for this project. Blasting sundries, e.g., abrasive media, are billed at $6/ hr. (Cornelius 2013). A total of 365 blasting hrs. was estimated for this project.

The costs for leasing a warehouse are estimated based on the best available information and were aimed to be representative of the current market. Warehouse leasing information was obtained through a commercial real estate broker and online searches. According to a commercial real estate broker, the market is rapidly improving and it will become more difficult and expensive to find landlords willing to agree to a four month lease (Bowman 2013). The price per square foot will likely be increased for short-term leases (Bowman 2013). This cost estimate reflects $0.44 per square foot, which represents an approximate 10% increase from the typical rate of $0.34 to $0.40 per square foot (Bowman 2013). This estimate assumes costs for triple net, which includes taxes, insurance and routine maintenance, to be $0.08 per square foot, and this value is fairly typical according to Bowman (2013). Utilities are the last cost associated with leasing a warehouse and utilities include gas, electric and phone (Bowman 2013). Utilities vary widely depending on the type of industry and it is difficult to estimate these costs (Bowman 2013). Utilities were estimated at $0.10 per square foot. Approximately 22,000 square feet of warehouse space is required for cleaning, painting, drying and curing 1,300 gratings and 156 flat bars within the project period. Warehouse space will also be used to assembly paint racks.

Renting or purchasing pole tents was explored as an option to mitigate inclement weather. There is a large empty lot located on the North shore of The Dalles Dam that could be used to set-up several large pole tents (Cordie 2013). Generators could be rented to provide electricity for heaters, dehumidifiers, lighting and air compressors. The tents for rent, however, are intended for weddings, receptions and other public events and the rental companies that were contacted would not allow them to be used for painting booths. Pole tents, not including walls, that are 6.1-m (20-ft) x 12.2-m (40-ft) are approximately $3,800 to purchase new and a 18.3-m (60-ft) x 48.8-m (160-ft) tent without walls is approximately $36,000 to purchase new. Therefore, it would require more than $87,000 to purchase new tents to meet space requirements, and these costs do not include tent walls or rentals for generators, heaters, dehumidifiers, lighting, fuel and security fencing. Used tents are available for purchase at a reduced price and this would likely be the best option for using pole tents for the painting station. It would be easier to control ambient temperature and humidity and provide electricity and security in a leased warehouse compared to pole tents, and the costs were comparable.

The weight of the gratings was estimated at 90.7-kg (200-lbs.) per grating. Grating weight was used to estimate freight shipping costs and loads on paint rack. The maximum weight per flatbed load is 20,412-kg. (45,000 lbs.), and 12 truckloads would be needed to ship gratings and bars to and from painting warehouse (Broome 2013). The National Motor Freight Classification (NMFC) class of 200 was used for the gratings. This classification evaluates an item's transportability depending on density, stowability, handling and liability (Broome 2013).

The costs for making paint racks was estimated for a design using angle steel bolted together. Angle steel 5.1-cm x 5.1-cm x 0.477-cm (2-in. x 2-in. x 0.188-in.) would be marked and drilled using 3/8" bits and a drill press and assembled using 5/16" hex bolts with flat washers, split lock washers and hex nuts. A quote for angle steel cut to dimensions was obtained from Metal Supermarkets and a quote for hardware was obtained from Oregon Bolt, Inc. Assembly is done by general laborers with total labor estimated at 640 hours, and labor costs estimated at $25/ hour. Assembly is done at the leased warehouse prior to the start of painting. Labor costs for paint rack assembly are included within total paint rack cost listed under equipment/ supplies in the project budget. Metal fabrication shops were contacted and provided schematic drawings in order to get an estimate on costs for welded construction, but no metal fabrication shops responded with estimates. Cost estimates for materials used to make 240 paint racks are provided in Table 12.

Table 12: Cost estimates for materials used to make 240 paint racks. Two gratings will be hung from each paint rack for cleaning, painting, drying and curing.

Qty	Product	Length/ Unit	Unit price	Total
480	HOT ROLLED ANGLE 2.000 X 2.000 X 0.188	96-in.	0.26	11,980.80
480	HOT ROLLED ANGLE 2.000 X 2.000 X 0.189	42-in.	0.26	5,241.60
480	HOT ROLLED ANGLE 2.000 X 2.000 X 0.190	60-in.	0.26	7,488.00
480	1/4"-20 x 3" SHOULDER MACHINE EYE BOLT		1.60	768.00
480	1/4"-20 FIN HEX NUT HDG		0.0246	11.81
480	1/4" USS FLAT WASHER HDG		0.01928	9.25
2400	5/16"-18 x 1-1/4" HEX CAP SCR GRD 2 HDG		0.1018	244.32
4800	5/16" USS FLAT WASH HDG		0.0592	284.16
2400	5/16" FIN HEX NUT HDG		0.0322	77.28
2400	5/16" SPLIT LOCK WASH HDG		0.0316	75.84
960	3-1/2" S HOOK ZN		2.10	2,016.00
15	3/8" BLACK OXIDE DRILL BIT		5.97	89.55
960	SWIVEL STEM CASTER WHEEL		10.39	9,974.40
			TOTAL	**$38,261.01**

Application Procedures

Application procedures

All cleaning and blasting is to be performed employing techniques in accordance with the product datasheets (Appendix A) and SSPC standards required for that particular area. All oil and/or grease contamination shall be removed by SSPC-SP1 Solvent Cleaning or other suitable means before starting blast cleaning. Blasting anchor profiles will be as recommended by FUJIFILM Smart Surfaces, LLC and blast cleaning will be scheduled so that coating can be applied to comply with FUJIFILM Smart Surfaces LLC recommendations. The abrasive media will be of sufficient size to yield the specifications for the specified anchor profile and degree of cleanliness. Impurities and or inclusions from the blasting media will not be allowed to remain on or become imbedded in the cleaned surface. Abrasive blasting will be done on surfaces during times that will not be wet after blasting or before painting. The surface will be swept clean with fresh, light abrasive blasting prior to application if determined necessary by painting contractor. Cleaning will be done so that dust and abrasive blasting debris does not interfere with painting operations and contaminate freshly coated surfaces.

All spray painting will be in accordance with FUJIFILM Smart Surfaces LLC recommendations using either conventional or airless spray. Each coat is continuously applied to all surfaces of the component and then allowed to dry for the appropriate time as determined by ambient conditions, coat thickness and according to product datasheets (Appendix A). Primer will be applied to cleaned surfaces before any rusting occurs. Surface temperature must be at least 15°C (5°F) above the dew point with no visible moisture on the surface before application may proceed. All coats will be allowed to dry thoroughly, but not less than manufacturer's specified time prior to application of a succeeding coat. Maximum re-coat windows will be adhered to at all times. All coating film thickness will be as specified in product datasheets and will be spot-checked during application with a wet mil gauge and after drying and curing with a calibrated dry film thickness gauge. Large surfaces will always receive passes in two directions at right angles to each other (cross-hatched). Parallel passes are acceptable in all other areas. Coating may be brushed on all areas that cannot be properly spray coated using brushes of style and quality that will enable proper application of materials. Coating will be worked into all crevices and corners, and all runs or sags will be brushed out in order to insure no air pockets, solvent bubbles, voids, or areas of excessive buildup.

State of the art equipment and application techniques will be used. An adequate moisture trap will be placed between the air supply and pressure feed to gun. Trap will continually bleed off any water or oil from air supply. Suitable and working regulators and gauges will be used for both air supply to pressure-pot and air supply to pressure gun. Separate regulators will be used to adjust the paint pot pressure and atomization pressure. Each regulator will be provided with a pressure gauge operating properly at all times. Atomizing air and paint pot pressure will each be regulated to the minimum amount required to properly atomize material for application without dry spray, runs or sags.

All coating components will be thoroughly stirred before, during and after mixing. The mixed coatings shall be continuously stirred by mechanical agitators or other approved means. The volume to be mixed will be accurately measured.

Containers, holding times and ambient conditions

All coating materials furnished by coating contractor and FUJIFILM Smart Surfaces LLC will be furnished in unopened, clearly identifiable containers. Mixing of different manufacturer's coatings shall not be permitted. Containers shall remain unopened until required for use. No coating will be used that has expired its shelf life. No coating will be used other than specified. All mixing will be done in clean containers, free from traces of grease, other types of coatings or other contaminants. All containers will be kept covered to prevent contamination by dust, dirt or rain. Paint and cleaners will be stored in a cool dry location prior to the start of the project. Paint will be moved into the drying area and warmed to ambient temperatures approximately 24 hours prior to application for optimal results (Hampton 2013).The paint supervisor will record shelf life and batch numbers stamped on containers when materials are opened for use. When the pot life is reached, the spray equipment will be emptied, the material destroyed and new material mixed. Indoor painting is allowed 24 hours a day if the specified metal and air temperatures and relative humidity requirements are met inside the building at all times during preparation, painting and curing. Painting contractor will obtain and follow the manufacturer's recommendations for drying and curing times at all temperatures. Ambient conditions will be controlled using heaters and dehumidifiers as needed to achieve desired curing times, i.e. drying time between coats is decreased at higher temperatures and lower humidity. The date and time for the application of each coat will be recorded on datasheets attached to each paint rack to ensure proper tracking.

Paint evaluation

Paint evaluation consists of measuring viscosity and wet film thickness (WFT), determining appropriate coverage and the minimum time to recoat and identifying potential problems during application and curing, e.g., presence of orange peel, fisheyes. In some cases, thinner is added to modify paint viscosity to improve spray ability, and this is measured by the painter using a viscosity cup (Music 2011). WFT is measured using a wet mil gauge that is pressed into the paint film immediately after application, and this is done to ensure each coat is appropriate thickness and that coverage is uniform (Music 2011). Painted surfaces are visually inspected after painting and drying to inspect for potential problems such as adhesion problems due to contamination (e.g., silicone or oil) indicated by fish-eyes, and improper application (e.g., viscosity, insufficient air pressure, wrong nozzle size, fluid flow, spray gun distance, etc.) indicated by orange peel (Music 2011). Dry film thickness of coating is spot checked on the finished product using a calibrated dry film thickness gauge. The curing time before immersion service is determined by temperature and humidity, and records of ambient conditions and holding times will be used to determine when gratings can be returned to service.

Equipment cleaning

Painting equipment is cleaned as needed using appropriate cleaners according to product datasheets (Appendix A) and as determined by painters. Lines and pot must be cleaned before adding new materials.

Product ID

Gratings are mapped and tagged before they are removed from fishways to identify each grating and its specific deployment location within facility. Tags are tied to grating and tag is transferred to the paint rack when gratings are hung for cleaning and painting. The date and time each coat is applied to a grating is recorded on the tag attached to the paint rack. Paint materials and cleaners are identified with a unique batch number and shelf life stamped on containers, and these numbers are recorded when containers are opened.

Chain of custody

USACE Fish Biologist GS12 personnel are responsible for mapping and tagging grating as it is removed from the fishway, and these data are also recorded in field datasheets maintained by USACE personnel. A bill of lading is completed by USACE Fish Biologist GS12 for each truckload of gratings and flat bars being shipped to painting warehouse, and these documents are transferred to the painting contractor supervisor when received. Construction contractors are responsible for unloading gratings from truck and loading onto paint racks, and these activities are monitored by the construction contractor supervisor. Painting contractor supervisor is responsible for tracking the gratings during the paint application process and this includes transferring the grating tags from each grating to the paint rack upon receipt, recording the date and time that each coat is applied, maintaining datasheets recording ambient conditions in paint warehouse, transferring tags on paint racks back onto each grating after curing, and completing a bill of lading for each truckload shipped to The Dalles Dam Project. The freight shipping company maintains responsibility for the materials during shipment. These articles and materials become the responsibility of USACE personnel when received at the Project.

Quality Control

Field and lab QC

Quality assurance and quality control (QA/QC) procedures in the field are the responsibility of USACE. Field QA/QC procedures include mapping and tagging grating during removal from fishway and inspection during and after installation to ensure compliance with FPP. Mapping is done to record individual grating position so that custom gratings can be reinstalled in the original position; approximately 40% of the grating is custom (Cordie 2013). Gratings are tagged to also track them throughout handling, transport, painting, drying, curing and installation.

Laboratory QA/QA procedures are the responsibility of the painting contractor supervisor, who is expected to cooperate with USACE and FUJIFILM Smart Surfaces LLC and allow access to all phases of the surface preparation and painting work. Laboratory QA/QC procedures include tracking gratings throughout painting process, recording ambient conditions and inspecting coatings for appropriate coverage and application. Each grating is tracked throughout the painting, drying and curing process using the tags attached to the paint rack, which record the time and date each coat is applied. Ambient conditions in the painting warehouse including the dry bulb temperature, wet bulb temperature, relative humidity, surface temperature and dew point are recorded at the onset of painting and thereafter at least every two hours when paint is being applied each day. Paint viscosity is measured using a viscosity cup and wet film thickness is measured by painters immediately after application using a wet mil gauge.

The finished work shall not contain sags, runs, wrinkles, spots, blisters, or other application flaws that cause premature coating failure. Prior to final acceptance, a final inspection shall be made by USACE, and the painting contractor supervisor. Dried and cured painted surfaces may be inspected with an Elcometer, Mikrotest II or III, or other calibrated dry film-thickness gauge.

Corrective action

USACE shall reject any coating system that does not conform to the specifications and contract drawings. All rejected work shall be repaired by painting contractor. Holidays in the final coat at edges, corners, welds and inaccessible areas may be repaired by hand brushing or spraying an additional layer of topcoat provided excessive buildup does not occur. Damage to intermediate coats, prior to application of the next coat, will be repaired by painting contractor to provide the coating sequence and film thickness as specified in product datasheets (Appendix A). Appropriate surface preparation shall be utilized before application of repairs. Areas where the coating system is damaged shall be repaired by power wire brushing down to the prime coat (if the prime coat has not been damaged) followed by application of the following coat(s). Areas where the coating system is damaged through the prime coat shall be repaired by abrasive blasting the area and applying the coating system as specified.

Budget

The total costs estimated to apply the Sher-Release/ Duplex foul-release coating system to 1,300 AWS diffuser gratings and 156 flat bars within the in-water work period for the East and North ladders located at The Dalles Dam Project is provided in Table 14. The detailed budget is provided in Table 15 and partitions labor for USACE personnel, construction contractors, industrial painting contractors and coating manufacturer technical support as well as individual costs for the types of equipment/ supplies and the other direct costs. The estimated total costs to apply the Sher-Release/ Duplex coating system to the 1,300 gratings and 156 steel bars from the adult fishways at The Dalles Dam Project are $1,111,855. The total surface area of components to be coated was estimated to be 10,390-m^2 (111,832-ft^2). Therefore, the costs to apply the Sher-Release/ Duplex system is $107/ m^2 ($9.94/ ft^2).

Table 13: A brief budget for the project showing costs for labor, equipment/ supplies and other direct costs to apply Sher-Release/ Duplex to 1,300 AWS diffuser gratings and 156 flat bars within the in-water work period for the North and East fishways at The Dalles Dam Project.

	$$$
Labor	572,217
Equipment/ supplies	466,277
Other	73,361
Direct Costs	**1,111,855**

Table 14: Detailed budget for applying Sher-Release/ Duplex coating to 1,300 AWS diffuser gratings and 156 flat bars at The Dalles Dam Project within the in-water work period.

	Rate	$$$
Labor		
USACE		
Chief, Planning, Environmental Resources and Fish Policy and Support Division	$145.88/ hr. @ 3 hrs.	438
Environmental Stewardship and Compliance Program Manager	$97.05/ hr. @ 8 hrs.	776
Project Manager, The Dalles Dam Project	$97.05/ hr. @ 14 hrs.	1,359
Fish Biologist GS12, Project Lead	$75.64/ hr. @ 642 hrs.	48,561
Engineer GS11, Safety and Security Officer	$73.59/ hr. @ 380 hrs.	27,964
Structural Crew, Crane Operator	$84.47/ hr. @ 402 hrs. + $113.66/ hr. OT @ 24 hrs.	36,685
Construction Contractor		
Supervisor	$110/ hr. @ 301 hrs. + $151.50/ hr. OT @ 29 hrs.	37,504
Journeyman	$105/ hr. @ 2,768 hrs. + $144.62/ hr. OT @ 80 hrs.	302,210
Industrial Painting Contractor		
Supervisor	$60/ hr. @ 245 hrs. + $85/ hr. OT @ 21 hrs.	16,485
Journeyman	$53/ hr. @ 1,554 hrs. + $73/ hr. OT @ 198 hrs.	96,816
FUJIFILM Smart Surfaces LLC		
VP Marketing and Technical Support	$95/ hr. @ 36 hrs.	3,420
Equipment/ Supplies		
Painting consumables	$4/ hr. painting @ 1,012.5 hrs.	4,050
Blasting sundries	$6/ hr. cleaning @ 364.5 hrs.	2,187
Painting safety sundries	$4/ hr. cleaning/painting @ 1,419 hrs.	5,676
Paint racks (metal, wheels, hardware and assembly)	Materials @ $38,261 + labor @ $25/ hr. @ 640 hrs.	54,261
Sher-Release/ Duplex coating materials	$3,515.25/ 5-gal. kit @ 112 kits	393,708
Cleaners	$14.39/ gal @ 56 gallons	806
Thinner	$23.02/ gal @ 56 gallons	1,289
4-ply 14' nylon rigging sleeves	$186.34/ ea. @ 8	1,491
super duty ratchet tie down	$26.99/ ea. @ 30	810
polyethylene foam 1/8" thick x 50'	$99.99/ ea. @ 20	2,000
Other		
Freight shipping	$760 per truckload @ 12 truckloads	9,120
Forklift rental 5K electric forklift w/ charger	$1,575/ mo./ ea. @ 2 units @ 3 mo. + $85/ hr. pickup/delivery @ 11 hrs.	10,385
Warehouse leasing	$0.44/ SF/mo. + $0.08/ SF/mo. triple net + $0.10/ SF/mo. utilities @ 21,716 SF for 4 months	53,856
Total Direct Costs		**$1,111,855**

Conclusions

The Sher-Release/ Duplex foul-release coating system is expensive, and the estimated costs for component removal, cleaning, painting and reinstallation, including labor, equipment and supplies and other direct costs were comparable to previous cost estimates for other foul-release coating systems. The total costs for applying the Sher-Release/ Duplex system to 1,300 AWS diffuser gratings and 156 flat bars located in the adult fish passage facilities located at The Dalles Dam Project within the in-water work period are $1,111,855 which breaks down to $107/ m^2 (9.94/ ft^2). Previous cost estimates for applying foul-release coating systems, including labor, installation and materials, were estimated between $44/ m^2 to $127/ m^2 (EPRI 1992; Gross 1997; Jones-Meehan et al. 1999).

Costs are exacerbated by the short turnaround time dictated by the in-water work period. Construction contractors were used for a bulk of the grating removal and reinstallation because it was assumed that USACE personnel would be unable to complete all of the project tasks in addition to the other scheduled maintenance and activities occurring during the in-water work period. Overtime was also billed in order to complete tasks within identified timelines.

There are cost saving measures that could be implemented when applying a foul-release type coating to a FCRPS facility component. Labor costs can be reduced by extending the project period over multiple years to reduce the amount of overtime billed. Construction contractor labor costs may be reduced through competitive bidding or by using USACE structural crew for more of the component removal and installation. Long-term investments in certain infrastructure, e.g., paint racks and pole tents, and coordinating the application between different FCRPS facilities and sharing this equipment, can be used to reduce equipment costs and costs associated with leasing a warehouse for paint application during the winter. It was not cost effective to buy large pole tents for the application of the Sher-Release/ Duplex system to the components at one USACE Project. Purchasing tents, however, may be cost effective if foul-release coatings are applied to multiple facilities over several years, and tents are shared amongst Projects. The paint racks made for applying the Sher-Release/ Duplex system to the gratings at The Dalles Dam could be used for painting gratings located at other facilities in the future. Paints racks would need to be stored, but these costs would likely be less than the materials and labor used to make new.

Foul-release type coatings including the Sher-Release/ Duplex coating system, are not a viable macrofouling option for FCRPS facilities at this time because none are registered under FIFRA for use in freshwater facilities to the authors' knowledge. Sher-Release/ Duplex, Intersleek970 and HempasilX3 are commercially available foul-release coatings that are effective against macrofouling and the topcoats of these coating systems do not contain biocides; however, these coatings make pesticidal claims and hence, are considered pesticides requiring registration under

FIFRA. Additionally, it is unknown if the Sher-Release/ Duplex coating or other commercially available foul-release coating systems affect salmonid behavior and fish passage.

Recommendations/ Next Steps

- Elucidate the permitting process and develop the costs for permitting the application of foul-release coatings to a FCRPS facility. Engage NMFS, USFWS, USEPA and others to explore permitting options and possible exemptions and other ways to comply with existing regulations regarding the use of foul-release coatings. Encourage coating manufacturers to register their products under FIFRA for use in freshwater hydropower facilities.

- Conduct experiments to determine if salmonid swimming behavior is affected by foul-release coating systems such as Sher-Release/ Duplex and Intersleek 970. If a foul-release system affects fish swimming behavior, this may impact fish passage and thus limit its application in fish passage facilities.

- Develop cost estimates for other control options for FCRPS components to aid cost/ benefit analyses. For example, what are the estimated costs to remove, manually clean and reinstall the 1,300 AWS diffuser gratings at The Dalles Dam Project?

- Continue developing a regional *Dreissena* sp. control roadmap that includes USBR facilities in the Northwest Region and USACE facilities in the Northwestern Division to identify best control options, predict rates of mussel colonization, increase coordination and efficacy and reduce costs. Pilot Projects can be used to better inform cost estimates and the efficacy of different control options by learning from others. Resources can be shared between facilities when possible to reduce costs, e.g. pole tents for protection from inclement weather and paint racks. Experiences from USBR and USACE facilities in waters infested with *Dreissena* can be used to inform the control roadmap.

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Appendix A

Protective & Marine Coatings

SHERWIN WILLIAMS

MACROPOXY® 646-100 FAST CURE EPOXY

PART A	B58-620	SERIES
PART B	B58V620	HARDENER

Revised: May 6, 2013

PRODUCT INFORMATION

4.52

PRODUCT DESCRIPTION

MACROPOXY 646-100 FAST CURE EPOXY is a high solids, less than 100 g/L VOC, high build, fast drying, polyamide epoxy designed to protect steel and concrete in industrial exposures. Ideal for maintenance painting and fabrication shop applications. The high solids content ensures adequate protection of sharp edges, corners, and welds. This product can be applied directly to marginally prepared steel surfaces.

- Low VOC,<100 g/L
- Low odor
- Outstanding application properties
- Chemical resistant
- Abrasion resistant

PRODUCT CHARACTERISTICS

Finish:	Semi-Gloss
Color:	Mill White and a wide range of colors available through tinting
Volume Solids: Mill White	73% ± 2%, mixed
Weight Solids: Mill White	83% ± 2%, mixed
VOC (EPA Method 24): mixed	Unreduced: <100 g/L; .83 lb/gal Reduced 10%: <100 g/L; .83 lb/gal
Mix Ratio:	1:1 by volume

Recommended Spreading Rate per coat:

	Minimum		Maximum	
Wet mils (microns)	**7.0**	(175)	**13.5**	(338)
Dry mils (microns)	**5.0***	(125)	**10.0***	(250)*
~Coverage sq ft/gal (m^2/L)	**116**	(2.8)	**232**	(5.7)
Theoretical coverage **sq ft/gal** (m^2/L) @ 1 mil / 25 microns dft	**1168**	(28.6)		

NOTE: Brush or roll application may require multiple coats to achieve maximum film thickness and uniformity of appearance.

*See Recommended Systems on reverse side. See Performance Tips section also.

Drying Schedule @ 7.0 mils wet (175 microns):

	@ 40°F/4.5°C	@ 77°F/25°C 50% RH	@ 100°F/38°C
To touch:	4-5 hours	2 hours	1.5 hours
To handle:	48 hours	8 hours	4.5 hours
To recoat:			
minimum:	48 hours	8 hours	4.5 hours
maximum:	1 year	1 year	1 year
Cure for			
service:	10 days	7 days	4 days
immersion:	14 days	7 days	4 days

If maximum recoat time is exceeded, abrade surface before recoating.
Drying time is temperature, humidity, and film thickness dependent.

Pot Life:	10 hours	4 hours	2 hours
Sweat-in-time:	30 minutes	30 minutes	15 minutes

Shelf Life:	36 months, unopened Store indoors at 40°F (4.5°C) to 100°F (38°C).
Flash Point:	61°F (16°C), PMCC, mixed
Reducer/Clean Up:	Reducer R7K111 or Oxsol 100

RECOMMENDED USES

- Marine applications
- Fabrication shops
- Pulp and paper mills
- Power plants
- Offshore platforms
- Refineries
- Chemical plants
- Tank exteriors
- Water treatment plants

- Mill White is acceptable for immersion use for salt water and fresh water
- Not acceptable for potable water
- Suitable for use in USDA inspected facilities
- Conforms to AWWA D102 OCS #5
- Approved with FIRETEX hydrocarbon coatings

PERFORMANCE CHARACTERISTICS

Substrate*: Steel
Surface Preparation*: SSPC-SP10/NACE 2
System Tested*:
1 ct. Macropoxy 646-100 Fast Cure @ 6.0 mils (150 microns) dft
*unless otherwise noted below

Test Name	Test Method	Results
Abrasion Resistance	ASTM D4060, CS17 wheel, 1000 cycles, 1 kg load	84 mg loss
Accelerated Weathering - QUV[1]	ASTM D4587, QUV-A, 12,000 hours	Passes
Adhesion	ASTM D4541	1,037 psi
Corrosion Weathering[1]	ASTM D5894, 36 cycles, 12,000 hours	Rating 10 per ASTM D714 for blistering; Rating 9 per ASTM D610 for rusting
Direct Impact Resistance	ASTM D2794	30 in. lb.
Dry Heat Resistance	ASTM D2485	250°F (121°C)
Exterior Durability	1 year at 45° South	Excellent, chalks
Flexibility	ASTM D522, 180° blend, 3/4" mandrel	Passes
Immersion	1 year fresh and salt water	Passes, no rusting, blistering, or loss of adhesion
Pencil Hardness	ASTM D3363	3H
Salt Fog Resistance[1]	ASTM B117, 6,500 hours	Rating 10 per ASTM D610 for rusting; Rating 9 per ASTM D1654 for corrosion
Water Vapor Permeance	ASTM D1653, Method B	1.16 grains/day

Epoxy coatings may darken or discolor following application and curing.

Footnotes:
[1] Zinc Clad II Plus Primer

www.sherwin-williams.com/protective

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Protective & Marine Coatings

MACROPOXY® 646-100 FAST CURE EPOXY

PART A	B58-620	SERIES
PART B	B58V620	HARDENER

PRODUCT INFORMATION

RECOMMENDED SYSTEMS

		Dry Film Thickness / ct. Mils	(Microns)
Immersion and atmospheric:			
Steel:			
2 cts.	Macropoxy 646-100	5.0-10.0	(125-250)
Concrete/Masonry, smooth:			
2 cts.	Macropoxy 646-100	5.0-10.0	(125-250)
Concrete Block:			
1 ct.	Kem Cati-Coat HS Epoxy Filler/Sealer as needed to fill voids and provide a continuous substrate.	10.0-20.0	(250-500)
2 cts.	Macropoxy 646-100	5.0-10.0	(125-250)
Atmospheric:			
***Steel:** (Shop applied system, new construction, AWWA D102, can also be used at 3 mils (75 microns) dft when used as an intermediate coat as part of a multi-coat system)			
1 ct.	Macropoxy 646-100 Fast Cure Epoxy	3.0-6.0	(75-150)
1-2 cts.	of recommended topcoat		
Steel:			
1 ct.	Recoatable Epoxy Primer	4.0-6.0	(100-150)
2 cts.	Macropoxy 646-100	5.0-10.0	(125-250)
Steel:			
1 ct.	Macropoxy 646-100	4.0-6.0	
1-2 cts.	Acrolon 218 Polyurethane	3.0-6.0	(75-150)
or	Hi-Solids Polyurethane	3.0-5.0	(75-125)
or	SherThane 2K Urethane	2.0-4.0	(50-100)
Steel:			
2 cts.	Macropoxy 646-100	5.0-10.0	(125-250)
1-2 cts.	Tile-Clad HS Epoxy	2.5-4.0	(63-100)
Steel:			
1 ct.	Zinc Clad II Plus	3.0-6.0	(75-150)
1 ct.	Macropoxy 646-100	5.0-10.0	(125-250)
1-2 cts.	Acrolon 218 Polyurethane	3.0-6.0	(75-150)
Steel:			
1 ct.	Zinc Clad III HS	3.0-5.0	(75-125)
or	Zinc Clad IV	3.0-5.0	(75-125)
1 ct.	Macropoxy 646-100	5.0-10.0	(125-250)
1-2 cts.	Hi-Solids Polyurethane-100	3.0-6.0	(75-150)
Aluminum:			
2 cts.	Macropoxy 646-100	5.0-10.0	(125-250)
Galvanizing:			
2 cts.	Macropoxy 646-100	5.0-10.0	(125-250)

The systems listed above are representative of the product's use, other systems may be appropriate.

DISCLAIMER

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SURFACE PREPARATION

Surface must be clean, dry, and in sound condition. Remove all oil, dust, grease, dirt, loose rust, and other foreign material to ensure adequate adhesion.

Refer to product Application Bulletin for detailed surface preparation information.

Minimum recommended surface preparation:

Iron & Steel	
Atmospheric:	SSPC-SP2/3
Immersion:	SSPC-SP10/NACE 2, 2-3 mil (50-75 micron) profile
Aluminum:	SSPC-SP1
Galvanizing:	SSPC-SP1
Concrete & Masonry	
Atmospheric:	SSPC-SP13/NACE 6, or ICRI No. 310.2, CSP 1-3
Immersion:	SSPC-SP13/NACE 6-4.3.1 or 4.3.2, or ICRI No. 310.2, CSP 1-3

Surface Preparation Standards

	Condition of Surface	ISO 8501-1 BS7079:A1	Swedish Std. SIS055900	SSPC	NACE
White Metal		Sa 3	Sa 3	SP 5	1
Near White Metal		Sa 2.5	Sa 2.5	SP 10	2
Commercial Blast		Sa 2	Sa 2	SP 6	3
Brush-Off Blast		Sa 1	Sa 1	SP 7	4
Hand Tool Cleaning	Rusted	C St 2	C St 2	SP 2	-
	Pitted & Rusted	D St 2	D St 2	SP 2	-
Power Tool Cleaning	Rusted	C St 3	C St 3	SP 3	-
	Pitted & Rusted	D St 3	D St 3	SP 3	-

TINTING

Tint Part A with Maxitoners at 150% strength. Five minutes minimum mixing on a mechanical shaker is required for complete mixing of color.

Tinting is not recommended for immersion service.

APPLICATION CONDITIONS

Temperature:	40°F (4.5°C) minimum, 140°F (60°C) maximum (air, surface, and material)
	At least 5°F (2.8°C) above dew point
Relative humidity:	85% maximum

Refer to product Application Bulletin for detailed application information.

ORDERING INFORMATION

Packaging:	
Part A:	1 gallon (3.78L) and 5 gallon (18.9L) containers
Part B:	1 gallon (3.78L) and 5 gallon (18.9L) containers
Weight:	13.24 ± 0.2 lb/gal ; 1.6 Kg/L mixed, may vary by color

SAFETY PRECAUTIONS

Refer to the MSDS sheet before use.

Published technical data and instructions are subject to change without notice. Contact your Sherwin-Williams representative for additional technical data and instructions.

WARRANTY

The Sherwin-Williams Company warrants our products to be free of manufacturing defects in accord with applicable Sherwin-Williams quality control procedures. Liability for products proven defective, if any, is limited to replacement of the defective product or the refund of the purchase price paid for the defective product as determined by Sherwin-Williams. NO OTHER WARRANTY OR GUARANTEE OF ANY KIND IS MADE BY SHERWIN-WILLIAMS, EXPRESSED OR IMPLIED, STATUTORY, BY OPERATION OF LAW OR OTHERWISE, INCLUDING MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

Protective & Marine Coatings

SHERWIN WILLIAMS.

MACROPOXY® 646-100 FAST CURE EPOXY

Part A	B58-620	Series
Part B	B58V620	Hardener

Revised: May 6, 2013

Application Bulletin

Surface Preparations

Surface must be clean, dry, and in sound condition. Remove all oil, dust, grease, dirt, loose rust, and other foreign material to ensure adequate adhesion.

Iron & Steel, Atmospheric Service:
Minimum surface preparation is Hand Tool Clean per SSPC-SP2. Remove all oil and grease from surface by Solvent Cleaning per SSPC-SP1. For better performance, use Commercial Blast Cleaning per SSPC-SP6/NACE 3, blast clean all surfaces using a sharp, angular abrasive for optimum surface profile (2 mils / 50 microns). Prime any bare steel within 8 hours or before flash rusting occurs.

Iron & Steel, Immersion Service:
Remove all oil and grease from surface by Solvent Cleaning per SSPC-SP1. Minimum surface preparation is Near White Metal Blast Cleaning per SSPC-SP10/NACE 2. Blast clean all surfaces using a sharp, angular abrasive for optimum surface profile (2-3 mils / 50-75 microns). Remove all weld spatter and round all sharp edges by grinding. Prime any bare steel the same day as it is cleaned.

Aluminum
Remove all oil, grease, dirt, oxide and other foreign material by Solvent Cleaning per SSPC-SP1.

Galvanized Steel
Allow to weather a minimum of six months prior to coating. Solvent Clean per SSPC-SP1 (recommended solvent is VM&P Naphtha). When weathering is not possible, or the surface has been treated with chromates or silicates, first Solvent Clean per SSPC-SP1 and apply a test patch. Allow paint to dry at least one week before testing adhesion. If adhesion is poor, brush blasting per SSPC-SP7 is necessary to remove these treatments. Rusty galvanizing requires a minimum of Hand Tool Cleaning per SSPC-SP2, prime the area the same day as cleaned.

Concrete and Masonry
For surface preparation, refer to SSPC-SP13/NACE 6, or ICRI No. 310.2, CSP 1-3. Surfaces should be thoroughly clean and dry. Concrete and mortar must be cured at least 28 days @ 75°F (24°C). Remove all loose mortar and foreign material. Surface must be free of laitance, concrete dust, dirt, form release agents, moisture curing membranes, loose cement and hardeners. Fill bug holes, air pockets and other voids with Steel-Seam FT910.

Concrete, Immersion Service:
For surface preparation, refer to SSPC-SP13/NACE 6, Section 4.3.1 or 1.3.2 or ICRI No. 310.2, CSP 1-3.

Follow the standard methods listed below when applicable:
ASTM D4258 Standard Practice for Cleaning Concrete.
ASTM D4259 Standard Practice for Abrading Concrete.
ASTM D4260 Standard Practice for Etching Concrete.
ASTM F1869 Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete.
SSPC-SP 13/Nace 6 Surface Preparation of Concrete.
ICRI No. 310.2 Concrete Surface Preparation.

Previously Painted Surfaces
If in sound condition, clean the surface of all foreign material. Smooth, hard or glossy coatings and surfaces should be dulled by abrading the surface. Apply a test area, allowing paint to dry one week before testing adhesion. If adhesion is poor, or if this product attacks the previous finish, removal of the previous coating may be necessary. If paint is peeling or badly weathered, clean surface to sound substrate and treat as a new surface as above.

Surface Preparation Standards

	Condition of Surface	ISO 8501-1 BS7079:A1	Swedish Std. SIS055900	SSPC	NACE
White Metal		Sa 3	Sa 3	SP 5	1
Near White Metal		Sa 2.5	Sa 2.5	SP 10	2
Commercial Blast		Sa 2	Sa 2	SP 6	3
Brush-Off Blast		Sa 1	Sa 1	SP 7	4
Hand Tool Cleaning	Rusted	C St 2	C St 2	SP 2	-
	Pitted & Rusted	D St 2	D St 2	SP 2	-
Power Tool Cleaning	Rusted	C St 3	C St 3	SP 3	-
	Pitted & Rusted	D St 3	D St 3	SP 3	-

Application Conditions

Temperature:	40°F (4.5°C) minimum, 140°F (60°C) maximum (air, surface, and material) At least 5°F (2.8°C) above dew point
Relative humidity:	85% maximum

Application Equipment

The following is a guide. Changes in pressures and tip sizes may be needed for proper spray characteristics. Always purge spray equipment before use with listed reducer. Any reduction must be compliant with existing VOC regulations and compatible with the existing environmental and application conditions.

Reducer/Clean Up ....Reducer R7K111 or Oxsol 100

Airless Spray
- Pump..............................30:1
- Pressure.........................2800 - 3000 psi
- Hose...............................1/4" ID
- Tip ....017" - .023"
- Filter ....60 mesh
- Reduction.......................As needed up to 10% by volume

Conventional Spray
- Gun ....DeVilbiss MBC-510
- Fluid Tip ....E
- Air Nozzle.......................704
- Atomization Pressure.....60-65 psi
- Fluid Pressure................10-20 psi
- Reduction.......................As needed up to 10% by volume
- Requires oil and moisture separators

Brush
- Brush.............................Nylon/Polyester or Natural Bristle
- Reduction.......................Not recommended

Roller
- Cover ....3/8" woven with solvent resistant core
- Reduction.......................Not recommended

If specific application equipment is not listed above, equivalent equipment may be substituted.

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Protective & Marine Coatings

MACROPOXY® 646-100 FAST CURE EPOXY

PART A	B58-620	SERIES
PART B	B58V620	HARDENER

APPLICATION BULLETIN

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APPLICATION PROCEDURES

Surface preparation must be completed as indicated.

Mix contents of each component thoroughly with low speed power agitation. Make certain no pigment remains on the bottom of the can. Then combine one part by volume of Part A with one part by volume of Part B. Thoroughly agitate the mixture with power agitation. Allow the material to sweat-in as indicated prior to application. Re-stir before using.

If reducer solvent is used, add only after both components have been thoroughly mixed, after sweat-in.

Apply paint at the recommended film thickness and spreading rate as indicated below:

Recommended Spreading Rate per coat:

	Minimum	Maximum
Wet mils (microns)	**7.0** (175)	**13.5** (338)
Dry mils (microns)	**5.0*** (125)	**10.0*** (250)*
~Coverage sq ft/gal (m^2/L)	**116** (2.8)	**232** (5.7)
Theoretical coverage **sq ft/gal** (m^2/L) @ 1 mil / 25 microns dft	**1168** (28.6)	

NOTE: Brush or roll application may require multiple coats to achieve maximum film thickness and uniformity of appearance.

*See Recommended Systems on reverse side. See Performance Tips section also.

Drying Schedule @ 7.0 mils wet (175 microns):

	@ 40°F/4.5°C	@ 77°F/25°C 50% RH	@ 100°F/38°C
To touch:	4-5 hours	2 hours	1.5 hours
To handle:	48 hours	8 hours	4.5 hours
To recoat:			
minimum:	48 hours	8 hours	4.5 hours
maximum:	1 year	1 year	1 year
Cure for			
service:	10 days	7 days	4 days
immersion:	14 days	7 days	4 days

If maximum recoat time is exceeded, abrade surface before recoating.

Drying time is temperature, humidity, and film thickness dependent.

Pot Life:	10 hours	4 hours	2 hours
Sweat-in-time:	30 minutes	30 minutes	15 minutes

Application of coating above maximum or below minimum recommended spreading rate may adversely affect coating performance.

CLEAN UP INSTRUCTIONS

Clean spills and spatters immediately with Reducer R7K111 or Oxsol 100. Clean tools immediately after use with Reducer R7K111 or Oxsol 100. Follow manufacturer's safety recommendations when using any solvent.

DISCLAIMER

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PERFORMANCE TIPS

Stripe coat all crevices, welds, and sharp angles to prevent early failure in these areas.

When using spray application, use a 50% overlap with each pass of the gun to avoid holidays, bare areas, and pinholes. If necessary, cross spray at a right angle

Spreading rates are calculated on volume solids and do not include an application loss factor due to surface profile, roughness or porosity of the surface, skill and technique of the applicator, method of application, various surface irregularities, material lost during mixing, spillage, overthinning, climatic conditions, and excessive film build.

Excessive reduction of material can affect film build, appearance, and adhesion.

Do not mix previously catalyzed material with new.

Do not apply the material beyond recommended pot life.

In order to avoid blockage of spray equipment, clean equipment before use or before periods of extended downtime with Reducer R7K111 or Oxsol 100.

Insufficient ventilation, incomplete mixing, miscatalyzation, and external heaters may cause premature yellowing.

Excessive film build, poor ventilation, and cool temperatures may cause solvent entrapment and premature coating failure.

Tinting is not recommended for immersion service.

Use only Mil White for immersion service.

Quik-Kick Epoxy Accelerator is acceptable for use. See data page 4.99 for details.

Application of coating above maximum or below minimum recommended spreading rate may adversely affect coating performance.

For Immersion Service: (if required) Holiday test in accordance with ASTM D5162 for steel, or ASTM D4787 for concrete.

When coating over aluminum and galvanizing, recommended dft is 2-4 mils (50-100 microns).

Acceptable for Concrete Floors.

Refer to Product Information sheet for additional performance characteristics and properties.

SAFETY PRECAUTIONS

Refer to the MSDS sheet before use.

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WARRANTY

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Protective & Marine Coatings

SHER-RELEASE SYSTEM
SEAGUARD® TIE COAT

PART A	P31W100
PART B	P31V100

PRODUCT INFORMATION

PRODUCT DESCRIPTION

SeaGuard Tie Coat is a durable coating that provides superior adhesion between the surface of the epoxy anti-corrosive coat and the SeaGuard Surface Coat. Together the products comprise the Sher-Release System (Silicone Foul Release).

PRODUCT CHARACTERISTICS

Finish: Low Gloss

Color: Dark Beige

Volume solids (ASTM D2697 modified): 74% (± 2%)

Components: 2

Mixing ratio (by volume) 4:1 (Part A to Part B)

VOC as Applied (Theoretical): 1.6 lb/gal 187 g/L

Recommended Spreading Rate per coat:

	Minimum	Maximum
Wet mils (microns)	**8.0** (200)	
Dry mils (microns)	**6.0** (150)	
~Coverage sq ft/gal (m^2/L)	**197** (4.85)	
Theoretical coverage sq ft/gal (m^2/L) @ 1 mil / 25 microns dft	**1187** (29.2)	

Drying Schedule @ 6.0 mils wet (150 microns):

	@ 40°F/4.5°C	@ 50°F/10°C	@ 75°F/24°C	@ 90°F/32°C
To recoat:				
minimum:	9 hours	7 hours	4 hours	3 hours
maximum:	108 hours	85 hours	48 hours	35 hours

If the maximum recoat window interval is exceeded, consult your Sherwin-Williams representative for corrective procedures.

Drying time is temperature, humidity, and film thickness dependent.

Pot Life: >1 hour @ 75°F (24°C)

Pot life times will be less at higher temperatures.

Sweat-in-Time: None required

Shelf Life: 12 months, unopened **Store indoors out of direct sunlight at 40°F (4.5°C) to 80°F (27°C)**

Flash Point: 86°F (30°C) SETA

Reducer*: Not recommended

Clean Up: VM&P Naphtha R1K3

*See Recommended Systems section

RECOMMENDED USES

The SeaGuard Tie Coat is an intregal component of the Sher-Release System.

PERFORMANCE CHARACTERISTICS

The Sher-Release System has been analyzed through the following test methods. **For specific test results consult your Sherwin Williams representative.**

- Standard practice for surface wettability of coatings, substrates and pigments by advancing contact angle measurement (ASTM D7444-08):
- Standard test method for surface wettability and absorbency of sheeted materials using an automated contact angle tester (ASTM D5725-99):
- Standard test method for measuring adhesion of organic coatings to plastic substrates by direct tensile testing (ASTM D5179-02):
- Standard test method for specular gloss at 60° (ASTM D523-89):
- Standard test method for measurement of barnacle adhesion strength in shear (ASTM D5618-94):
- Standard test method for scratch hardness of materials using a diamond stylus (ASTM G171-03):
- Standard test method for apparent shear strength of single-lap-joint adhesively bonded metal specimens by tension loading (metal-to-metal) (ASTM D1002-03):
- Standard test method for abrasion resistance of organic coatings by the taber abraser (ASTM D4060-07):
- Standard test method for adhesion of organic coatings by scrape adhesion (ASTM D2197-98):

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Protective & Marine Coatings

SHER-RELEASE SYSTEM
SEAGUARD® TIE COAT

PART A P31W100
PART B P31V100

PRODUCT INFORMATION

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RECOMMENDED SYSTEMS

		Dry Film Thickness / ct. Mils	(Microns)
Recommended MARINE systems for Sher-Release System:			
Steel, Immersion:			
1 ct..	SeaGuard 6100 Epoxy*	6.0	(150)
1 ct.	SeaGuard 6100 Epoxy*	6.0	(150)
1 ct.	SeaGuard Tie Coat	6.0	(150)
1 ct.	SeaGuard Surface Coat	6.0	(150)
Aluminum, Immersion:			
1 ct.	SeaGuard MP Epoxy	3.0-4.0	(75-100)
	or		
1 ct.	SeaGuard 6100 Epoxy*	6.0	(150)
1 ct.	SeaGuard 6100 Epoxy*	6.0	(150)
1 ct.	SeaGuard Tie Coat	6.0	(150)
1 ct.	SeaGuard Surface Coat	6.0	(150)
Fiberglass, Immersion:			
1 ct..	SeaGuard 6100 Epoxy*	6.0	(150)
1 ct.	SeaGuard 6100 Epoxy*	6.0	(150)
1 ct.	SeaGuard Tie Coat	6.0	(150)
1 ct.	SeaGuard Surface Coat	6.0	(150)
Recommended PROTECTIVE & INDUSTRIAL systems for Sher-Release System:			
Steel, Immersion:			
1 ct.	Macropoxy 646 PW	6.0	(150)
1 ct.	Macropoxy 646 PW	6.0	(150)
1 ct.	SeaGuard Tie Coat	6.0	(150)
1 ct.	SeaGuard Surface Coat	6.0	(150)
Steel, Immersion:			
1 ct.	Euronavy ES301L	6.0	(150)
1 ct.	Euronavy ES301L	6.0	(150)
1 ct.	SeaGuard Tie Coat	6.0	(150)
1 ct.	SeaGuard Surface Coat	6.0	(150)
Steel, Immersion:			
1 ct.	Euronavy ES301K	6.0	(150)
1 ct.	Euronavy ES301K	6.0	(150)
1 ct.	SeaGuard Tie Coat	6.0	(150)
1 ct.	SeaGuard Surface Coat	6.0	(150)
Steel, Immersion:			
1 ct.	Macropoxy 646 - 100 PW	6.0	(150)
1 ct.	Macropoxy 646 - 100 PW	6.0	(150)
1 ct.	SeaGuard Tie Coat	6.0	(150)
1 ct.	SeaGuard Surface Coat	6.0	(150)

*NOTE: R7K104 is the required Reducer for SeaGuard 6100 Epoxy when used in conjunction with SeaGuard Tie Coat.

The systems listed above are representative of the product's use, other systems may be appropriate.

DISCLAIMER

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SURFACE PREPARATION

Surface must be clean, dry, and in sound condition. Remove all oil, dust, grease, dirt, loose rust, and other foreign material to ensure adequate adhesion.

Apply over epoxy of selected Sher-Release Recommended System. Observe specified recoat intervals. Epoxy of selected Sher-Release Recommended System must be slightly tacky at time of overcoating.

Drydocking: Abrasive blast to SSPC-SP 6
New Building: Abrasive blast to SSPC-SP 10
Aluminum: SSPC-SP 1

* Consult your Sherwin-Williams representative for advice.

Surface Preparation Standards

	Condition of Surface	ISO 8501-1 BS7079:A1	Swedish Std. SIS055900	SSPC	NACE
White Metal		Sa 3	Sa 3	SP 5	1
Near White Metal		Sa 2.5	Sa 2.5	SP 10	2
Commercial Blast		Sa 2	Sa 2	SP 6	3
Brush-Off Blast		Sa 1	Sa 1	SP 7	4
Hand Tool Cleaning	Rusted	C St 2	C St 2	SP 2	-
	Pitted & Rusted	D St 2	D St 2	SP 2	-
Power Tool Cleaning	Rusted	C St 3	C St 3	SP 3	-
	Pitted & Rusted	D St 3	D St 3	SP 3	-

APPLICATION CONDITIONS

Temperature: 40°F (4.5°C) minimum, 90°F (32°C) maximum
(air and surface)
At least 5°F (2.8°C) above dew point

Material should be at least 40°F (4.5°C) for optimal performance.

Relative humidity: 80% maximum

ORDERING INFORMATION

Packaging: 5 gallon (18.9L) containers

Shipping weight (approx):	**lb**	**kg**
5-gal (18.9L) kit	40	18.1

Part A: 4 gallons (15.1L) in a 5 gallon (18.9L) steel pail
Part B: 1 gallon (3.78L) in a 1 gallon (3.78L) steel can

Shelf life when stored indoors at 40°F (4.5°C) to 80°F (25°C) 1 year from shipment date

SAFETY PRECAUTIONS

Refer to the MSDS sheet before use.

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WARRANTY

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Protective & Marine Coatings

SHER-RELEASE SYSTEM
SEAGUARD® TIE COAT

PART A	P31W100
PART B	P31V100

Revised 1/11

APPLICATION BULLETIN

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SURFACE PREPARATIONS

Surface must be clean, dry, and in sound condition. Remove all oil, dust, grease, dirt, loose rust, and other foreign material to ensure adequate adhesion.

Sher-Release System

Apply over epoxy of selected Sher-Release Recommended System. Observe specified recoat intervals. Epoxy of selected Sher-Release Recommended System must be slightly tacky at time of overcoating.

Drydocking: Abrasive blast to SSPC-SP 6
New Building: Abrasive blast to SSPC-SP 10
Aluminum: SSPC-SP 1

* Consult your Sherwin-Williams representative for advice.

Surface Preparation Standards

	Condition of Surface	ISO 8501-1 BS7079:A1	Swedish Std. SIS055900	SSPC	NACE
White Metal		Sa 3	Sa 3	SP 5	1
Near White Metal		Sa 2.5	Sa 2.5	SP 10	2
Commercial Blast		Sa 2	Sa 2	SP 6	3
Brush-Off Blast		Sa 1	Sa 1	SP 7	4
Hand Tool Cleaning	Rusted	C St 2	C St 2	SP 2	-
	Pitted & Rusted	D St 2	D St 2	SP 2	-
Power Tool Cleaning	Rusted	C St 3	C St 3	SP 3	-
	Pitted & Rusted	D St 3	D St 3	SP 3	-

APPLICATION CONDITIONS

Temperature: 40°F (4.5°C) minimum, 90°F (32°C) maximum
(air and surface)
At least 5°F (2.8°C) above dew point
Material should be at least 40°F (4.5°C) for optimal performance.

Relative humidity: 80% maximum

APPLICATION EQUIPMENT

The following is a guide. Changes in pressures and tip sizes may be needed for proper spray characteristics. **Always purge spray equipment before use with VM&P Naphtha R1K3.** Any reduction must be compliant with existing VOC regulations and compatible with the existing environmental and application conditions. Thoroughly mix material using a mixer powered by air or an explosion-proof electric motor.

*It is recommended to use dedicated fluid lines for this material

Reducer............................Not recommended*
*See Recommended Systems section

Clean Up...........................VM&P Naphtha R1K3

Airless Spray
Unit................................Graco 56:1 or equivalent
Pressure.........................3600-4000 psi
Hose...............................1/4" - 3/8"
Tip.................................0.021 inch (0.53mm)
Filter...............................40 or 60 mesh
Reduction........................Not recommended

If specific application equipment is not listed above, equivalent equipment may be substituted.

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Protective & Marine Coatings

SHERWIN WILLIAMS.

SHER-RELEASE SYSTEM
SEAGUARD® TIE COAT

PART A	P31W100
PART B	P31V100

APPLICATION BULLETIN
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APPLICATION PROCEDURES

Sher-Release System

1. Thinning not recommended.

2. Apply a wet coat in even, parallel passes; overlap each pass 50 percent to avoid pinholes, bare areas or holidays. Give special attention to weld seams, rough or badly pitted areas. If required, cross spray at right angles.

- Apply the first coat of epoxy as per specification / product data sheet instructions.
- **The second coat of epoxy should be as specified in the selected Sher-Release Recommended System.**

__Application of the SeaGuard Tie Coat must occur when the last coat of epoxy, as specified in the selected Sher-Release Recommended System, is still slightly tacky.__

- The SeaGuard Tie Coat is applied at 6 mils (150 microns) dft. Please refer to detailed specification.

3. For touch-up and repair, utilize the Sherwin-Williams Repair procedure. Consult your representative for specific recommendations.

4. CLEAN APPLICATION EQUIPMENT IMMEDIATELY AFTER USE! Very thorough cleaning with VM&P Naphtha R1K3, leaving no residue, is required to prevent hardening and setting of sprayer ball valves. After cleaning, flush the pump and lines thoroughly with VM&P Naphtha R1K3. For best results, always purge spray equipment before use with VM&P Naphtha R1K3.

Avoid overspray onto adjacent areas to prevent contamination issues (fish eyes, etc...).

CLEAN UP INSTRUCTIONS

Clean spills and spatters immediately with VM&P Naphtha R1K3. Clean tools immediately after use with VM&P Naphtha R1K3. Follow manufacturer's safety recommendations when using any solvent.

DISCLAIMER

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PERFORMANCE TIPS

When using spray application, use a 50% overlap with each pass of the gun to avoid holidays, bare areas, and pinholes. If necessary, cross spray at a right angle

Spreading rates are based upon volume solids and do not include an application loss factor due to surface profile, roughness or porosity of the surface, skill and technique of the applicator, method of application, various surface irregularities, material lost during mixing, spillage, overthinning, climatic conditions, and excessive film build.

Excessive reduction of material can affect film build, appearance, and adhesion.

Do not mix previously catalyzed material with new.

Do not apply the material beyond recommended pot life.

Refer to Product Information sheet for additional performance characteristics and properties.

SAFETY PRECAUTIONS

Refer to the MSDS sheet before use.

Published technical data and instructions are subject to change without notice. Contact your Sherwin-Williams representative for additional technical data and instructions.

WARRANTY

The Sherwin-Williams Company warrants our products to be free of manufacturing defects in accord with applicable Sherwin-Williams quality control procedures. Liability for products proven defective, if any, is limited to replacement of the defective product or the refund of the purchase price paid for the defective product as determined by Sherwin-Williams. NO OTHER WARRANTY OR GUARANTEE OF ANY KIND IS MADE BY SHERWIN-WILLIAMS, EXPRESSED OR IMPLIED, STATUTORY, BY OPERATION OF LAW OR OTHERWISE, INCLUDING MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

Protective & Marine Coatings

SHER-RELEASE SYSTEM
SEAGUARD® SURFACE COAT

PART A P31-200 SERIES
PART B P31V-200 SERIES

Revised 7/11 **PRODUCT INFORMATION** 9.57

PRODUCT DESCRIPTION

SeaGuard Surface Coat is a silicone based, biocide free, topcoat in the Sher-Release System. The low surface energy provides excellent foul release properties. The SeaGuard Surface Coat provides superior durability as compared to traditional silicone foul release systems.

Provides owners with rapid return on investment due to reduction in fuel consumption.

PRODUCT CHARACTERISTICS

Finish:	Semi-Gloss
Color:	Black, Red, White and Blue
Volume solids (ASTM D2697 modified):	80% (± 2%)
Components:	2
Mixing ratio (by volume)	~4:1 (Part A to Part B)
VOC as Applied (Theoretical):	1.24 lb/gal 149 g/L

Recommended Spreading Rate per coat:

	Minimum	Maximum
Wet mils (microns)	**8.0** (200)	
Dry mils (microns)	**6.0** (150)	
~Coverage sq ft/gal (m^2/L)	**214** (5.27)	
Theoretical coverage sq ft/gal (m^2/L) @ 1 mil / 25 microns dft	**1283** (31.6)	

Drying Schedule @ 6.0 mils wet (150 microns):

	@ 40°F/4.5°C	@ 50°F/10°C	@ 75°F/24°C	@ 90°F/32°C
Before immersion:	48 hours	36 hours	24 hours	24 hours

If the maximum recoat window interval is exceeded, consult your Sherwin-Williams representative for corrective procedures.

Drying time is temperature, humidity, and film thickness dependent.

Pot Life:	1 hour @ 75°F/24°C
Sweat-in-Time:	None required

Shelf Life:	12 months, unopened **Store indoors out of direct sunlight at 40°F (4.5°C) to 80°F (27°C)**
Flash Point:	93°F (34°C) SETA
Reducer:	Not normally required. If necessary, thin up to maximum of 3 ounces per gallon using VM&P Naphtha R1K3.
Clean Up:	VM&P Naphtha R1K3

RECOMMENDED USES

- Where long-life fouling protection in severe service is required
- Where reduction in operating costs and extended drydocking intervals is desirable
- Suitable for most vessels in a wide range of operating environments trading at >10 knots
- For lower operating speeds, please inquire
- Container ships, cruise vessels, Ro-Ro's, tankers, etc.
- Structures and operating equipment including intake tunnels and tubes, trash racks, gates, water boxes, service water systems, etc.
- Industrial or municipal facilities with high water usage including Power Generation, Water Treatment, and Pulp & Paper.
- Please consult your local Sherwin-Williams Technical Representative prior to using on vessels with cooling coils or cooling equipment positioned on submerged hull exteriors due to the coating system's insulating effects.

PERFORMANCE CHARACTERISTICS

The Sher-Release System has been analyzed through the following test methods. **For specific test results consult your Sherwin Williams representative.**

- Standard practice for surface wettability of coatings, substrates and pigments by advancing contact angle measurement (ASTM D7444-08):
- Standard test method for surface wettability and absorbency of sheeted materials using an automated contact angle tester (ASTM D5725-99):
- Standard test method for measuring adhesion of organic coatings to plastic substrates by direct tensile testing (ASTM D5179-02):
- Standard test method for specular gloss at 60° (ASTM D523-89):
- Standard test method for measurement of barnacle adhesion strength in shear (ASTM D5618-94):
- Standard test method for scratch hardness of materials using a diamond stylus (ASTM G171-03):
- Standard test method for apparent shear strength of single-lap-joint adhesively bonded metal specimens by tension loading (metal-to-metal) (ASTM D1002-03):
- Standard test method for abrasion resistance of organic coatings by the taber abraser (ASTM D4060-07):
- Standard test method for adhesion of organic coatings by scrape adhesion (ASTM D2197-98):

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Protective & Marine Coatings

SHER-RELEASE SYSTEM
SEAGUARD® SURFACE COAT

PART A P31-200 SERIES
PART B P31V-200 SERIES

PRODUCT INFORMATION

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RECOMMENDED SYSTEMS

	Dry Film Thickness / ct. Mils	(Microns)
Recommended MARINE systems for Sher-Release System:		
Steel, Immersion:		
1 ct.. SeaGuard 6100 Epoxy	6.0	(150)
1 ct. SeaGuard 6100 Epoxy	6.0	(150)
1 ct. SeaGuard Tie Coat	6.0	(150)
1 ct. SeaGuard Surface Coat	6.0	(150)
Aluminum, Immersion:		
1 ct. SeaGuard MP Epoxy	3.0-4.0	(75-100)
or		
1 ct. SeaGuard 6100 Epoxy	6.0	(150)
1 ct. SeaGuard 6100 Epoxy	6.0	(150)
1 ct. SeaGuard Tie Coat	6.0	(150)
1 ct. SeaGuard Surface Coat	6.0	(150)
Fiberglass, Immersion:		
1 ct.. SeaGuard 6100 Epoxy	6.0	(150)
1 ct. SeaGuard 6100 Epoxy	6.0	(150)
1 ct. SeaGuard Tie Coat	6.0	(150)
1 ct. SeaGuard Surface Coat	6.0	(150)
Recommended PROTECTIVE & INDUSTRIAL systems for Sher-Release System:		
Steel, Immersion:		
1 ct. Macropoxy 646 PW	6.0	(150)
1 ct. Macropoxy 646 PW	6.0	(150)
1 ct. SeaGuard Tie Coat	6.0	(150)
1 ct. SeaGuard Surface Coat	6.0	(150)
Steel, Immersion:		
1 ct. Euronavy ES301L	6.0	(150)
1 ct. Euronavy ES301L	6.0	(150)
1 ct. SeaGuard Tie Coat	6.0	(150)
1 ct. SeaGuard Surface Coat	6.0	(150)
Steel, Immersion:		
1 ct. Euronavy ES301K	6.0	(150)
1 ct. Euronavy ES301K	6.0	(150)
1 ct. SeaGuard Tie Coat	6.0	(150)
1 ct. SeaGuard Surface Coat	6.0	(150)
Steel, Immersion:		
1 ct. Macropoxy 646 - 100 PW	6.0	(150)
1 ct. Macropoxy 646 - 100 PW	6.0	(150)
1 ct. SeaGuard Tie Coat	6.0	(150)
1 ct. SeaGuard Surface Coat	6.0	(150)

The systems listed above are representative of the product's use, other systems may be appropriate.

DISCLAIMER

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SURFACE PREPARATION

Sher-Release System

Apply over SeaGuard Tie Coat. Observe specified recoat intervals. Tie coat must be dry and free of any surface contamination.

* Consult your Sherwin-Williams representative for advice.

Surface Preparation Standards

	Condition of Surface	ISO 8501-1 BS7079:A1	Swedish Std. SIS055900	SSPC	NACE
White Metal		Sa 3	Sa 3	SP 5	1
Near White Metal		Sa 2.5	Sa 2.5	SP 10	2
Commercial Blast		Sa 2	Sa 2	SP 6	3
Brush-Off Blast		Sa 1	Sa 1	SP 7	4
Hand Tool Cleaning	Rusted	C St 2	C St 2	SP 2	-
	Pitted & Rusted	D St 2	D St 2	SP 2	-
Power Tool Cleaning	Rusted	C St 3	C St 3	SP 3	-
	Pitted & Rusted	D St 3	D St 3	SP 3	-

APPLICATION CONDITIONS

Temperature: 40°F (4.5°C) minimum, 90°F (32°C) maximum (air and surface) At least 5°F (2.8°C) above dew point

Material should be at least 40°F (4.5°C) for optimal performance.

Relative humidity: 80% maximum

*Protect mixed material from water

ORDERING INFORMATION

Packaging:
Part A: 4.05 gallons (15.3L) in a 5-gallon (18.9L) container
Part B: 0.95 gallons (3.60L) in a 1-gallon (3.78L) container

Shipping weight (approx):	lb	kg
5-gal (18.9L) kit	40	18.1

Shelf life when stored indoors at 40°F (4.5°C) to 80°F (25°C) 1 year from shipment date

SAFETY PRECAUTIONS

Refer to the MSDS sheet before use.

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WARRANTY

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Protective & Marine Coatings

SHER-RELEASE SYSTEM
SEAGUARD® SURFACE COAT

PART A P31-200 SERIES
PART B P31V-200 SERIES

Revised 7/11 **APPLICATION BULLETIN** 9.57

SURFACE PREPARATIONS

Sher-Release System

Apply over SeaGuard Tie Coat. Observe specified recoat intervals. Tie coat must be dry and free of any surface contamination.

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Surface Preparation Standards

	Condition of Surface	ISO 8501-1 BS7079:A1	Swedish Std. SIS055900	SSPC	NACE
White Metal		Sa 3	Sa 3	SP 5	1
Near White Metal		Sa 2.5	Sa 2.5	SP 10	2
Commercial Blast		Sa 2	Sa 2	SP 6	3
Brush-Off Blast		Sa 1	Sa 1	SP 7	4
Hand Tool Cleaning	Rusted	C St 2	C St 2	SP 2	-
	Pitted & Rusted	D St 2	D St 2	SP 2	-
Power Tool Cleaning	Rusted	C St 3	C St 3	SP 3	-
	Pitted & Rusted	D St 3	D St 3	SP 3	-

APPLICATION CONDITIONS

Temperature: 40°F (4.5°C) minimum, 90°F (32°C) maximum
(air and surface)
At least 5°F (2.8°C) above dew point

Material should be at least 40°F (4.5°C) for optimal performance.

Relative humidity: 80% maximum

APPLICATION EQUIPMENT

The following is a guide. Changes in pressures and tip sizes may be needed for proper spray characteristics. **Always purge spray equipment before use with VM&P Naphtha R1K3.** Any reduction must be compliant with existing VOC regulations and compatible with the existing environmental and application conditions. Thoroughly mix material using a mixer powered by air or an explosion-proof electric motor.

*It is recommended to use dedicated fluid lines for this material

Reducer/Clean Up ....VM&P Naphtha R1K3

Airless Spray
- Unit................................Graco 56:1 or equivalent
- Pressure.........................3600-4000 psi
- Hose...............................3/8"
- Tip..................................0.021 inch (0.53mm)
- Filter...............................40 or 60 mesh
- Reduction.......................Not recommended (Thin only for workablilty)

If specific application equipment is not listed above, equivalent equipment may be substituted.

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Protective & Marine Coatings

SHER-RELEASE SYSTEM
SEAGUARD® SURFACE COAT

PART A P31-200 SERIES
PART B P31V-200 SERIES

APPLICATION BULLETIN

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APPLICATION PROCEDURES

Sher-Release System

1. Thinning generally not needed. Thin only for workability; no more than 3 ounces VM&P Naphtha R1K3 per gallon (3.78L) of Seaguard Surface Coat.

2. Apply a wet coat in even, parallel passes; overlap each pass 50 percent to avoid pinholes, bare areas or holidays. Give special attention to weld seams, rough or badly pitted areas.
- Apply the first coat of epoxy as per specification / product data sheet instructions.
- The SeaGuard Tie Coat is applied at 6 mils (150 microns) DFT. Please refer to detailed specification.

3. For touch-up and repair, utilize the Sherwin-Williams Repair procedure. Consult your representative for specific recommendations.

4. CLEAN APPLICATION EQUIPMENT IMMEDIATELY AFTER USE! Very thorough cleaning with VM&P Naphtha R1K3, leaving no residue, is required to prevent hardening and setting of sprayer ball valves. After cleaning, flush the pump and lines thoroughly with VM&P Naphtha R1K3. For best results, always purge spray equipment before use with VM&P Naphtha R1K3

Avoid overspray onto adjacent areas to prevent contamination issues (fish eyes, etc...).

CLEAN UP INSTRUCTIONS

Clean spills and spatters immediately with VM&P Naphtha R1K3. Clean tools immediately after use with VM&P Naphtha R1K3. Follow manufacturer's safety recommendations when using any solvent.

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PERFORMANCE TIPS

When using spray application, use a 50% overlap with each pass of the gun to avoid holidays, bare areas, and pinholes. If necessary, cross spray at a right angle

Spreading rates are based upon volume solids and do not include an application loss factor due to surface profile, roughness or porosity of the surface, skill and technique of the applicator, method of application, various surface irregularities, material lost during mixing, spillage, overthinning, climatic conditions, and excessive film build.

Excessive reduction of material can affect film build, appearance, and adhesion.

Do not mix previously catalyzed material with new.

Do not apply the material beyond recommended pot life.

Refer to Product Information sheet for additional performance characteristics and properties.

SAFETY PRECAUTIONS

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