California Water Science Center Proposal 2022-09
Southwest Region, WMA, USGS
Principal Investigator: Keith Bouma-Gregson
Cooperator: CA Department of Water Resources

INTERAGENCY AGREEMENT
WORK ORDER

Work Order No.:	HABDSB-01
Contractor:	United States Geological Survey (USGS)
Request for Services:	Under Standard Agreement No. 4600014088
Dated:	March 7, 2022

As stated in Agreement 4600014088 hereinafter referred to as "the agreement" (Exhibit A-Section III), the "USGS is a federal entity, a bureau of the Department of the Interior, and not a contractor". All references to "Contractor" shall mean USGS, a U.S. Government agency. The following text uses the term DWR Project Manager and Work Order (WO) Manager equivalently.

The Department of Water Resources (DWR) is implementing activities needed to construct and operate Emergency Drought Barriers (EDBs) in response to the Governor's Emergency Drought Proclamation on May 10, 2021 which extends the drought emergency to include the Sacramento-San Joaquin Delta. Currently, an EDB is installed in West False River (Figure 1).

The field work, analysis, and reporting described in this WO is intended to document the effects of the Temporary Urgency Change Petitions (TUCP) and the West False River on the abundance and distribution of toxic cyanobacterial harmful algal blooms (cyanoHABs) in the Sacramento/San Joaquin Delta.

BACKGROUND

This WO provides detailed scopes of work, budgets, timelines, and deliverables associated with USGS' ongoing participation in field work related to the impact of EDBs on water quality and algal toxins in the Delta. The total period of performance of this WO is from the date of WO execution through February 28, 2024. This period of performance allows for data collection one year from the date of the WO being executed and additional months to conclude analysis and report writing after all data have been collected from the field. This period of performance could change if drought conditions continue.

DESCRIPTION OF TASKS

OVERVIEW

The tasks involved in this WO include: Project Management (Task 1); High-resolution mapping surveys in Miner Slough, Steamboat Slough, Lindsey Slough, Cache Slough Complex, and the Sacramento River (Task 2, Figure 2); High-resolution mapping surveys around Franks Tract and Mildred Island (Task 3, Figure 3); Cyanotoxin monitoring at DWR's Franks Tract (FRK) station (Task 4); Water Quality, Phytoplankton, and cyanoHABs data analysis and interpretation (Task 5); Field-validation of remote sensing cyanoHAB algorithm (Task 6); Analysis and Reporting (Task 7).

Task 1 – Project Management

Period of performance: **Date of WO execution through February 28, 2024.**

Description

Contractor shall manage this work order including coordinating with DWR, providing progress reports, participating in coordination calls, and reviewing/approving deliverables.

Contractor shall attend monthly drought monitoring coordination teleconferences with DWR WO Manager and core team members (as directed by DWR WO Manager) and provide updates and monthly progress documentation of WO tasks, discuss progress/status such as risks, performance issues, completed task(s), and anticipated completion dates of task(s). Contractor and DWR WO manager will collaborate, develop, and adopt the monthly progress report template prior to the first monthly coordination and status meeting. DWR may request additional coordination and briefing teleconferences as the drought proceeds including monitoring design, logistics, implementation, data analysis/reporting, explanation of the methods and results, and presentations at interagency meetings, conferences, and/or agency executives. Contractor shall coordinate and communicate (via email or phone) with DWR WO Manager for approval prior to implementing a change in scope.

Deliverables

1.1 Monthly progress reports on status of tasks

Task 2 – High-resolution mapping surveys Miner Slough, Steamboat Slough, Lindsey Slough, Cache Slough Complex, and Sacramento River

Period of performance: **Date of WO execution through October 31, 2022**

Description

Contractor will be conducting 3 high-resolution mapping surveys in spring, summer and fall (~May, July and October) of 2022 (see Table 1 for high-resolution and discrete parameters). These are boat-based surveys that involve continuously measuring water quality parameters while underway and collecting water quality samples at ~30 samples across the Delta. The surveys during 2022 are being funded by an agreement between the USGS and the State Water contractors. However, Miner, Steamboat, Lindsey, and upper Cache Sloughs are not covered by these surveys. Under this task, the three 2022 surveys will be extended to cover these additional waterways that may be impacted by the EDBs. If hydrologic conditions do not warrant the installation of EDBs in Miner and Steamboat Sloughs in 2022, data will be collected to obtain baseline data of water quality conditions without the EDBs.

Under this task

- Contractor will extend the 2022 Spring, Summer and Fall mapping surveys to include Miner and Steamboat Sloughs. Contractor also will extend mapping surveys up Lindsey Slough to where it meets Barker Slough and feeds water to the North Bay Aqueduct Pumping Plant to assess potential drinking water impacts (e.g., salinity, dissolved organic carbon).

- Parameters indicative of water residence time (stable isotopes of water, d2H and d16O) will be added to 1 mapping surveys conducted in the Northern Delta and collected in Miner, Steamboat, and Lindsey, and Barker Sloughs. Water residence time parameters – including in situ continuous measurements made during the mapping survey and collection of discrete water samples collected at key locations (Table 1) – will be collected during the Summer (July/August) survey, when flows are lower and cyanoHABs most likely. These data will be compared to USGS residence time calculations from prior years without EDBs in place (Figure 2).

The timing of all data collection in Task 2 will be coordinated with DWR to ensure the collection of data best suits the study objectives.

Deliverables

DWR will be informed via email of updates to the sampling strategy, any data collection anomalies including equipment failure, sensor fouling, or other changes/concerns as the study progresses. Provisional data will be made available upon request from DWR WO manager.

2.1 Public data release (e.g. NWIS, ScienceBase) of USGS-approved data collected through this task by February 28, 2024. Working collaboratively, USGS and DWR staff will either, add a record in DWR DELVE database to link DELVE with the location of the data in a USGS data repository (e.g. NWIS or ScienceBase) or will add the data directly to the DWR DELVE database.

Task 3 – High-resolution mapping surveys around Franks Tract and Mildred Island

Period of performance: **Date of WO execution through October 31, 2022**

Description

To describe the phytoplankton species composition and bloom density around the False River Barrier, Contractor will conduct high-resolution mapping in and around Franks Tract, as well as in and around Mildred Island which will serve as a control (no EDB) site.

- Contractor will conduct 3 mapping surveys of Franks Tract and Mildred Island between approximately, May-October 2022. Exact timing of surveys will depend on observations of bloom formation. Continuous and discrete water quality and phytoplankton measurements will be collected during each survey. All parameters listed in Table 1 will be collected, except continuous ammonium data.

- Water residence time parameters – both in situ continuous measurements made during the mapping survey and collection of discrete water samples collected at key locations (stable isotopes listed in Table 1) – will be collected across both flooded islands. In Franks Tract, the boat path will cross the gradient of low-to-high residence time posited by DWR hydrodynamic modeling results (Figure 3).
    - Residence time measurements will be used to help validate and calibrate the DWR hydrodynamic models.

The timing of all data collection in Task 3 will be closely coordinated with DWR to ensure data collection efforts best suit the study objectives.

Deliverables

DWR will be informed via email of updates to the sampling strategy, any data collection anomalies including equipment failure, sensor fouling, or other changes/concerns as the study progresses. Provisional data will be made available upon request from DWR WO manager.

3.1 Public data release (e.g. NWIS, ScienceBase) of USGS-approved data collected through this task by February 28, 2024. Working collaboratively, USGS and DWR staff

will either, add a record in DWR DELVE database to link DELVE with the location of the data in a USGS data repository (e.g. NWIS or ScienceBase) or will add the data directly to the DWR DELVE database.

Task 4 – Cyanotoxin monitoring at Franks Tract (FRK) station

Period of performance: **Date of WO execution through March 31, 2023**

Description

- Contractor will assist DWR in monitoring for cyanotoxins at the DWR monitoring station in Franks Tract (FRK) for one year (~April 2022-April 2023).
- Sample collection, handling, and analyses will follow protocols used by USGS and DWR for cyanotoxin data collection efforts at other stations in the Delta.
    - Cyanotoxin samples (both discrete whole water and solid phase adsorption toxin tracking (SPATT) samplers) will be collected approximately monthly for the months of November to April and approximately twice a month for the months of May through October for a total of 18 samples per year.
    - All Samples will be analyzed by LC-MS/MS by Lumigen Instrument Center (http://chem.wayne.edu/lumigen/) and 20% subset of samples will be analyzed by ELISA method by BSA Environmental Services (https://www.bsaenv.com). Funding for cyanotoxin analysis is being provided by the Delta Science Program through a separate agreement with Lumigen Instrument Center and BSA Environmental Services and is not included in this work order.
    - An additional ~10% of samples will be collected for QA/QC (field duplicates, lab replicates, blanks, and spikes)
- Contractor will assemble solid phase adsorption toxin tracking (SPATT) samplers to monitor cyanotoxins in Franks Tract. After constructing SPATT samplers, Contractor will ship samplers to DWR who will deploy samplers in Franks Tract.
- DWR will collect discrete whole water samples and deploy SPATT samplers at FRK. These cyanotoxin samples will be delivered to Contractor, who will arrange shipment to analytical laboratories, and receive and manage results and data from the lab.
- Provisional data will be shared with DWR within 1 business days of receipt from laboratory.

Deliverables

DWR will be informed via email of updates to the sampling strategy and any anomalies including equipment failure, analytical issues, or other changes/concerns as the study progresses.

4.1 Assembled SPATT samplers will be supplied to DWR within 10 business days of a request from DWR.

4.2 DWR will be informed via email within 24 hours when samples are shipped to analytical labs.

4.3 Provisional cyanotoxin data will be shared with DWR within 1 business day of receipt from laboratory.

4.4 Public data release (e.g. NWIS, ScienceBase) of USGS-approved data collected through this task by February 28, 2024. Working collaboratively, USGS and DWR staff will either, add a record in DWR DELVE database to link DELVE with the location of the data in a USGS data repository (e.g. NWIS or ScienceBase) or will add the data directly to the DWR DELVE database. Data will also be made available to DWR to publish in Environmental Data Initiative (EDI).

Task 5 – Water Quality, phytoplankton, and cyanoHABs data analysis and interpretation.

Period of performance: **Date of WO execution through February 28, 2024**

Description

Hydrologic and climatic conditions influence the community composition, abundance, and spatial distribution of phytoplankton, including cyanoHABs. Water operations in the Delta are adjusted in response to weather and precipitation patterns. How water is managed in the Delta changes the water quality conditions phytoplankton experience and alter how the phytoplankton community develops over time. Through the Interagency Ecological Program (IEP) and other efforts, DWR analyzes water quality data to inform how the aquatic food-web responds to different environmental conditions, including drought, and water management.

When requested by DWR, Contractor will consider participating in DWR data analysis and interpretation projects relating to water quality, phytoplankton, and food-webs in the Delta. Participation in each project will depend on the availability of USGS scientists. DWR and Contractor will agree upon the scope of Contractor involvement at the outset of each project in this task.

Deliverables

5.1 USGS will contribute to data analysis projects coordinated or led by DWR and will help plan future data collection or analysis efforts. A written summary will be provided to DWR each quarter summarizing what was accomplished under this task.

Task 6 – Field-validation of remote sensing cyanoHAB algorithm

Period of performance: **Date of WO execution through October 31, 2023**

Description

Remotely sensed data is useful for tracking bloom dynamics on large water bodies that would be costly to sample frequently with field visits. Satellite algorithms to estimate cyanobacterial density in the top (about 1 Secchi depth) of surface waters have been developed by National Oceanographic and Atmospheric Administration (NOAA). The Cyanobacterial Index (CI) algorithm is applied to data from the Ocean Land Color Instrument OLCI sensor on the Sentinel-3 satellites for the continental United States (Wynne et al. 2018). These data are freely available from NOAA. The satellite sensor has a pixel size of 300 meters, so only larger channels in the Delta are resolvable with the CI algorithm.

While remote sensed data provides high spatial and temporal coverage (return time 2-3 days), certain water conditions can confound the algorithm and generate spurious results. However, ground-truthing of remote sensed data can be accomplished with handheld hyperspectral field measurements (Figure 4). By analyzing the reflectance spectra under different conditions, it is possible to generate custom “flags” to identify satellite pixels likely to be falsely indicating a cyanoHAB and minimize erroneous satellite detections of cyanoHABs in the Delta. This will improve the utility of satellite remote sensing data across all regions of the Delta.

- Contractor will collect handheld hyperspectral radiometer measurements to field validate the CI algorithm against confounding factors such as submerged aquatic vegetation, filamentous algae, and suspended sediments (Figure 4). Discrete samples for chlorophyll-a, phytoplankton enumeration, dissolved organic compounds, and suspended particles will also be collected during surveys.

- Contractor will conduct at least 3 survey days across a variety of seasons and water conditions. This will enable the creation of a hyperspectral library representing different environmental and water quality conditions in the Delta. Contractor will then run the CI algorithm on each of the collected spectra and identify which conditions triggered a false positive or false-negative from the algorithm.

- Contractor will develop a Delta-specific “flagging” algorithm to identify these confounding results and record the CI value as “questionable.”

Deliverables
DWR will be informed via email of updates to the sampling strategy and any anomalies including equipment failure, analytical issues, or other changes/concerns as the study progresses.

6.1 Public data release (e.g. NWIS, ScienceBase) of USGS-approved data collected through this task by February 28, 2024. Working collaboratively, USGS and DWR staff will either, add a record in DWR DELVE database to link DELVE with the location of the data in a USGS data repository (e.g. NWIS or ScienceBase) or will add the data directly to the DWR DELVE database.

Task 7 – Analysis and Reporting

Period of performance: **Date of WO execution through February 28, 2024**

Description
Analyses of data collected in Tasks 2 (mapping of North Delta Sloughs), will be conducted to assess the direct or potential influence of EDBs on the phytoplankton community and cyanoHABs in the North Delta. If EDBs are not placed in the North Delta in 2022, then analyses in Task 2 will describe baseline environmental conditions to enable future comparisons if EDBs are installed in Miner or Steamboat Sloughs.

Analyses of data collected in Tasks 3-4 (Mapping of Franks Tract and Mildred Island, Cyanotoxin Monitoring at Franks Tract) will be conducted to assess the influence of the False River EDB on water quality, the phytoplankton community and cyanoHABs in the Central Delta.

Analysis of data in Task 6 will be conducted to assess the effectiveness of satellite remote sensed data for monitoring of cyanobacterial blooms during drought conditions.

Deliverables
Contractor shall analyze the data collected in Task 2, 3, 4, and 6 and will contribute, in a collaborative process, text and graphics to the interim reports below based on the indicated timelines. Additional updates or presentations will be given upon request by DWR. If study findings warrant, USGS staff will lead or co-author a journal article(s) or USGS Scientific Investigations Report(s).

7.1 USGS will contribute to DWR-led comprehensive report covering monitoring period June 2021 to November 2022: Due in Fall 2023 / Winter 2024

TABLES

Table 1. Continuously and discretely measured parameters collected during high-resolution mapping surveys.

Continuously measured parameters	
Temperature	Chlorophyll-*a*
Specific conductivity	Fluorescence of dissolved organic matter (fDOM)
pH	Nitrate
Dissolved Oxygen	Ammonium
Turbidity	Phytoplankton taxonomy (Fluoroprobe)
Water Residence time: stable isotopes δ^2H and $\delta^{18}O$ **(Optional parameter)**	
Discretely sampled parameters	
Nitrate (NO3-N) and Nitrite (NO2-N) (µM)	Soluble reactive phosphate (SRP, PO4) (µM)
Ammonium (µM)	Chlorophyll-*a* & Phaeophytin (mg L^{-1})
Total Dissolved Nitrogen (TDN) (µM)	Phytoplankton Enumeration (cells L-1 and cm^3 L-1 by species)
Dissolved Organic Nitrogen (DON) (µM)	Picocyanobaceria (cells L^{-1} and cm^3 L^{-1})
Optical Properties of dissolved organic matter (absorbance, fluorescence) (intensity)	Water Residence time: stable isotopes δ^2H and $\delta^{18}O$ **(Optional parameter)**

FIGURES

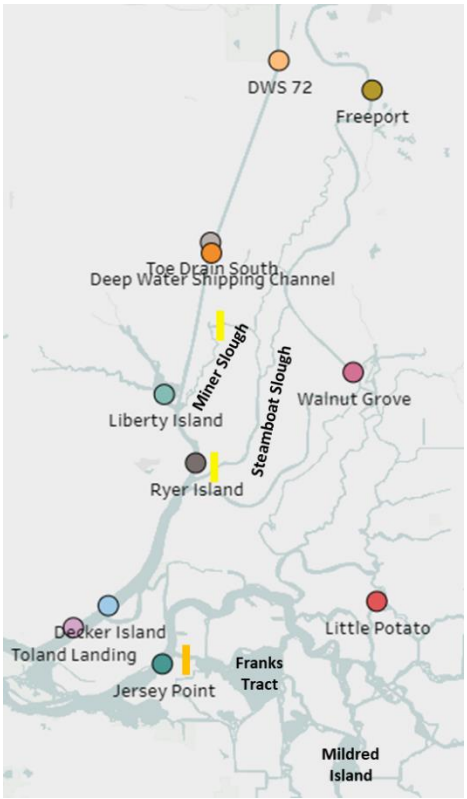

Figure 1. Map of the study region of the Sacramento San Joaquin Delta showing current False River Barrier (orange bar), proposed barriers in Miner and Steamboat Sloughs

(yellow bars), and current USGS continuous water quality monitoring stations (colored points).

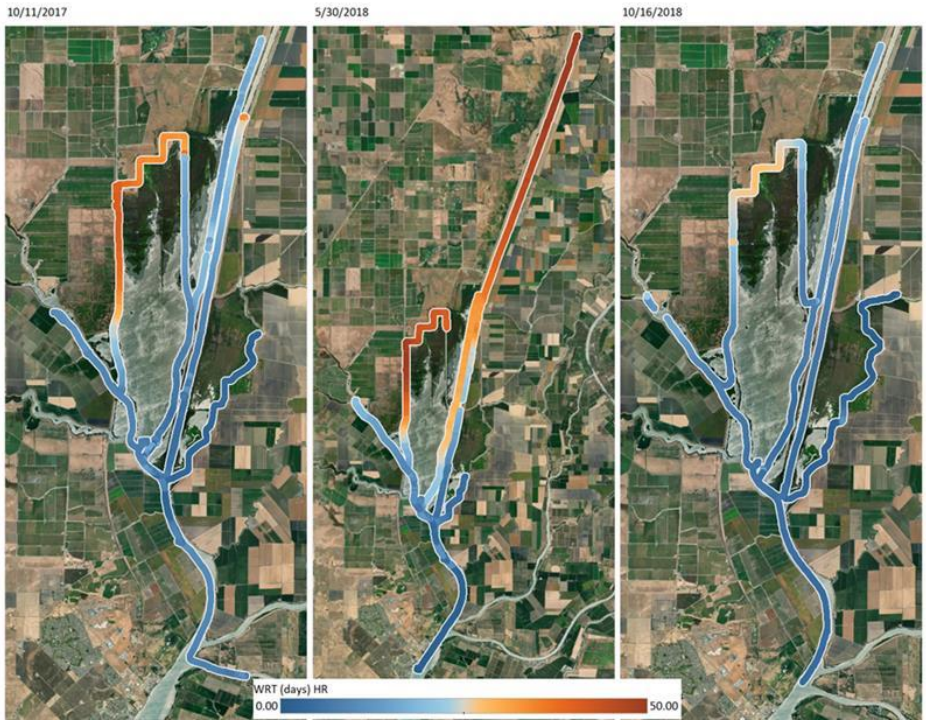

Figure 2. Water Residence Time (WRT) measurements from 2018 in Cache Slough Complex.

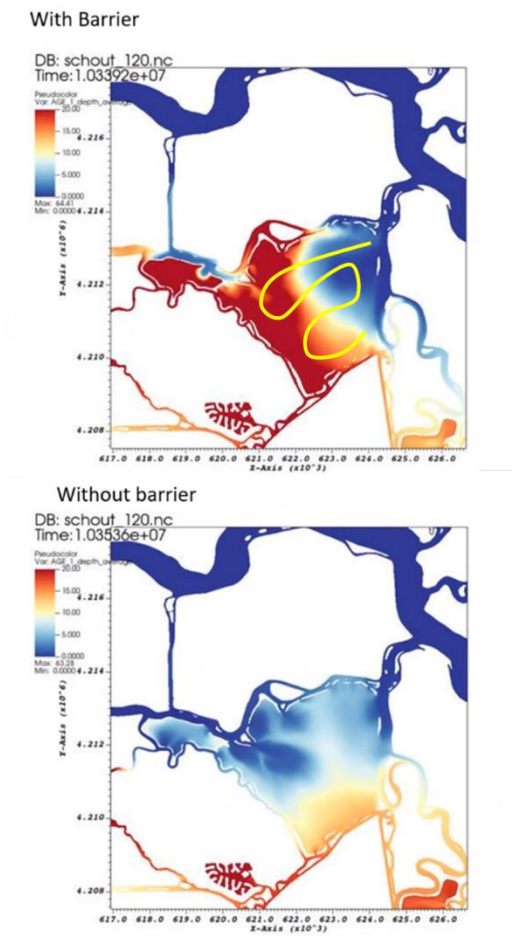

Figure 3. Water residence time (days) in Franks Tract with (top panel) and with the False River Barrier (middle panel). Yellow line shows potential mapping and sampling route across the gradient of young to old water moving from northeast to southwest. (Model output: Eli Ateljevich, DWR)

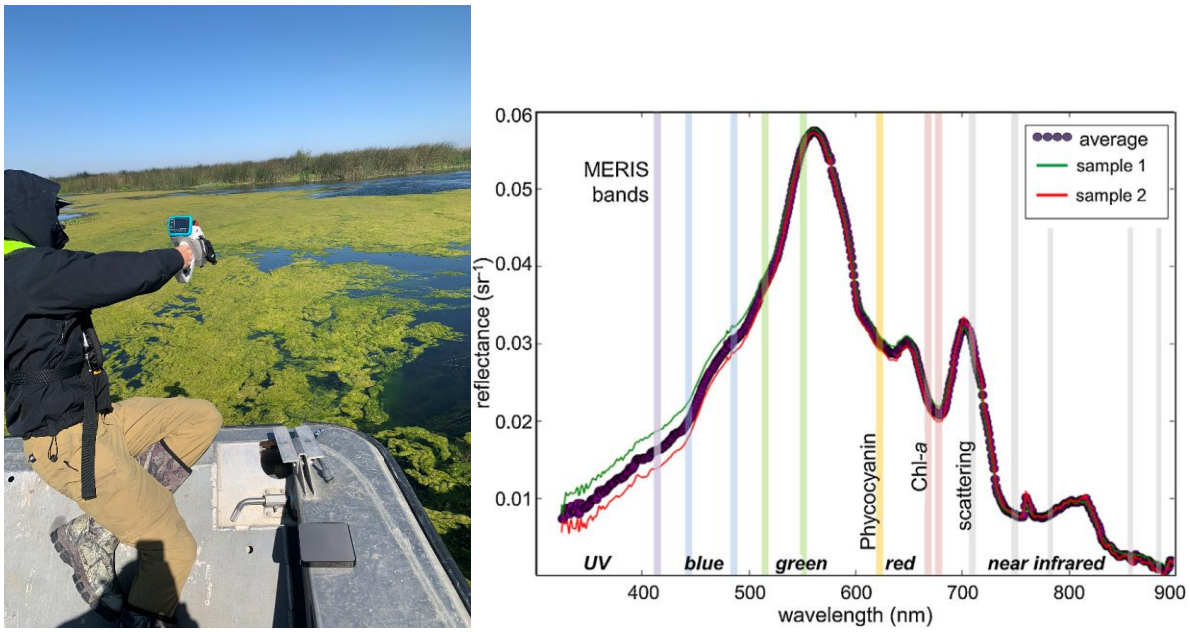

Figure 4. Left panel: Collecting hyperspectral data from a floating algal mat in Franks Tract. Right panel: Example hyperspectral reflectance from handheld radiometer. The absorbance of chlorophyll-a can be seen at 680-700 nanometers. The MERIS satellite bands are shown as vertical bars. (Image from Stumpf et al. 2016)

REFERENCES

Stumpf, R.P., Davis, T.W., Wynne, T.T., Graham, J.L., Loftin, K.A., Johengen, T.H., Gossiaux, D., Palladino, D., Burtner, A., 2016. Challenges for mapping cyanotoxin patterns from remote sensing of cyanobacteria. Harmful Algae 54, 160–173. https://doi.org/10.1016/j.hal.2016.01.005

Wynne, T.T., Meredith, A., Briggs, T., Litaker, W., Stumpf, R.P., 2018. Harmful Algal Bloom Forecasting Branch Ocean Color Satellite Imagery Processing Guidelines. NOAA Technical Memorandum NOS NCCOS ; 252. https://doi.org/10.25923/twc0-f025

SCHEDULE

Contractor will be prepared to begin work upon receipt of this signed Work Order by DWR through February 28, 2024. All deliverables will be provided to the DWR Work Order manager by the dates indicated below. Permission for deliverable time extensions not beyond the end date of this Work Order requires approval in writing from the DWR Work Order manager.

The projected schedule for completing the work follows:

Schedule of Deliverables - 1		
Task No.	**Deliverable**	**Deliverable Date**
Task 1 – Project Management	1.1 Monthly progress reports on status of tasks	Monthly and ongoing with WO manager. Within 30 days
Task 2 – High-resolution mapping surveys Miner Slough, Steamboat Slough, Lindsey Slough, Cache Slough Complex, and Sacramento River	2.1 Public data release (e.g. NWIS, ScienceBase) of USGS-approved data collected through this task. A record of the data release will be added to the DWR DELVE database.	February 28, 2024
Task 3 - High-resolution mapping surveys around Franks Tract and Mildred Island	3.1 Public data release (e.g. NWIS, ScienceBase) of USGS-approved data collected through this task by February 28, 2024. A record of the data release will be added to the DWR DELVE database or a link in DWR DELVE database to redirect DWR to USGS website for data access as appropriate.	February 28, 2024
Task 4 – Cyanotoxin monitoring at Franks Tract (FRK) station	4.1 Assembled SPATT samplers will be supplied to DWR within 10 business days of a request from DWR. 4.2 DWR will be informed via email within 24 hours when samples are shipped to analytical labs. 4.3 Provisional cyanotoxin data will be shared with DWR within 1 business days of receipt from laboratory.	4.1 10 business days of a request from DWR 4.2 Within 24 hours of shipment 4.3 Within 1 business days of receipt from laboratory

Schedule of Deliverables - 1		
Task No.	**Deliverable**	**Deliverable Date**
	4.4 Public data release (e.g. NWIS, ScienceBase) of USGS-approved data collected through this task by February 28, 2024. A record of the data release will be added to the DWR DELVE database or as a link in DELVE database to redirect DWR to EDI or USGS website for data access as appropriate. Data will also be made available to DWR to publish in Environmental Data Initiative (EDI).	4.4 February 28, 2024
Task 5 - Phytoplankton and cyanoHABs data analysis and interpretation.	5.1 USGS will contribute to data analysis projects coordinated or led by DWR and will help plan future data collection or analysis efforts. A written summary will be provided to DWR each quarter summarizing what was accomplished under this task.	Quarterly
Task 6 - Field-validation of remote sensing cyanoHAB algorithm	6.1 Public data release (e.g. NWIS, ScienceBase) of USGS-approved data collected through this task. A record of the data release will be added to the DWR DELVE database.	6.1 February 28, 2024
Task 7 – Analysis and Reporting	7.1 Contribute to DWR led comprehensive report covering monitoring period June 2021 to November 2022: Due in Fall 2023 / Winter 2024	7.1 Comprehensive report covering monitoring period June 2021 to November 2022: Due in Fall 2023 / Winter 2024

All deliverables listed above shall be packaged and delivered to DWR by email, in applicable Microsoft Office (word, excel, etc.), Adobe (pdf), or other file formats acceptable to the DWR WO Manager.

All deliverables shall be completed (including all required USGS review steps) and submitted to the DWR Work Order Manager on or before the indicated date. DWR staff shall provide comments and input to the deliverables in advance to the stated due dates as practicable and as requested by USGS staff.

DETAILED COSTS

Contractor shall invoice all services in accordance with Exhibit A, of the master contract. The total amount of this Work Order shall not exceed **$613,581**. See Attachment 1 for complete budget cost details.

WORK ORDER SUMMARY

SUMMARY BY TASK

Work Order HABDSB-01	
General Project Description	
Task	**Total by Task**
Task 1 – Project Management	$60,429.64
Task 2 – High-resolution mapping surveys Miner Slough, Steamboat Slough, Lindsey Slough, Cache Slough Complex, and Sacramento River	$96,670.93
Task 3 - High-resolution mapping surveys around Franks Tract and Mildred Island	$129,426.33
Task 4 – Cyanotoxin monitoring at Franks Tract (FRK) station	$28,169.15
Task 5 - Phytoplankton and cyanoHABs data analysis and interpretation.	$19,991.32
Task 6 - Field-validation of remote sensing cyanoHAB algorithm	$120,056.97
Task 7 – Analysis and Reporting	$158,836.13
Total	**$613,581**

CONTACT PERSONS

DWR's Work Order Manager:

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AUTHORIZED SIGNATURES

Contractor and State agree that these services will be performed in accordance with the terms and conditions of Standard Agreement Number 4600014088.

State of California
Department of Water Resources

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Behzad Soltanzadeh
Assistant Division Manager 2
Division of Operations and Maintenance

3/15/2022
Date

United States Geologic Survey

MICHAEL SCHMIDT Digitally signed by MICHAEL SCHMIDT Date: 2022.03.11 10:59:40 -08'00'

Michael Schmidt, Director
Western Fisheries Research Center

Date

ATTACHMENT 1 - PROJECT STAFFING

USGS personnel listed below are among the primary staff who may bill to this Work Order. Additional staff approved by DWR may be assigned to this Work Order (see Attachment 1 for more detail).

- Keith Bouma-Gregson
- Tamara Kraus
- Brian Bergamaschi
- Elizabeth Stumpner
- Angela Hansen
- Emily Richardson
- Brendan Wakefield
- Katy O'Donnell
- Crystal Sturgeon
- Tim Baxter
- Jeniffer Soto-Perez
- Dylan Burau
- Balthasar Von Hoyningen huene
- Ayelet Delascagigas
- Nathan Jumps
- Summer Burdick

ATTACHMENT 2 - DETAILED BUDGET SHEETS

Task 1 total: $60,429.64

CAWSC subtotal: $52,551.72

CRRL subtotal: $7,877.92

TASK 1 - Project Management

Employee Name	Tas	Task Name	Fiscal Y	Hour	Hourly Rat	Hourly Tot	Leave Dis	Total (Net)	Total (Gross)
Biologist	1.1	Project meeting	2022	21	$ 51.86	$ 1,089.11	$ 234.16	$ 1,323.27	$ 2,492.30
Soil Scientist	1.1	Project meeting	2022	14	$ 85.73	$ 1,200.28	$ 258.06	$ 1,458.34	$ 2,746.70
Chemist	1.1	Project meeting	2022	14	$ 111.17	$ 1,556.43	$ 334.63	$ 1,891.06	$ 3,561.72
Physical Scientist	1.1	Project meeting	2022	21	$ 38.81	$ 814.99	$ 175.22	$ 990.21	$ 1,865.01
Biologist	1.2	Progress report	2022	12	$ 51.86	$ 622.35	$ 133.80	$ 756.15	$ 1,424.17
Soil Scientist	1.2	Progress report	2022	4	$ 85.73	$ 342.94	$ 73.73	$ 416.67	$ 784.77
Chemist	1.2	Progress report	2022	4	$ 111.17	$ 444.69	$ 95.61	$ 540.30	$ 1,017.63
Physical Scientist	1.2	Progress report	2022	12	$ 38.81	$ 465.71	$ 100.13	$ 565.83	$ 1,065.72
Biologist	1.1	Project meeting	2023	36	$ 53.42	$ 1,923.05	$ 413.46	$ 2,336.51	$ 4,400.70
Soil Scientist	1.1	Project meeting	2023	24	$ 88.31	$ 2,119.34	$ 455.66	$ 2,575.00	$ 4,849.89
Chemist	1.1	Project meeting	2023	24	$ 114.51	$ 2,748.21	$ 590.86	$ 3,339.07	$ 6,288.97
Physical Scientist	1.1	Project meeting	2023	36	$ 39.97	$ 1,439.03	$ 309.39	$ 1,748.43	$ 3,293.07
Biologist	1.2	Progress report	2023	24	$ 53.42	$ 1,282.03	$ 275.64	$ 1,557.67	$ 2,933.80
Soil Scientist	1.2	Progress report	2023	8	$ 88.31	$ 706.45	$ 151.89	$ 858.33	$ 1,616.63
Chemist	1.2	Progress report	2023	8	$ 114.51	$ 916.07	$ 196.95	$ 1,113.02	$ 2,096.32
Physical Scientist	1.2	Progress report	2023	24	$ 39.97	$ 959.36	$ 206.26	$ 1,165.62	$ 2,195.38
Biologist	1.1	Project meeting	2024	15	$ 55.02	$ 825.31	$ 177.44	$ 1,002.75	$ 1,888.63
Soil Scientist	1.1	Project meeting	2024	10	$ 90.96	$ 909.55	$ 195.55	$ 1,105.11	$ 2,081.41
Chemist	1.1	Project meeting	2024	10	$ 117.94	$ 1,179.44	$ 253.58	$ 1,433.02	$ 2,699.02
Physical Scientist	1.1	Project meeting	2024	15	$ 41.17	$ 617.59	$ 132.78	$ 750.37	$ 1,413.28
Biologist	1.2	Progress report	2024	4	$ 55.02	$ 220.08	$ 47.32	$ 267.40	$ 503.64
Soil Scientist	1.2	Progress report	2024	2	$ 90.96	$ 181.91	$ 39.11	$ 221.02	$ 416.28
Chemist	1.2	Progress report	2024	2	$ 117.94	$ 235.89	$ 50.72	$ 286.60	$ 539.80
Physical Scientist	1.2	Progress report	2024	4	$ 41.17	$ 164.69	$ 35.41	$ 200.10	$ 376.87
								Task 1 CAWSC Total	**$ 52,551.72**

Task 1 - Project Management CRRL

Employee Name	Task	Activity	Fiscal Year	Hours	Hourly Rate	Hourly Total	Leave Dist	Total (Net)	Total (Gross)	Period	Total
Fisheries Biologist	1.0 (Period 1)	Contract and Work Order management	2022	80	62.84	5027.2	0	5027.2	7,877.92	1	$7,877.92
									Task 1 Total		**$7,877.92**

TASK 2 - High-resolution mapping surveys Miner S., Steamboat S., Lindsey S., Cache Slough Complex, and Sacramento R.

Personnel / Expense Category	Task	Fiscal Year	Hours	Expense	Hourly Rate	Hourly Total	Leave Dist	Total (Net)	Total (Gross)	Total
Field Work										
Chemist	2.1	2022	9		$ 111.17	$ 1,000.56	$ 215.12	$ 1,215.68	$ 2,289.67	
Hydrotech	2.1	2022	0		$ 29.02	$ -	$ -	$ -	$ -	
Physical Scientist	2.1	2022	30		$ 38.81	$ 1,164.27	$ 250.32	$ 1,414.58	$ 2,664.30	
Hydrotech	2.1	2022	39		$ 35.65	$ 1,390.42	$ 298.94	$ 1,689.36	$ 3,181.82	
Physical Scientist	2.1	2022	3		$ 31.65	$ 94.94	$ 20.41	$ 115.35	$ 217.25	
Soil Scientist	2.1	2022	12		$ 85.73	$ 1,028.81	$ 221.19	$ 1,250.00	$ 2,354.32	
Hydrotech	2.1	2022	110		$ 48.26	$ 5,308.99	$ 1,141.43	$ 6,450.42	$ 12,149.04	
Hydrotech	2.1	2022	36		$ 32.94	$ 1,185.66	$ 254.92	$ 1,440.58	$ 2,713.25	
Hydrotech	2.1	2022	24		$ 17.72	$ 425.26	$ 91.43	$ 516.69	$ 973.17	
Hydrotech	2.1	2022	0		$ 23.62	$ -	$ -	$ -	$ -	
Hydrologist	2.1	2022	24		$ 58.67	$ 1,407.97	$ 302.71	$ 1,710.68	$ 3,221.98	
Hydrotech	2.1	2022	40		$ 35.61	$ 1,424.59	$ 306.29	$ 1,730.88	$ 3,260.02	
Hydrotech	2.1	2022	15		$ 33.12	$ 496.78	$ 106.81	$ 603.58	$ 1,136.82	
Biologist	2.1	2022	60		$ 51.86	$ 3,111.74	$ 669.02	$ 3,780.76	$ 7,120.87	
Hydrologist	2.1	2022	0		$ 59.33	$ -	$ -	$ -	$ -	
										$ 41,282.51
Continuous ammonium										
Physical Scientist	2.1	2022	43		$ 39.97	$ 1,718.85	$ 369.55	$ 2,088.40	$ 3,933.39	
Physical Scientist	2.1	2022	39		$ 32.59	$ 1,271.18	$ 273.30	$ 1,544.48	$ 2,908.96	
Chemist	2.1	2022	3		$ 88.31	$ 264.92	$ 56.96	$ 321.88	$ 606.24	
Hydrotech	2.1	2022	12		$ 49.71	$ 596.54	$ 128.26	$ 724.79	$ 1,365.11	
										$ 8,813.69
Equipment and supplies										
Equipment	2.1	2022		$ 3,000.00				$ 3,000.00	$ 5,650.35	
Supplies	2.1	2022		$ 3,000.00				$ 3,000.00	$ 5,650.35	
Trucks	2.1	2022		$ 450.00				$ 450.00	$ 847.55	
Boats	2.1	2022		$ 1,350.00				$ 1,350.00	$ 2,542.66	
										$ 14,690.91
Laboratory Analyses										
Shipping	2.1	2022		$ 150.00				$ 150.00	$ 282.52	
NWQL Supplies (G&S)	2.1	2022		$ 1,608.47				$ 1,608.47	$ 1,801.49	
NWQL water quality samples	2.1	2022		$ 15,751.21				$ 15,751.21	$ 17,641.35	
NWQL stable isotope samples	2.1	2022		$ 9,273.60				$ 2,704.80	$ 3,029.38	
										$ 22,754.74
Data management and analysis										
Hydrotech	2.1	2022	30		$ 48.26	$ 1,447.91	$ 311.30	$ 1,759.20	$ 3,313.37	
Chemist	2.1	2022	10		$ 111.17	$ 1,111.73	$ 239.02	$ 1,350.76	$ 2,544.08	
Hydrotech	2.1	2022	16		$ 29.02	$ 464.39	$ 99.84	$ 564.24	$ 1,062.72	
Hydrotech	2.1	2023	20		$ 48.26	$ 965.27	$ 207.53	$ 1,172.80	$ 2,208.92	
										$ 9,129.09
									Task 2 total	**$ 96,670.93**

TASK 3 - High-resolution mapping surveys around Franks Tract and Mildred Island.										
Personnel / Expense Category	**Task**	**Fiscal Yea**	**Hours**	**Expense**	**Hourly Rate**	**Hourly Total**	**Leave Dist**	**Total (Net)**	**Total (Gross)**	**Total**
Field Work										
Chemist	3.1	2022	40		$ 111.17	$ 4,446.94	$ 956.09	$ 5,403.03	$ 10,176.33	
Hydrotech	3.1	2022	39		$ 35.65	$ 1,390.42	$ 298.94	$ 1,689.36	$ 3,181.82	
Hydrotech	3.1	2022	147		$ 48.26	$ 7,094.73	$ 1,525.37	$ 8,620.10	$ 16,235.53	
Hydrotech	3.1	2022	66		$ 32.94	$ 2,173.71	$ 467.35	$ 2,641.06	$ 4,974.30	
Hydrotech	3.1	2022	42		$ 17.72	$ 744.21	$ 160.01	$ 904.22	$ 1,703.05	
Hydrotech	3.1	2022	51		$ 58.67	$ 1,407.97	$ 302.71	$ 1,710.68	$ 3,221.98	
Hydrotech	3.1	2022	24		$ 35.61	$ 1,816.35	$ 390.52	$ 2,206.87	$ 4,156.53	
Biologist	3.1	2022	66		$ 33.12	$ 794.84	$ 170.89	$ 965.73	$ 1,818.91	
										$ 45,468.44
Equipment and supplies										
Equipment	3.1	2022		$ 3,000.00				$ 3,000.00	$ 5,650.35	
Supplies	3.1	2022		$ 3,000.00				$ 3,000.00	$ 5,650.35	
Trucks	3.1	2022		$ 450.00				$ 450.00	$ 847.55	
Boats	3.1	2022		$ 1,350.00				$ 1,350.00	$ 2,542.66	
										$ 14,690.91
Laboratory Analyses										
Shipping	3.1	2022		$ 150.00				$ 150.00	$ 282.52	
NWQL Supplies (G&S)	3.1	2022		$ 1,577.67				$ 1,577.67	$ 1,766.99	
NWQL water quality samples	3.1	2022		$ 21,356.70				$ 21,356.70	$ 23,919.50	
NWQL stable isotope samples	3.1	2022		$ 5,382.00				$ 5,709.76	$ 6,394.94	
										$ 32,363.95
Data management and analysis										
Hydrotech	3.1	2022	90		$ 51.20	$ 4,608.25	$ 990.77	$ 5,599.02	$ 10,545.47	
Chemist	3.1	2022	60		$ 117.94	$ 7,076.63	$ 1,521.48	$ 8,598.11	$ 16,194.10	
Hydrotech	3.1	2022	16		$ 29.02	$ 464.39	$ 99.84	$ 564.24	$ 1,062.72	
Hydrotech	3.1	2023	80		$ 49.71	$ 3,976.91	$ 855.04	$ 4,831.95	$ 9,100.73	
										$ 36,903.03
									Task 3 Total	**$ 129,426.33**

TASK 4 - Franks Tract Cyanotoxin Monitoring									
Employee Name/Expense Category	**Task**	**Task Name**	**Fiscal Year**	**Hours**	**Hourly Rate**	**Hourly Total**	**Leave Dist**	**Total (Net)**	**Total (Gross)**
Hydrologic technician	4.1	SPATT samplers	2022	21	$ 32.94	$ 691.64	$ 148.70	$ 840.34	$ 1,582.73
Hydrologic technician	4.1	SPATT samplers	2022	21	$ 17.72	$ 372.11	$ 80.00	$ 452.11	$ 851.52
Hydrologist	4.1	SPATT samplers	2022	14	$ 59.33	$ 830.63	$ 178.59	$ 1,009.22	$ 1,900.81
Hydrologic technician	4.2	Sample handling	2022	21	$ 32.94	$ 691.64	$ 148.70	$ 840.34	$ 1,582.73
Hydrologic technician	4.2	Sample handling	2022	21	$ 17.72	$ 372.11	$ 80.00	$ 452.11	$ 851.52
Hydrologist	4.2	Sample handling	2022	14	$ 59.33	$ 830.63	$ 178.59	$ 1,009.22	$ 1,900.81
Hydrologic technician	4.3	Data management	2022	21	$ 32.94	$ 691.64	$ 148.70	$ 840.34	$ 1,582.73
Hydrologist	4.3	Data management	2022	21	$ 59.33	$ 1,245.95	$ 267.88	$ 1,513.83	$ 2,851.22
Hydrologic technician	4.3	Data management	2022	21	$ 48.26	$ 1,013.53	$ 217.91	$ 1,231.44	$ 2,319.36
Hydrologic technician	4.1	SPATT samplers	2023	15	$ 33.92	$ 508.85	$ 109.40	$ 618.25	$ 1,164.44
Hydrologic technician	4.1	SPATT samplers	2023	15	$ 18.25	$ 273.76	$ 58.86	$ 332.62	$ 626.48
Hydrologist	4.1	SPATT samplers	2023	15	$ 61.11	$ 916.66	$ 197.08	$ 1,113.74	$ 2,097.68
Hydrologic technician	4.2	Sample handling	2023	15	$ 33.92	$ 508.85	$ 109.40	$ 618.25	$ 1,164.44
Hydrologic technician	4.2	Sample handling	2023	15	$ 18.25	$ 273.76	$ 58.86	$ 332.62	$ 626.48
Hydrologist	4.2	Sample handling	2023	15	$ 61.11	$ 916.66	$ 197.08	$ 1,113.74	$ 2,097.68
Hydrologic technician	4.3	Data management	2023	15	$ 33.92	$ 508.85	$ 109.40	$ 618.25	$ 1,164.44
Hydrologist	4.3	Data management	2023	15	$ 61.11	$ 916.66	$ 197.08	$ 1,113.74	$ 2,097.68
Hydrologic technician	4.3	Data management	2023	15	$ 49.71	$ 745.67	$ 160.32	$ 905.99	$ 1,706.39
								Task 4 total	**$ 28,169.15**

TASK 5 - Water Quality, phytoplankton and cyanoHABs data analysis and interpretation									
Employee Name/Expense Category	**Task**	**Task Name**	**Fiscal Year**	**Hours**	**Hourly Rate**	**Hourly Total**	**Leave Dist**	**Total (Net)**	**Total (Gross)**
Biologist	5.1	Data analysis	2022	100.0	$ 51.86	$ 5,186.23	$ 1,115.04	$ 6,301.26	$ 11,868.11
Physical Scientist	5.1	Data analysis	2022	50.0	$ 38.81	$ 1,940.44	$ 417.20	$ 2,357.64	$ 4,440.50
Hydrologic technician	5.1	Data analysis	2022	20.0	$ 29.02	$ 580.49	$ 124.81	$ 705.30	$ 1,328.39
Soil Scientist	5.1	Data analysis	2022	12.0	$ 85.73	$ 1,028.81	$ 221.19	$ 1,250.00	$ 2,354.32
								Task 5 total	**$ 19,991.32**

TASK 6 – Field-validation of remote sensing cyanoHAB algorithm

Employee Name/Expense Category	Task	Task Name	Fiscal Year	Hours	Hourly Rate	Hourly Total	Leave Dist	Total (Net)	Total (Gross)	
Chemist	6.1	Field work	2022	12	$ 111.17	$ 1,334.08	$ 286.83	$ 1,620.91	$ 3,052.90	
Hydrologic technician	6.1	Field work	2022	3	$ 29.02	$ 87.07	$ 18.72	$ 105.79	$ 199.26	
Physical scientist	6.1	Field work	2022	60	$ 38.81	$ 2,328.53	$ 500.63	$ 2,829.17	$ 5,328.59	
Hydrologic technician	6.1	Field work	2022	39	$ 35.65	$ 1,390.42	$ 298.94	$ 1,689.36	$ 3,181.82	
Physical scientist	6.1	Field work	2022	30	$ 31.65	$ 949.35	$ 204.11	$ 1,153.46	$ 2,172.48	
Soil Scientist	6.1	Field work	2022	12	$ 85.73	$ 1,028.81	$ 221.19	$ 1,250.00	$ 2,354.32	
Hydrologic technician	6.1	Field work	2022	99	$ 48.26	$ 4,778.09	$ 1,027.29	$ 5,805.38	$ 10,934.13	
Hydrologic technician	6.1	Field work	2022	48	$ 32.94	$ 1,580.88	$ 339.89	$ 1,920.77	$ 3,617.67	
Hydrologic technician	6.1	Field work	2022	24	$ 17.72	$ 425.26	$ 91.43	$ 516.69	$ 973.17	
Hydrologist	6.1	Field work	2022	12	$ 23.62	$ -	$ -	$ -	$ -	
Hydrologic technician	6.1	Field work	2022	9	$ 58.67	$ 703.98	$ 151.36	$ 855.34	$ 1,610.99	
Hydrologic technician	6.1	Field work	2022	9	$ 35.61	$ 320.53	$ 68.91	$ 389.45	$ 733.50	
Biologist	6.1	Field work	2022	84	$ 33.12	$ 298.07	$ 64.08	$ 362.15	$ 682.09	
										$ 34,840.94
Equipment and supplies										
Equipment	6.1		2022					$ 3,000.00	$ 5,650.35	
Supplies	6.1		2022					$ 3,000.00	$ 5,650.35	
Trucks	6.1		2022					$ 450.00	$ 847.55	
Boats	6.1		2022					$ 1,350.00	$ 2,542.66	
										$ 14,690.91
Laboratory Analyses										
Shipping	6.1		2022					$ 150.00	$ 282.52	
NWQL Supplies (G&S)	6.1		2022					$ 11,702.67	$ 13,106.99	
NWQL water quality samples	6.1		2022					$ 39,033.00	$ 43,716.96	
										$ 57,106.47
Data management and analysis										
Hydrotech	6.1		2023	80	$ 49.71	$ 3,976.91	$ 855.04	$ 4,831.95	$ 9,100.73	
Biologist	6.1		2023	20	$ 53.42	$ 1,068.36	$ 229.70	$ 1,298.06	$ 2,444.83	
Physical scientist	6.1		2023	20	$ 40.93	$ 818.52	$ 175.98	$ 994.50	$ 1,873.09	
										$ 13,418.66
									Task 6 Total	**$ 120,056.97**

TASK 7 - Report Writing									
Employee Name/Expense Categor	Task	Task Name	Fiscal Year	Hours	Hourly Rate	Hourly Total	Leave Dist	Total (Net)	Total (Gross)
Biologist	2	North Delta Mapping	2023	120	$ 53.42	$ 6,410.17	$ 1,378.19	$ 7,788.36	$ 14,668.99
Soil Scientist	2	North Delta Mapping	2023	40	$ 88.31	$ 3,532.24	$ 759.43	$ 4,291.67	$ 8,083.15
Chemist	2	North Delta Mapping	2023	40	$ 114.51	$ 4,580.34	$ 984.77	$ 5,565.12	$ 10,481.62
Physical Scientist	2	North Delta Mapping	2023	40	$ 39.97	$ 1,598.93	$ 343.77	$ 1,942.69	$ 3,658.97
Geologist	2	North Delta Mapping	2023	40	$ 60.43	$ 2,417.01	$ 519.66	$ 2,936.67	$ 5,531.07
Biologist	3	Franks Tract Mapping	2023	120	$ 88.31	$ 10,596.72	$ 2,278.30	$ 12,875.02	$ 24,249.45
Soil Scientist	3	Franks Tract Mapping	2023	40	$ 114.51	$ 4,580.34	$ 984.77	$ 5,565.12	$ 10,481.62
Chemist	3	Franks Tract Mapping	2023	40	$ 39.97	$ 1,598.93	$ 343.77	$ 1,942.69	$ 3,658.97
Physical Scientist	3	Franks Tract Mapping	2023	40	$ 60.43	$ 2,417.01	$ 519.66	$ 2,936.67	$ 5,531.07
Geologist	3	North Delta Mapping	2023	40	$ 53.42	$ 2,136.72	$ 459.40	$ 2,596.12	$ 4,889.66
Biologist	4	Franks Tract Cyanotoxins	2023	80	$ 114.51	$ 9,160.69	$ 1,969.55	$ 11,130.23	$ 20,963.24
Soil Scientist	4	Franks Tract Cyanotoxins	2023	20	$ 39.97	$ 799.46	$ 171.88	$ 971.35	$ 1,829.48
Biologist	6	Remote Sensing validatio	2023	120	$ 53.42	$ 6,410.17	$ 1,378.19	$ 7,788.36	$ 14,668.99
Soil Scientist	6	Remote Sensing validatio	2023	25	$ 88.31	$ 2,207.65	$ 474.64	$ 2,682.30	$ 5,051.97
Chemist	6	Remote Sensing validatio	2023	60	$ 114.51	$ 6,870.51	$ 1,477.16	$ 8,347.68	$ 15,722.43
Physical Scientist	6	Remote Sensing validatio	2023	100	$ 40.93	$ 4,092.59	$ 879.91	$ 4,972.50	$ 9,365.45
								Task 7 Total	**$ 158,836.13**

Annually established indirect rate applies. Salary rates and leave assessment amounts listed are estimates. Actual salary rates may fluctuate over the term of this Work Order as required by the Office of Personnel Management. https://www.opm.gov/policy-data-oversight/pay-leave/salaries-wages/.

ATTACHMENT 3 - GENERAL PROVISIONS APPLICABLE TO ALL DELIVERABLES AND WORK PRODUCTS:

G1: All provisional and USGS-approved (QA/QC'd) data, deliverables and work products developed by the Contractor under this Work Order will be transferred to DWR. As stated in Exhibit B; page 6 of 11 of the original agreement, signed by Department of General Services (DGS) on November 17, 2021, all data and information obtained and/or received under this agreement shall be in the public domain.

G2: Contractor shall maintain copies of all data and work products throughout the term of this Work Order and any subsequent Work Orders or extensions. Contractor is encouraged to maintain all files.

G3: A complete electronic copy of all final documents will be provided in both the associated Microsoft Office application format and as an indexed and searchable Adobe portable document format.

G4: Execution of this Work Order will require the Contractor to work closely with DWR and other agency staff (e.g. NMFS, USFWS, USBR, and CDFW) as well as other DWR contractors.

G5: Invoicing will provide adequate documentation to justify expenses allowed within the Work Order. DWR and the Contractor will come to an agreement about the template to be used for billing prior to the first invoice being issued.

G6: All written deliverables shall be provided to the DWR Work Order Manager as a draft with at least a one-week period for DWR review and comment before the DWR Work Order manager will approve the deliverable.