CERMAK & INGLIN, LLP
12121 Wilshire Blvd.
Suite 322
Los Angeles, CA 90025

Sonja A. Inglin
direct dial: 424.465.1532
singlin@cermaklegal.com

June 20, 2022

BY EMAIL

Kevin, Lin, P.E.
Los Angeles Regional Quality Control Board
320 West Fourth Street, Suite 200
Los Angeles, California 90013

Re: Project Update and Notice of Opportunity to Comment dated May 18, 2022 ("Public Notice") - Skypark Commercial Properties, 24701–24777 Crenshaw Blvd and 2530, 2540 and 2600 Skypark Drive, Torrance, California (Skypark Study Area) - Comments of Esterline Technologies Corporation

Dear Mr. Lin:

This letter is submitted on behalf of Esterline Technologies Corporation ("Esterline") in response to the above-referenced Public Notice.[1] It provides the Los Angeles Regional Water Quality Control Board ("RWQCB") with comments on the Groundwater Removal Action Work Plan dated January 31, 2022, prepared by Terraphase Engineering on behalf of the City of Torrance (the "Groundwater RAW").

The Groundwater RAW was submitted to the RWQCB pursuant to Cleanup and Abatement Order No. R4-2021-0079 ("Order"), which names the City of Torrance as well as others, including Esterline, as dischargers. Esterline disputes that it was properly named as a discharger in the Order and denies any liability or responsibility associated with groundwater contamination addressed in the Groundwater RAW or any other aspect of the Order.[2]

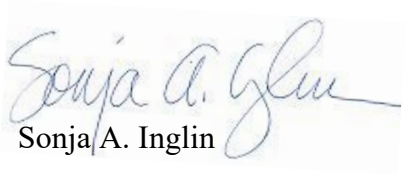
[1] As addressed in our email communications regarding the Public Notice, in that the date listed in the Public Notice for providing comments fell on Saturday, June 18, 2022, the deadline for submitting comments is today.

[2] Esterline has a filed a Petition for Review of the Order which is pending before the State Water Resources Control Board. As addressed in that Petition and in submissions to the Regional Board, Esterline never occupied or conducted operations at any of the properties subject to the Order and denies that it can be named as a discharger based on the activities of a former long-dissolved subsidiary which operated at one of those properties (and whose activities in any event did not cause or contribute to the conditions addressed in the Order).

Notwithstanding the above, and reserving all of its rights and defenses, Esterline is providing the RWQCB with the attached memorandum prepared by Esterline's technical consultant, Scott Warner P.G., C.HG., C.EG. of the BBJ Group, LLC ("Memorandum"). The Memorandum contains comments on the remedial measures proposed in the Groundwater RAW and identifies additional data-gathering and analysis that Mr. Warner concludes is necessary to the success and cost-effectiveness of any such measures that the RWQCB adopts.[3] As noted in Memorandum, Mr. Warner's comments draw on his specific knowledge and experience with both primary remedial technologies proposed in the Groundwater RAW – the application of groundwater treatment barrier using zero valent iron and the application of enhanced in-situ bioremediation to mitigate chemically affected groundwater.

Thank you for your consideration of Esterline's comments. Mr. Warner is available to meet with you and other RWQCB staff to discuss any questions regarding Esterline's comments.

Sincerely yours,



Sonja A. Inglin

Encl.

cc: Thomas Schmidt, Esq., Hi-Shear (tpjschmidt@gmail.com)
Jillian Ly, RWQCB (jillian.ly@waterboards.ca.gov)
Tamarin Austin (tamarin.austin@waterboards.ca.gov)
Arthur Heath, RWQCB (Arthur.Heath@waterboards.ca.gov)
Carla Dillon, City of Lomita (c.dillon@lomitacity.com)
Steve Van der Hoven, Genesis Engineering & Redevelopment (svanderhoven@gercorp.com)
Travis Van Ligten, Esq., City of Torrance (TVanLigten@rutan.com)
Joseph Liles, Water Replenishment District (jliles@wrd.org)
Ryan Smoot, City of Lomita (r.smoot@lomitacity.com)
Dmitriy Ginzburg, State Water Board Division of Drinking Water (dmitriy.ginzburg@waterboards.ca.gov)
Richard G. Montevideo, Esq., City of Torrance (rmontevideo@rutan.com)
William Beverly, Esq., Dasco (beverlylawcorp@aol.com)

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[3] Consistent with this focus, Esterline's comments do not address statements contained in the Public Notice and the Groundwater RAW with respect to Esterline's alleged liability or the operations of its former subsidiary, but that should not be viewed as an admission or acknowledgment that such statements are in fact correct.

Brian M. Ledger, Esq., Robinson Helicopter (bledger@grsm.com)
David L. Evans, Esq., Hi-Shear (dlevans@hamricklaw.com)
Aram Chaparyan, City of Torrance (AChaparyan@TorranceCA.gov)
Christopher Dow, Esq., DCH (cdow@behblaw.com)
Alan B. Fenstermacher, Esq., City of Torrance (afenstermacher@rutan.com)
Brian D. Langa, Esq., Lexus (BLanga@DDSFFIRM.com)
Jeff W. Poole, Esq., Hi-Shear (jpoole@hamricklaw.com)

BBJ GROUP

MEMORANDUM

TO: Kevin Lin, Los Angeles Regional Water Quality Control Board (LARWQCB)

FROM: Scott D. Warner, P.G., C.HG., C.EG., BBJ Group, LLC (BBJ Group)

SUBJECT: Comments on the Groundwater Removal Action Plan (Groundwater RAW) for the Skypark Project Site in Torrance, California

DATE: June 20, 2022

This memorandum provides comments, on behalf of Esterline Technologies Corporation (Esterline), in response to the Los Angeles Regional Water Quality Control Board's (LARWQCB's) *Project Update and Notice of Opportunity to Comment* dated May 18, 2022 (Public Notice). In the Public Notice, the LARWQCB seeks comments on the January 31, 2022 Groundwater Removal Action Plan (Groundwater RAW) submitted by Terraphase Engineering (Terraphase) on behalf of the City of Torrance (Groundwater RAW) for the Skypark Commercial Properties project located at 24701-24777 Crenshaw Boulevard and 2430, 2540, and 2600 Skypark Drive in Torrance California (collectively referred here to as "the Skypark project site"). [1]

The Skypark project site is bounded on the east by Crenshaw Boulevard and both residential and commercial property in the City of Lomita and on the south by the Torrance Municipal Airport, on which a Nike Missile Defense facility (not discussed in the Public Notice and known as Nike Missile Site Number LA-57) was located in the 1950s and 1960s. Esterline has been identified by the LARWQCB as a party associated with one of those properties, referred to as EA Property 1 (24777 and 24751 Crenshaw Boulevard).

My comments address the specific groundwater remedies described in the Groundwater RAW - the application of groundwater treatment barrier (sometimes referred to as a permeable reactive barrier, or PRB) using zero valent iron (ZVI) to be located over a 500-foot stretch of Crenshaw Boulevard, and the application of enhanced in-situ bioremediation (EISB) to mitigate chemically affected groundwater under portions of the Skypark project site. Based on the LARWQCB's statements in the Public Notice, I have evaluated these remedies as potential interim remedial measures even though the Terraphase report appears to consider these as final measures. My comments below focus on the additional data required – and not yet developed with respect to the Skypark project site – to understand site conditions and sources and to screen, design and evaluate the performance of interim groundwater remedies. This memorandum also includes comments specific to implementation of ZVI and EISB, as proposed in the Groundwater RAW. Additional comments on specific provisions of the Groundwater RAW are included in Appendix A.

As an initial comment, I want to emphasize that the remedies selected by the GW RAW require detailed analysis of the subsurface hydraulic and biogeochemical conditions to develop a technically effective and cost-efficient design as well as to properly locate the remedies for most effective application. If these

[1] These comments are to provide the LARWQCB with technical input to assist it in evaluating what action to take with respect the Groundwater RAW. It is not intended to comprehensively address those documents, including any specific statements or conclusions that may be in them related to responsibility of Esterline or others for conditions within the Skypark project site.

remedies identified by the GW RAW are selected and implemented without requiring the additional data and analysis, the remedies may fail and if so, certainly would not be cost effective.

Relevant to the comments in this memorandum, BBJ Group, under my technical lead, submitted two documents to the LARWCQB on behalf of Esterline in September 2021 that interpret historical and current site characteristics important to assessing the environmental conditions and identifying and proposing steps to fill data gaps in the understanding of site conditions. These documents were prepared specifically for evaluating conditions related to EA Property 1, but relate to the entire Skypark project area (referred to as the "Skypark Study Area" in the September 2021 reports) and include:

- Preliminary Site Conceptual Model Report, September 10, 2021(2021 pSCM)
- Data Gap and Preliminary Site Assessment Work Plan, September 10, 2021 (2021 Data Gap Work Plan)

Both documents were submitted to the LARWQCB and are available on the Geotracker website.[2] The information, analyses, and conclusions provided by the reports remain consistent with our current assessment and understanding of the subsurface conditions beneath the Skypark project site,[3] including the need to investigate the adjacent former Nike missile property located on the southern boundary of EA Property 1 as a potential source of groundwater contamination within the Skypark project site as part of the data gap investigation proposed by Esterline.

In providing these comments, I have substantial technical background and experience related to the environmental contaminant conditions that affect soil, soil vapor, and groundwater beneath the Skypark project site. I have worked on numerous similar projects over the past 35 years, having designed and implemented a substantial number of site characterization and assessment projects, and having analyzed, selected, designed, implemented, and monitored the performance of remedial actions and technologies that are proposed by the Groundwater RAW. In fact, I have specific knowledge and experience related to both ZVI and EISB, including as a lead on the design and implementation of the very first system in California (and in the country) that used ZVI to treat groundwater, and as the technical lead for a second site that was one of the first in California to apply EISB; both of these sites were affected by the same type of organic contaminants as at the Skypark project site. A copy of my CV is attached.

Need for Additional Site Characterization

The specific "in situ" groundwater remedial actions proposed by the Groundwater RAW, including bioremediation using EISB and the use of a PRB system composed ZVI, require focused and detailed characterization information so they can be properly designed and assessed for their potential success in meeting water quality objectives.

From our review of the Groundwater RAW, the Skypark project site has **NOT** yet been characterized with sufficient detail to select remedies as proposed by the Groundwater RAW nor as consistent with the Water Board's own guidelines under the Site Cleanup Program process that lists as essential the requirement to

[2] https://geotracker.waterboards.ca.gov/profile_report?global_id=T10000013835

[3] The LARWQCB has not yet responded to or provided comments on these reports. Esterline subsequently requested that the LAWRQCB approve an updated data gap investigation plan submitted by Magellan Aerospace, Middletown, Inc, following submission of the Groundwater RAW that included the data gap investigation proposed in Esterline's Work Plan. That request remains under submission.

perform a "soil and water investigation to determine the source, nature, and extent of the discharge with sufficient detail to provide the basis for decisions regarding subsequent clean-up and abatement actions."[4]

The gaps in site characterization data include an incomplete understanding of contaminant sources, including specifically the former Nike Missile site adjoining Property 1 (which is discussed below), and a lack of understanding of the hydraulic and geochemical conditions that affect the migration characteristics, including the direction, fate, and rate of transport, of the contaminants from all potential source areas beneath the Skypark Study site. Furthermore, if contaminant source areas are identified on the former Nike Missile property, the in situ remedies, specifically the PRB proposed for Crenshaw Boulevard, may be insufficiently located and designed for treating this source area.

Our comments in the following paragraphs highlight numerous reasons why the current level of characterization in a number of respects is not yet sufficient to select or design in situ remedies identified in the Groundwater RAW, in particular, the ZVI barrier. As an example, the success of both primary remedies identified, EISB and PRB – ZVI, are dependent on the hydraulic conditions of the aquifer being treated. There has been extremely limited, if any, reported specific characterization of the physical hydraulic flow conditions (e.g., groundwater velocity, site wide vertical hydraulic gradients, etc.) of the aquifer system in which these remedies would be applied. Additionally, there has been essentially no, or extremely limited reported characterization of the biogeochemical conditions of the aquifer in the areas proposed for the groundwater remedies. Both the bioremediation through EISB and the PRB technologies are geobiochemical remedies themselves and are strongly influenced by ambient conditions and even past remedial efforts (including, potentially, the past bioremediation program implemented at the Hi Shear property). Certain conditions may make selection of these remedies infeasible or uncertain, or may require a substantially different design that would add substantial additional time, more complex logistics, and significant cost to implement at the Skypark Study area. Selection of these remedies, or any remedy for that matter, should not be finalized until the appropriate hydraulic and geobiochemical conditions are more completely assessed. When sufficient site characterization is completed, which could be done expeditiously over just a few months, remedy selection would be substantially improved to the point that interim remedies could be selected and efficiently tested at the Skypark project site to assure performance needs prior to potential full-scale implementation

Another element of the additional site characterization is to require consistent and more comprehensive monitoring of soil, soil vapor and groundwater, as addressed below.

Also, regarding the soil vapor extraction system on the HSC property, as noted in the Public Notice,[5] as part of a more comprehensive site characterization program, that system should be evaluated not only for "optimization" of its mechanical system but should be subject to additional site characterization to identify potential additional contaminant source areas on the HSC property. The data from the February 2022 SVE Monitoring Report indicates a higher than anticipated mass of contaminants in the influent to the SVE was detected by the monitoring program as reported in the February 2022 report for the 4th Quarter 2021 SVE monitoring program.[6] No explanation supported by technically defensible characterization data has been provided by HSC as to the source of the higher than anticipated mass. This work should be paramount to assessing efficacy of the system and whether expansion of vapor extraction wells to other areas of the

[4] https://www.waterboards.ca.gov/losangeles/water_issues/programs/remediation/
[5] Public notice at page 2, paragraph 2.
[6] https://www.waterboards.ca.gov/losangeles/water_issues/programs/remediation/

project site should occur. There also has been no evaluation as to the potential additional vapor phase that may have been produced through transformation of contaminants associated with the HSC bioremediation program performed from 2013 to 2017; the LARWQCB should require that a technical evaluation of these actions be performed in concert with the RAW.[7]

Investigation of Former Nike Missile Base as a Potential Source of Groundwater Contaminants[8]

The Public Notice does not mention that the adjacent Torrance Municipal Airport also formerly housed a Nike Missile Defense Site (Site Number LA-57) – located both immediately to the south of EA Property 1 and in part, on property that today is part of South Bay Lexus operations. Based on available records, Nike Missile Sites, in general, included activities that involved the use of chemicals, including chlorinated solvents like trichloroethylene, petroleum fuel compounds, and possibly energetic compounds such as perchlorate[9] – these are the same list of contaminants that are also being investigated in relation to the Skypark Study area. The further investigation of the former Nike Missile site is being addressed in connection the separate East Adjacent Properties Removal Action Plan (EA RAW), also submitted by Terraphase on behalf of the City, but it is noted here because of the impact that the results of that investigation for purposes of developing interim groundwater remedies.

Historical aerial photographs, including those provided in the Esterline September 2021 Preliminary Conceptual Site Model report, with two examples attached to this memorandum (**Appendix B**) for convenience, show facility use, the location of construction or related debris, storage containers, and missile silos located immediately adjacent and south of the Skypark project site. The Groundwater RAW needs to acknowledge the historical use of the former Nike Missile site (this use is not even identified in Section 2.2 "Adjacent Properties" of the Groundwater RAW) and take into account the information that is observable on the historical aerial photographs as well as in historical documents that are available on the use of the former Nike Missile site and the common practices that the United States implemented for operating these missile defense sites including use of organic solvents, energetics used in fuel for the missile systems, and other materials that are known environmental contaminants.

Even though the Groundwater RAW states that its focus is primarily on the "Hi Shear" source to groundwater and the so-called "Plume Margin", without completing characterization of the former Nike Missile site to the extent that potential chemical sources, and the conditions that affect the chemical occurrence and migration are evaluated, selection and assessment of interim or final groundwater remedies may not be successful. Further discussion of the former Nike Missile site is included within the 2021 pCSM beginning on page 12, section 2.5.[10]

Need for Consistent Monitoring of Soil Vapor, the Soil Vapor Extraction System, and Groundwater[11]

The Public Notice briefly summarizes the assessment of on-site soil vapor intrusion potential, off-site soil vapor intrusion, and the combined consideration of soil vapor and groundwater monitoring. The LARWQCB states that some vapor intrusion and human health risk assessments have shown that some properties

[7] Esterline proposed such an evaluation take place in its 2021 Data Gap Work Plan, which is still pending comments by the LARWQCB.

[8] Public Notice at Page 1, Paragraph 4.

[9] U.S. Army Corps of Engineers (USACE). 2003. Final Report, Nike Missile Battery Environmental Conditions Assessment Guide. Defense Environmental Restoration Program Formerly Used Defense Sites (DERP-FUDS). July.

[10] https://documents.geotracker.waterboards.ca.gov/esi/uploads/geo_report/4629703104/T10000013835.PDF

[11] Public Notice, Page 1, Paragraphs 7 -9.

(e.g., the current South Bay Lexus site) have been shown to have no indoor air issues related to subsurface conditions (see Frey, 2021).[12] However, in the very brief paragraph related to Soil Vapor and Groundwater Monitoring (Paragraph 9 of the Public Notice), it is apparent that consistent monitoring has not taken place, which limits the ability to develop a technically successful and cost-effective approaches to remediation.

Regular, consistent, and comprehensive monitoring will allow the development of a technically representative site-wide conceptual model, as well as to the identification of data gaps (including complete characterization of the adjacent former Nike defense site) necessary to implement appropriate investigation and remediation plans. Furthermore, the report for recent monitoring of the soil vapor extraction (SVE) system operating on the HSC property[13] shows an increase in the influent concentrations to the SVE system. This suggests that trends are dynamic and the characterization program should consider such data in evaluating the site and selecting potential remedial approaches. In addition, as discussed below, monitoring specific to evaluate the effectiveness of ZVI or a similar barrier system, as well as for an EISB remedy and other potential in situ groundwater remedies, should also be required.

Perchlorate Should be Included as a Key Constituent[14]

Perchlorate, in addition to being a contaminant, is reported to have been used by HSC as part of its manufacturing activities and is found on HSC property (upgradient of EA Property 1). Perchlorate also is useful as a tracer for characterizing groundwater flow conditions including flow direction and can be useful as a tool in determining potential sources of chemical release to the ground. Perchlorate has also been identified as an issue with respect to former Nike Missile defense site. Therefore, future monitoring and investigation should be required to include identification of perchlorate as a contaminant of concern.

Need to Develop Interim Remedial Goals Supporting the IRAP

The objectives of the Groundwater RAW are stated in Section 1.2, Page 6 of the Terraphase document and include:

1. Reduce the potential for VI risk into the City of Lomita's residential community east of Crenshaw Boulevard by addressing the principal cause of the soil vapor contamination in the area – the VOC-impacted regional groundwater that continues to migrate from the Hi-Shear property;

2. Further reduce contaminant mass and migration at the Hi-Shear Source area to diminish the VOC source, longevity, and on-going growth of the Hi-Shear Plume to achieve water quality objectives within a reasonable time frame; and,

3. Achieve water quality objectives in the regional groundwater (i.e., MCLs) east of Crenshaw Boulevard within a reasonable time frame.

These objectives, which are conventional for managing a site area of this type, are more consistent with **final**, rather than **interim**, remedial objectives, but may not be appropriate at this stage of the project. Rather, we recommend adoption of interim remedial objectives that are achievable in an expeditious

[12] Frey Environmental 2021)
[13] https://geotracker.waterboards.ca.gov/esi/uploads/geo_report/4841128766/SL204231523.PDF
[14] Page 1, Paragraph 6 of the Public Notice

timeframe and will promote effective progress toward selecting and implementing final management and remedial measures. These recommendations for interim objectives include:

- Complete site characterization of the Skypark project site, including the former Nike Missile site on the Torrance Airport.
    - Characterization should include both a detailed hydraulic analysis and geochemical analysis of the Skypark Study area and HSC areas. Without performing these activities, there can be no reasonable estimate of contaminant time of travel, fate, and transport; anticipated future extent of the impacted area; and any prediction of success, and the design process itself, cannot be achieved with confidence.
- Complete a site conceptual model for the entire Skypark project site, including off-site areas east of Crenshaw Boulevard to best identify and select remedial alternatives that can meet regulatory objectives for managing and mitigating contaminants in the subsurface. As of now, there has been no regulatory-approved complete site conceptual model for the entirety of the Skypark Study area, including the potential contribution from the former Nike Missile site.

Need for Integration with RAW for the East Adjacent Properties of the Skypark Project Area (EA RAW)[15]

The Groundwater RAW (or IRAP as noted by the LARWQCB) notes that the "Groundwater IRAP does not address the soil, soil vapor or Groundwater at, or beneath" the East Adjacent Properties, that include the Lexus, Dasco Engineering and Robinson Helicopter properties and these items are addressed in a separate plan (the "EA RAW" identified previously in this memorandum) currently under review by the LARWQCB. The two remedial action programs should be integrated, as there are numerous common issues concerning the properties, the contaminants and their distribution, the groundwater hydraulic characteristics, and the eventual remedial alternatives that should be developed together. As noted above, the investigation of the former Nike Missile site is an example of an activity under one plan that impact the other. Separating these programs and addressing them two different plans has the potential to leave one or more remedies vulnerable to inefficient characterization, excessive costs, and more importantly, remedies that may be negatively impacted by opposing technical processes (e.g., a bioremedial solution injected within proximity to a ZVI-based system could result in excessive fouling or hydraulic interference; or a chemical oxidation injection within proximity to an EISB remedy may interfere with each other's performance). Technical design can avoid potential issues, but the risk is greater if the remedial programs are not integrated. Furthermore, the source areas and contaminant distribution under the entirety of the Skypark Study area has related characteristics and should be evaluated as a single conceptual model and not under separate programs.

Specific Comments on the Proposed Remedies

Below are technical comments about the two remedies described in the Groundwater RAW – PRB – ZVI along Crenshaw Boulevard and the EISB program for "regional Groundwater." As noted above, additional detailed comments regarding the proposed remedies are provided in Appendix A.

1. The lateral hydraulic gradient has not been defined within the Groundwater RAW with sufficient

[15] Public Notice at Page 2, Paragraph 1

detail to locate a passive groundwater remedy such as a PRB (for example, the shallow hydraulic gradient shown in Figure 3 of the RAW is shown to be in a direction that is nearly parallel (e.g., North-South) to the proposed alignment of the PRB as shown in Figure 4 of the RAW. A design of this type is more prone to failure because of the insufficient capture of the contaminated groundwater as well as the potential for insufficient contact time with the implemented treatment.

2. The Groundwater RAW has not calculated, nor reasonably estimated, a groundwater velocity for determining the appropriate spacing, alignment, and composition of either the PRB-ZVI system or the EISB system flow.

3. The Groundwater RAW should provide for completion of a conceptual hydrogeologic model that integrates specific technical information regarding the perching horizons and their potential impact to the EISB and PRB remedies; the stratigraphic cross-sections are provided, but the detailed descriptions of the remedies do not investigate the effect of this geologic structure on the remedy design or performance.

4. The Groundwater RAW only discusses two applied remedies – PRB-ZVI and EISB, with secondary MNA – but does not identify the potential use of in-situ oxidation as a remedy as presented by the EA RAW. The mixing of different remedies needs to be integrated into an overall plan to avoid competition among the remedies where residual or areal impact may affect neighboring remedies and preclude necessary treatment. This also could exacerbate the occurrence and distribution of contaminants that also would degrade the overall system and increase both complexity and cost of the remedial program.

5. The proposed EISB Program for so-called "regional Groundwater" notes the pilot testing of this related technology on the HSC property but does not include a detailed analysis of that program's impact, effect on adjacent groundwater conditions, or rebound. Such an analysis should be required as a step in implementing it as an interim remedy.

6. The Groundwater RAW proposes that EISB on the HSC property portion of the Skypark project site in the vicinity of the past 2013-2017 pilot bioremediation program conducted by HSC. Reporting indicates EISB was tested from 2013 to 2017 only on portions of the HSC property and involved the use of over 75 injection wells that applied a bioremediation enhancement solution to the underlying Groundwater. The Public Notice[16] notes that the testing was "successful" but does not clarify that contaminated groundwater had already migrated downgradient from HSC to the EA properties and east of Crenshaw Boulevard and could not be treated by this groundwater remedy. Also, there is a strong indication that the EISB program may have: (1) bifurcated the large groundwater plume into two "apparent" but related plume areas – one beneath HSC and one beneath the EA Properties; and (2) created transformation (i.e., degradation contaminants from the primary contaminants including PCE and TCE) that have also migrated to the EA Properties and beyond affecting groundwater and soil vapor. Furthermore, there is some indication that rebound of the program has occurred with noted increases in target chemicals including TCE. The groundwater monitoring program and analysis, as reported most often by HSC (e.g., see the Geotracker list of available, but infrequent monitoring reports[17]) have not addressed these trends with sufficient technical detail or explanation. In particular, increases have been noted in chlorinated VOCs and perchlorate followed

[16] Public Notice at page 2, paragraphs 3 and 4.
[17] https://geotracker.waterboards.ca.gov/profile_report?global_id=SL204231523

by decrease, and subsequent rebound of concentration levels. Furthermore, the groundwater monitoring reports do not include an analysis of other potential groundwater parameters (e.g., geochemical and biochemical constituents including pH, redox potential and redox-sensitive inorganic constituents, microbial counts in groundwater, etc.) that are typical for assessing bioremediation project performance. If EISB using the same injection wells as during the 2013-2017 program, but an expanded area of application (according the "still in review" EA RAW), a fully comprehensive geochemical and hydraulic evaluation of the 2013-2017 program should be required prior to designing and implementing that program.

7. The use of ZVI within a PRB is a developed technology that has nearly 30 years of application in treating similar VOCs in groundwater at sites both throughout California, nationally, and globally. Successful and durable performance of the technology requires comprehensive site characterization and design considerations. The ZVI system proposed by the IRAP is **NOT** a continuous barrier but is proposed to be installed using a series of injection wells that would inject a ZVI-based solution to emplace the treatment media.[18]

8. The Groundwater RAW also proposes integrating ZVI with EISB and possibly with an augmented bio-culture to increase microbial activity. These latter additions to the ZVI system are design matters that require sufficient background evaluation and testing for successful application and should be first tested in a laboratory or as a small-scale, well monitored field test. ZVI sites that fail do so primarily due to: (1) insufficient hydraulic characterization; (2) insufficient ZVI emplacement (e.g., not enough, wrong location, insufficient vertical or lateral placement), and (3) biofouling or aging that can limit both short-and long-term viability of the system. Also, the proposed design appears to extend from an area where more shallow perched Groundwater and fine-grained sediments may occur (in the south) compared to the northern extent of the proposed alignment along Crenshaw Boulevard, and also from where the level of contamination in the subsurface in the south is not well understood. While the concept of the ZVI barrier system has merit, the site characterization details are insufficient for completing this design, and the Groundwater RAW is not currently comprehensive or targeted enough to provide such detail based on our experience.

9. For the PRB-ZVI remedy, the Groundwater RAW should also:

   - Develop a multi-level monitoring well network with locations upgradient, downgradient, cross-gradient and within (to the extent practicable) the PRB.

   - Analyze groundwater samples, in addition to the target contaminants, for parameters that can assess PRB performance related to potential mineralization (e.g., general anions and cations), the progress of the treatment process (e.g., dissolved hydrocarbon gases plus dissolved hydrogen) and the standard water quality parameters including dissolved oxygen, redox potential, and pH.

10. Finally, the Groundwater RAW indicates that the two groundwater treatment systems – EISB and the ZVI system - will provide remediation in a reasonable time frame. The Groundwater RAW does not include the results of hydraulic characterization or projected performance information by which such a declaration can be technically defended; we thus request that such analysis be provided. An

[18] Comment 8, Page 2, Paragraph 5.

estimate of projected mass flux reduction through the PRB over time using numerical modeling and the results of hydraulic testing and biogeochemical analysis should be proposed by the Groundwater RAW to help accomplish this objective.

To summarize my comments, the Groundwater RAW's proposed selection of remedial actions for groundwater is premature without completing additional detailed characterization of the project area (i.e., the Skypark project site and adjacent potential source areas including the adjacent former Nike Missile property). The characterization necessary, could be performed expeditiously, and would provide critical information for determining the occurrence, distribution, and characteristics of groundwater contaminants including potential source areas not yet identified. Additionally, the specific "in situ" groundwater remedial actions proposed by the Groundwater RAW require focused and detailed characterization information so they can be property assessed for their potential success in meeting water quality objectives. Without completing appropriate site characterization activities, remedies could be selected that either are not appropriate for the site, are located incorrectly, or are inadequately designed – each issue would lead to further delays in implementing appropriate remedies and likely significant additional costs. These issues need to be addressed if the LAWRWQCB is to select cost- and technically-effective interim remedies.

Thank you for your consideration of these comments. I would be happy to answer questions you may have and have a discussion with LARWQCB staff assigned to this project on the issues provided herein. I reserve the right to provide additional comments on these or other project topics at a later date.

Sincerely,

Scott D. Warner PG 5938, CHG 73, CEG 1896
Principal Hydrogeologist
BBJ Group, Inc.
Larkspur, California

Appendices

Appendix A.	Additional Detailed Comments on the Groundwater RAW (IRAP)
Appendix B.	Selected Historical Aerial Photographs for the Skypark Project Area Site
Appendix C.	Curriculum Vitae for Scott Warner

Appendix A: Additional Detailed Comments on the GROUNDWATER RAW (IRAP)

The following are specific comments on the Groundwater RAW document itself. The following specific comments address the Sections that focus on the proposed remedial plans beginning with Section 5, Removal Action Objectives and Goals.

Comment A1. Page 16 – Section 5

We note that the stated remedial action objectives (RAOs) focus on vapor intrusion (VI) risk to property east of Crenshaw Boulevard that result from the principal cause of the VI risk. However, the source of VI risk to this area east of Crenshaw Boulevard has not been completely determined. This part of the Groundwater RAW should be clarified and be updated with a statement that upon completion of the study area characterization and development of the site conceptual model, an appropriate remedial plan based on site specific remedial action objectives can be developed.

Comment A2. Page 17 – Section 6

The rationale for selecting the four different proposed removal actions:

- No Action Alternative
- Monitoring natural attenuation (MNA)
- Enhanced in situ bioremediation (EISB)
- Zero-valent Iron (ZVI) barrier

has not been presented. Except for the automatic inclusion of the "no action alternative" we recommend that additional detail be provided that indicates how these remedies were determined as most appropriate for initial consideration to meet the stated remedial objectives.

Comment A3. Page 17 – 21 - Section 6.1 (6.1.1 – 6.1.6), Identification of Removal Alternatives.

- (A3a) For both the No Action and MNA alternatives, we recommend including additional background that more completely describes the commonalities and differences of these remedy approaches.

- (A3b) *Section 6.1.2*. MNA is not an active remedy but is a comprehensive monitoring program that works to estimate the rate of contaminant reduction and time to regulatory goals. Regarding MNA, we have several comments:

    - MNA should be retained as a primary management approach (i.e., it should not be eliminated) as it may appropriate for dilute, low concentration areas of contaminant impact.

    - MNA also is NOT intended to be a specific vapor remedy but could be a groundwater remedy in parts of the study area. The last sentence of section 6.1.2 states that MNA may be used in combo with other remedies, which we agree. We recommend that this use of MNA be emphasized earlier in the section.

- (A3c) *Section 6.1.3*. The description of EISB should be enhanced. We recommend including a definition that is based on the state of the practice, such as: *enhanced bioremediation relies on*

improving the environment for microbial reduction of contaminants by adding nutrients to the groundwater conditions and MAY / MAY NOT also apply non-native microbial cultures. The RAW indicates that EISB commonly is augmented by biological culture addition, but this is not correct. Augmentation is primarily used if characterization of the subsurface microbial conditions indicate that augmentation is necessary and pilot testing or other quantitative site analysis is performed. No such analysis has yet been performed at this site. We therefore recommend clarification of the description in this section.

- (A3d) The last paragraph on Page 18 states "this technology typically can be maintained for 3 or more years after is application, depending on the geochemistry and substrate to establish EISB conditions." The Groundwater RAW does not provide supporting information to these claims; we recommend that descriptions of both the potential duration of treatment and geochemical influence are enhanced and that the issues that may limit remedy performance (effectiveness and duration) are described. Please consider adding project examples, quantitative analysis, and any other supporting information. From our experience, we know inadequate performance of similar methods can occur due to incomplete characterization or not considering future changes to the site conditions. Please also add methods that would be used to maintain appropriate EISB / geobiochemical conditions after the remedy application.

- (A3e) On Page 19, the Groundwater RAW claims success from the EISB at HSC. A technical analysis of the 2013-2017 program including assessment of mass reduction, geochemical conditioning, statistical monitoring, aquifer volume of impact, and impact on transformation product (secondary VOCs) development should be added.

- (A3f) Throughout Page 19, the Groundwater RAW proposes facts that are not yet developed including the potential need to use a specific commercial bioaugmentation culture, the specifics of selecting the plume margin zone of a "EISB Barrier" along Crenshaw, the need to have a specific number of injections (5) over a specific time frame (14 years), and then a specific cost. Please include design details (even if preliminary), calculations, and justification for whether a biological augmentation is needed. Also, please include the hydraulic characterization analysis that is a necessity for designing and implementing a successful in situ remedy application.

- (A3g) *Section 6.1.4*. Page 20 – ZVI. The opening statement under 6.1.4 intended to describe the reaction from zero valent iron (ZVI) that promotes contaminant mitigation in groundwater is incomplete. An established publicly available guidance (e.g., from the Interstate Technology Regulatory Council – ITRC,[19] for example) should be used. Note that ZVI is produced in nano to macro size and is also installed without slurry material for placement. Also, the reaction to reduce contaminants occurs both directly through surface reactions and indirectly via biological enhancements. The statement implies that it is only "hydrogen" that promotes cVOC transformation – this is not correct, though the creation of dissolved hydrogen through the ZVI corrosion process is an enhancement for biologically-mediated reactions.

- (A3h) The Groundwater RAW does not include remedy-specific site characterization data to defend the choice of remedy, its proposed design, effectiveness, or cost. Comprehensive site hydrogeological and chemical data has not been collected from the proposed remedy alignment,

[19] https://itrcweb.org/teams/projects/permeable-reactive-barriers

thus estimated cost may be significantly inaccurate. The statement. "A ZVI remedy, with EISB substrates, will be protective of human health and the environment, comply with RAOs, and be effective in the short and long term" is not yet established based on the existing site data, or supporting laboratory and/or pilot tests. Also, there is no specific data presented by the Groundwater RAW that integrates EISB with ZVI potential application at this field site. A treatment barrier along this alignment not designed using site specific hydraulic data may likely have a high degree of uncertain performance or would have to be substantially overdesigned (at great cost) to increase potential performance success.

Comment A4. Page 22 – Section 6.2.3 – Groundwater Pump and Treat (P&T)

The discussion regarding the potential viability of this technology should include more discussion and clarity regarding the choice to not retain this alternative. Although the document correctly notes that P&T does not typically treat groundwater to MCLs, the method can be quite effective, if designed with site specific hydraulic data, to capture and contain affected water and prevent it from migrating downgradient. Also, the method can create a hydraulic capture that in some cases can be effective for allowing downgradient resources to slowly recover. While P&T may not be a final remedy, the Groundwater RAW should more fully examine the specific technical detail for comparing this to the other remedies and not just discard the alternative without being analyzed.

Comment A5. Page 24-25 – Section 6.2.6 - EISB

Similar comments to the previous discussion, with additional notes. The Groundwater RAW proposes to rely on the existing (?) 77 dual nested injection wells on the HSC site. However, there is no indication that these wells still are in usable condition. There also is no analysis stating that each of the 77 locations are necessary based on site conditions, and there has been no critical analysis (hydraulic, geochemical, biochemical) of the HSC program that ended in 2017. Without this information and critical analysis, the proposed design, cost, and effectiveness is highly speculative and should not be used with any certainty. Please complete the analysis to allow a more comprehensive examination to occur.

Comment A6. Page 25 – Section 6.3 – Removal Action Alternatives

This entire section appears to be incomplete with respect to describing the technical information important to remedy selection as required by the NCP. NCP guidance requests specific analysis and not just highly speculative qualified statements that support selection criteria for remedy alternatives including analysis of long-term effectiveness and performance, short-term performance, and ability to reduce toxicity, mobility and/or volume reduction through treatment. The Groundwater RAW does not include sufficient technical analysis on the proposed alternatives, therefore, an accurate representation of potential effectiveness cannot be completed. We recommend inclusion of **interim remedial objectives** such as a detailed site characterization program, followed by analysis (and possibly in parallel with pilot or lab studies to assess remedy selection) be performed. Otherwise, the projections of performance success and cost are highly speculative.

Comment A7. Page 27 – Section 6.3.1.1 – Discussion on Long and Short-Term Effectiveness of the Remedies

The Groundwater RAW contains no specific example or analysis to estimate the length of effectiveness of the remedies. The Groundwater RAW also does not appear to fully describe the known effectiveness

characteristics of ZVI for which performance and durability is based on numerous factors, including ZVI size, aquifer geochemistry, hydrology, and application. The statement that purports a "5- to 10-year duration" is not technically sufficient as sufficient information on this technology could be integrated with existing site data or estimated new site characterization information to develop a more rigorous analysis and estimate of potential longevity using projected design needs. Examples of ZVI performance in an application ranges from less than 1 year (where design flaws have occurred) to over 25 years for early applications.

Comment A8. Page 30 – Section 6.3.2.1

The statement under Long-Term Effectiveness that "*EISB, provides a moderate level of long-term effectiveness by reducing VOCs in groundwater [and will require] repetition [of injections] until VOC concentrations are reduced to acceptable levels"* should be clarified as being speculative until site specific information is analyzed and evaluated. There also is no data supporting the statement for this site that "*EISB provides good coverage due to its mobility with water."* We recognize that HSC has already installed numerous (77) EISB injection wells for past use, however, there is no information provided showing that these wells remain viable and usable for the proposed new EISB program. The Groundwater RAW should include a program to assess the former injection wells for potential use and offer an alternative program in case such wells are not available due to their condition.

Comment A9. Page 32 – Section 6.4.1 – Plume Margin

The Groundwater RAW proposes a 500-ft long combined ZVI, EISB, MNA remedy only along Crenshaw Bl. While each of the remedy components have been used and proven as successful stand-alone remedies at other sites for several decades, the Groundwater RAW has not provided a detailed analysis of the site characteristics, contaminant occurrence and distribution along Crenshaw, and hydraulic evaluation, performance and design needs to assure this to be a successful remedy alternative. The proposed remedy is a complicated system that also would not directly affect any significant downgradient contaminant impact. The Groundwater RAW also does not include data-based projections on longevity specific to the Skypark study area characteristics. As described by the Groundwater RAW, the proposed remedy implantation would not create a physical "barrier" per se but rather a geo-biochemically enhanced aquifer zone. Injected ZVI systems are not likely to be uniform in construction – this could lead to discontinuities in performance. Substantial effort for predesign and post monitoring network design approaches would be necessary and is not described by the Groundwater RAW. The GROUNDWATER RAW proposes the inclusion of bioaugmentation with a commercial product combined with ZVI. There has been no testing of these two components and any performance is overly speculative. There is no indication of compatibility provided by the Groundwater RAW.

Comment A10. Page 38 – Section 7.3 – Fieldwork Preparation and Permits

Crenshaw is a highly traveled busy highway. Extreme caution must be provided particularly for remedy construction as proposed by the Groundwater RAW. Pressure injection methods (for ZVI) also must first be tested to assure safety and compatibility with all infrastructure.

Comment A11. Page 40 – Section 8 – WDR Groundwater Monitoring Program

The Groundwater RAW should include a remedy specific detailed verification and performance monitoring program. The WDR program is insufficient to assess remedy performance for the purposes of adjusting the remedy, assessing detailed performance, assessing longevity, and is not remedy specific. The EISB and ZVI remedies rely on more than "standard" Groundwater monitoring for assuring success of the implementation. The Groundwater RAW should rely on the numerous technical guidance documents that have been produced over the past 20 years for these remedies. There is no indication that such as been relied on.

APPENDIX B

SELECTED HISTORICAL AERIAL PHOTOGRAPHS FOR THE SKYPARK PROJECT AREA SITE

SOURCES: AERIAL PHOTOGRAPH PROVIDED BY EDR AERIAL PHOTO DECADE PACKAGE ON MARCH 11, 2021.

LEGEND

APPROXIMATE PROPERTY LINE

N

0 430

APPROX. SCALE IN FEET

1989 HISTORIC AERIAL

24777 CRENSHAW BOULEVARD
TORRANCE, CALIFORNIA

APPENDIX

B-1

SOURCES:AERIAL PHOTOGRAPH PROVIDED BY EDR AERIAL PHOTO DECADE PACKAGE ON MARCH 11, 2021.

LEGEND

APPROXIMATE PROPERTY LINE

N

0 470

APPROX. SCALE IN FEET

1994 HISTORIC AERIAL

24777 CRENSHAW BOULEVARD
TORRANCE, CALIFORNIA

APPENDIX

B-2

APPENDIX C

CURRICULUM VITAE FOR SCOTT WARNER

Scott D. Warner, PG CHG CEG
Principal Hydrogeologist swarner@bbjgroup.com **415-799-1743**

Education
B.S., Engineering Geology
University of California, Los Angeles, 1983

M.S., Geology – (Hydrogeology), Indiana University, 1986

PhD Candidate – Enviro. Remediation/Climate Impact (In Progress/Part Time), University of Newcastle, Australia, 2019-Present

Professional Registration
Professional Geologist, Certified Hydrogeologist, Certified Engineering Geologist – California

Licensed Geologist / Hydrogeologist – Washington

Professional Associations
American Bar Association

Groundwater Resources Association of California

SF Bay Planning Coalition

Board Positions Held
American Bar Association – Vice Chair Water Resources Committee

Bay Planning Coalition, San Francisco (BPC) – Board of Directors, Former President

GENERAL CAREER BACKGROUND

Mr. Warner is a globally recognized environmental consultant with expertise in contaminant and site assessment, innovative remediation design, geochemistry, water resources protection, and litigation support. For approximately 35 years, his focus has been in groundwater and soil characterization and remediation, hydrogeology, hydrochemistry/geochemistry, water resources management, litigation support and expert witness assignments, policy and regulatory (including NCP, RCRA, CERCLA) review, and engineering geology. Work has been performed on behalf of industrial, agricultural, energy, waste and landfill, and private party and government organizations throughout California and North America as well as in Denmark, England, Scotland, Brazil, Hong Kong and Australia. Mr. Warner has provided lectures and short courses often and for both professional organizations and at academic institutions. He was a codeveloper and instructor for past State and US EPA led courses on innovative groundwater remediation using permeable reactive barrier (PRB) approaches developed by the US Interstate Technology Regulatory Council (ITRC) and Remediation Technology Development Forum (RTDF) and was a primary developer and lecturer for the CRC CARE (Australia) courses on site investigation and remediation.

REPRESENTATIVE EXPERTISE

Mr. Warner has worked on environmental and water resource matters for clients in the energy, food/beverage, manufacturing, mining, transportation, agriculture, recreation, government, legal, insurance, financial, and water supply communities.

For environmental projects, Mr. Warner has provided characterization, assessment and mitigation, and regulatory/policy support for soil, rock, surface water and groundwater sites impacted by legacy, chronic and catastrophic releases of inorganics and metals (including, but not limited to chloride salts, PCBs, lead, nickel, chromium, nitrate, sulfate, arsenic and radionuclides), petroleum hydrocarbons (including crude oil, benzene, toluene, and related additives including MTBE), chlorinated volatile organic compounds (including PCE, TCE and related degradation products), inorganic oxidizers (including perchlorate) and solvent stabilizers (such as 1,4 dioxane) and is involved in research into remediation alternatives for polyfluoroalkyl substances (PFAS) and related compounds.

Since 1991, Mr. Warner has specialized in the design, installation, and evaluation of numerous in situ groundwater remedies such as permeable reactive barriers (PRBs) and geochemical-based remediation at various sites including the first commercial site in California (1994) and a government site in New York (2011) that received the National Ground Water Association's Outstanding Remediation Project Award for a PRB site in New York USA.

For water resource projects, he has designed new and assessed aging water resource production wells, developed capture zone plans, and has assisted transaction projects involving assessment of water resource reliability and sustainability for food and beverage, recreation and manufacturing facilities in the US and internationally.

GEOGRAPHICAL EXPERIENCE

Mr. Warner's history includes work with most EPA Regions and numerous state regulatory agencies. He has worked on projects using Brownfield and/or voluntary cleanup regulations and state Superfund programs as well as provincial, territory, or country-specific regulatory programs. He has worked on sites in many U.S. states (including but not limited to Alabama, Arizona, California, Colorado, Georgia, Hawaii, Idaho, Illinois, Kentucky, Indiana, Michigan, Minnesota, Montana, Nevada, North Dakota, New York, Ohio, Oregon, Tennessee, and Washington), and in Australia, Brazil, Canada, Denmark, England, Hong Kong, Scotland, Sweden, Switzerland, and The Netherlands.

EXAMPLE PROJECTS (NOT LIMITED TO)

- Technical lead for numerous PRB-type projects including, but not limited to, the first-in-the-world PRB installation using zero valent iron in northern California in the early-mid 1990s, a dual PRB system for TCE and perchlorate in the 2000s and project director and lead designer for a PRB remedy site in western New York that received the 2011 Outstanding Groundwater Remediation Project Award from the National Ground Water Association for removal of radioactive strontium-90.
- Development/evaluation of landfill sites, including RCRA permits, statistical analysis, groundwater monitoring, and remedial approaches for facilities in: CA, AL, KS, OR, OK, WA, IL, HI, NV, ID, MI and Hong Kong.
- Expert witness support for assessing the effect of brine and petroleum releases to the soil and groundwater from energy resource work and saltwater well disposal activities, and the subsequent remedial efforts and cost of restoration for large agricultural property in North Dakota.
- Lead hydrologic consultant for assessing groundwater conditions in the Mono Lake/Owens Valley, California area related to air quality management projects along the Los Angeles Aqueduct system.
- Forensic evaluation of soil, surface water and groundwater remedial measures and performance for major contaminant releases from train derailments in Alabama and Ontario, Canada, manufactured gas plant sites in northern California, and a major refinery site in southern California.
- Water resource availability and reliability assessment for ski & swim facilities in 17 US States and Canada; assessment of water resource stress conditions for 30 global manufacturing sites; evaluation of long-term water availability for beverage making in low water drought environment.
- Lead consultant assessing source and migration of VOC impact to soil, soil gas and groundwater beneath multiple PRP site involving manufacturing, aerospace, and defense sites in southern California.
- Multi-property MGP site assessment including occurrence and distribution of contaminants, historical infrastructure review, shoreline conditions, remedial actions, regulatory review, and cost allocation.
- Evaluation of groundwater/surface water interaction and transport of

pesticide chemicals from source areas into a sensitive major riverway, northwest Oregon.

- Principal investigator for natural hazard assessment (earthquakes, tsunamis, lava flow and air quality impact) using GIS and large data set analysis for a large coastal property Hawai'i County, Hawai'i.
- Lead investigator for development of innovative groundwater restoration methods for treating inorganic contamination (perchlorate, chromium, excess TDS) at a major former manufacturing site near Las Vegas, Nevada.
- Evaluation of PCB impacts in areas of potential residential use (Northern California) and where impacted water is used as water supply (Hudson River Valley, New York).
- Closure plan evaluation for a Rocky Mtn. copper mine with consideration of impact from long-term climatic change to slope and pit lake characteristics.
- Development of sulfate-reduction technology for groundwater adjacent to an active large iron mine site in northern Minnesota.
- Site assessment, investigation, and regulatory document development for radioactive waste repositories in various states.
- Review and analysis of water rights and long-term water resource security and sustainability for food/beverage, commercial manufacturing, and recreation sites in California (including Central Valley agricultural, mountain, and coast range sites) and numerous U.S. States (e.g., Washington, Colorado, Utah, Vermont, New Hampshire, New York, Oklahoma, etc.) related to property/business transactions.
- Site response, site characterization, remedy design and implementation, and regulatory support for major catastrophic releases as well as legacy tank releases of petroleum (crude and refined product– and including additives such as methyl tertiary butyl ether [MTBE]) at numerous pipeline, terminal, and distribution sites in California, and tank releases in California and Montana, USA.
- Expert witness support for remediation assessment at a chemical manufacturing/storage facility in Georgia.
- Deposition testimony regarding the impact of site characterization on PCE contaminant distribution and remediation in southern California.
- Arbitration support regarding environmental claims of impact and investigation and review of regulatory actions, including NCP compliance, for Manufactured Gas Plant sites in northern California.
- Trial (by jury) and deposition testimony as expert in hydrogeology, and fate and transport of chlorinated hydrocarbon compounds, including PCE and TCE:), CERCLA, hydrogeology, aerial photographic interpretation of waste storage and environmental conditions, historical forensic evaluation of the source, chlorinated hydrocarbon fate and transport, chemical source area field characterization and review of regulatory actions.

PUBLICATION SHORT LIST

Warner, S. D. and Ritchie, C.J. 2022. The Practitioner's Perspective of Zero-Valent Iron as a Pragmatic Media for Contaminant Remediation: It's not 1995 Anymore! 12th Annual Conference on Remediation of Chlorinated and Recalcitrant Compounds. Battelle Memorial Institute, Palm Springs, California, May 2022.

Newell, C. J., DiGuiseepi, W. H., Cassidy, D. P., Divine, C. E., Fenstermacher, J. M., Hagelin, N. W., Thomas, R. A., Tomiczek III, P., **Warner, S. D**., Xiong, Z (J)., AND Hatzinger, P. B. 2022. PFAS Experts Symposium 2: Evolution from past to present, current efforts, and potential futures. Remediation Journal, http://10.1002/rem.21705

Naidu, R., Nadebaum, P., Fang, C., Cousins, I., Pennell, K., Conder, J., Newell, C.J., Longpre, D., **Warner, S.**, Crosbie, N.D., Surapaneni., A., Bekele, D., Spiese, R., Bradshaw, T., Slee., D, Liu, Y., Qi, F., Mallavarapu, M., Duan, L., McLeod, L., Bowman, M., Richmond, B., Srivstava, P., Chadalavada, S., Umeh, A., Biswas, B., Barclay, A., Simon, J. and P. Nathanail. 2020. Per and polyfluoroalkyl substances (PFAS): Current status and research needs. *Environmental Technology & Innovation* V. 19, 18p. https://doi.org/10.1016/j.eti.2020.100915

Warner, S.D., Bekele D.N., and P. Hadley (2019). Sustainable Remediation: Integrating Risk, Science, and Sustainability Principles. Ency. Sustainability of Science and Technology. https://doi.org/10.1007/978-1-4939-2493-6_55-5

Rowe, D., Greene, G., **Warner, S.** and Gimre, K. 2017. Remediation and water resource protection under changing climatic conditions. *Environmental Technology & Innovation*, 8 (2017) pp. 291-298. http://dx.doi.org/10.1016/j.eti.2017.07.008

Warner, S.D., 2015. Two Decades of Application of Permeable Reactive Barriers to Groundwater Remediation in *Permeable Reactive Barrier Sustainable Groundwater Remediation; Naidu, R., Birke, V., Eds*, pp.25-39.

Henry S. and **Warner S**. 2003. *Chlorinated Solvent and DNAPL Remediation: Innovative Strategies for Subsurface Cleanup.* ACS Symposium Series 837, American Chemical Society, 330 pp. January.S

Sorel D., **Warner S**., Longino B., Honniball J., and Hamilton L. 2003. *Performance Monitoring and Dissolved Hydrogen Measurements at a Permeable Zero Valent Iron Reactive Barrier.* In Chlorinated Solvent and DNAPL Remediation: Innovative Strategies for Subsurface Cleanup, ACS Symposium Series 837, American Chemical Society, pp. 278-285. January.

Warner S., Yamane C.L., Gallinatti J.D., and Hankins D.A. 1998. *Considerations for Monitoring Permeable Ground-Water Treatment Walls*. Journal of Environmental Engineering (ASCE), v. 124, no. 6, pp. 524-529.

Warner S., Szerdy F.S., and Yamane C.L. 1997. *Permeable Reactive Treatment Zones: A Technology Update.* 12th Annual Contaminated Soils Conference, University of Massachusetts, Amherst, MA. October 22, 1997, p315-327, in Calabrese, E.J., P.T. Kostecki, and M. Bonazountas, (eds) Contaminated Soils, Volume 3, p. 315-327.

Warner S. and Szerdy F. 1995. *Design and Evaluation of an In-Situ Ground Water Treatment Wall Composed of Zero Valent Iron.* Ground Water, v. 33, no. 5, pp. 834-835.

Gallinatti J.D. and **Warner S**. 1994. Hydraulic Design Considerations for Permeable In Situ Groundwater Treatment Wells. AGWSE Educational Program, Groundwater Remediation: Existing Technology and Future Direction in Groundwater, v. 32, no. 5, p. 851.

Warner S., Krothe N.C., Solomon G.C., and Steinkampf W.C. 1986. *Modeling the Geochemical Evolution of Groundwater within the Grande Ronde Basalt, Columbia Plateau, Washington.* (Abs.) Geo. Soc. America Abs. with Programs, v. 18, p. 782. 1986.

SELECTED PRESENTATIONS

Battelle Conference on Innovations in Climate Resilience – "The Anthrohydrologic Conceptual Model for Groundwater Remedy Design." March 29-30, 2022, Columbus, Ohio.

Radio ABC (Australia) radio broadcast – "Cleaning up chemical contaminants" https://www.abc.net.au/radionational/programs/bigideas/cleaning-up-chemical-contaminants/11533770

CRC CARE Short Course – From Risk to Remediation. March 4-8, 2019, Newcastle, NSW Australia

Halfmoon Short Course – Legal Considerations in Water Resources, February 2019, Sacramento, CA

ITRC Web based courses on Permeable Reactive Barrier Technology – Numerous deliveries between 2000 and 2010 attracting over 2000 students globally.

RTDF Short Courses on Permeable Reactive Barrier Technology, 12 Cities (EPA Lead Cities plus Northern California and Southern California). Sponsored by States and EPA. February 1999 – November 2000

Academic presentations given at: Stanford University; University of California, Berkeley; University of Ferrara, Italy; State University of New York, Buffalo; Oregon Graduate Institute; Colorado State University; University of Nevada, Las Vegas; California State University, Maritime; Indiana University, Bloomington; University of Newcastle, Australia

LITIGATION EXPERIENCE

Mr. Warner was qualified as an expert in hydrogeology and remediation for cases (involving petroleum hydrocarbon and fuel constituents and chlorinated solvent chemicals) with the Court of Federal Claims (expert testimony at a jury trial for over 11 hours) and the Federal District Court of Northern California (expert testimony at a bench trial for more than 4 hours) and served as an expert, including testimony, in front of an arbitration tribunal in Amsterdam, The Netherlands. Some examples of litigation, trial, and resolution and deposition experience are listed here:

- Expert witness support for evaluating the performance of remedy applications for VOC affected groundwater (Superfund Case, New Hampshire – ongoing project CONFIDENTIAL). (2020 – 2021)
- Expert witness support for evaluation of VOC impact to soil, soil gas, and groundwater, and chemical fate and migration beneath multiple responsible party case for industrial/aerospace sites (Southern California, ongoing project CONFIDENTIAL). (2019 – 2021)
- Expert witness support for assessing the effect of brine and petroleum releases to the soil and groundwater from energy resource work and salt water well disposal activities, and the subsequent remedial efforts and cost of restoration for large agricultural property in Bottineau County, North Dakota. *D. Peterson and C. Peterson v. Petro Harvester Operating Company, LLC, District Court, Northeast Judicial District, State of North Dakota, County of Bottineau, Civil No. 05-2016-CV-00073.* (2018)
- Arbitration expert report and testimony for an international dispute involving remediation costs of specialty chemical/contaminant components, approaches, and regulatory process related to RCRA and State Response. *ChemicaInvest Holding B.V. and Fibrant LLC v. Koninklijke DSM NV*, Netherlands Arbitration Institute NAI 4464 (2017)
- Expert witness support for remediation assessment at a chemical manufacturing/storage facility in Kennesaw, Georgia. *Davis v. Baychem et al.* Superior Court of Cobb County, Georgia, Civil Action No. 16-1-2518-99 (2017).
- Deposition testimony regarding the impact of site characterization on PCE contaminant distribution and remediation, southern California. *Goldberg v. Goss-Jewett, Inc., et al (Intervenors) v. Pacific Engineering; and PPG Industries*. US District Court Central District of California Case 5:14-CV-01872-DSF (SHx) (2016).
- Deposition testimony regarding the remediation of inorganic constituents (perchlorate and lead) beneath a propellant device manufacturer in Mesa, Arizona. *Nammo Talley, Inc. vs. Allstate Insurance,* United States District Court, District of Arizona, Case No. CV-01007-PHX-GMS (2014).
- Expert witness support, assessment of petroleum impacts at a petroleum

(crude) tank farm in Cut Bank, Montana, *Sundquist, et al v. Ashland, Inc./Black Eagle LLC*, Case No. CV 13-00075-DLC-RKS, United States District Court for the District of Montana, Great Falls Division (2014).

- Expert witness/litigation support on behalf of a large timber mill in coastal northern California relating to history of chemical releases, remediation, and regulatory approach including review of NCP compliance and CERCLA related responses.
- Expert witness review and report development for assessing the fate and migration of PCBs along a river stretch in New York State and potential impact to shoreline aquifer and water resource collection systems for a small town alongside the river.
- Arbitration support regarding environmental claims of impact and investigation and review of regulatory actions, including NCP compliance, for Manufactured Gas Plant sites in northern California (2013).
- Trial (by jury) and deposition testimony as expert in hydrogeology, and fate and transport of chlorinated hydrocarbon compounds, including PCE and TCE:), CERCLA, hydrogeology, aerial photographic interpretation of waste storage and environmental conditions, historical forensic evaluation of the source, chlorinated hydrocarbon fate and transport, chemical source area field characterization and review of regulatory actions Walnut Creek Manor, Ltd. v. Mayhew Center, Ltd., United States District Court, Northern District of California No. C-07-05664 CW (2009) (various declarations continuing into 2014).
- Litigation support regarding a claim of land failure beneath a residential property due to improper construction of a water well (2009).
- Arbitration support regarding the impact of PCE beneath a dry cleaning site in San Jose, California (2008).
- Litigation support regarding a remediation patent infringement matter, Adventus v. Remediation Products, Inc. United States District Court, District of North Carolina, Civil Action No. 3:07cv00153 (2008).
- Deposition testimony as expert in hydrogeology, contaminant fate and transport, contaminants including VOCs, petroleum, and inorganic compounds, and tidal hydrology. Humboldt Baykeeper and Ecological Rights Foundation v. Union Pacific Railroad Company, United States District Court (Northern District of California Case Number 03:2006-cv-02560. (2008).
- Deposition testimony as fact witness: Angeles Chemical v. McKesson, US District Court, Central District California, site specific aspects of groundwater and chemical occurrence of VOCs including PCE, TCE and 1,4-dioxane (2007). Case Number 01-cv-10532
- Deposition testimony as expert in hydrogeology for an east SF Bay Landfill: West Coast Home Builders v. Ashland, Inc. US District Court (Northern California), direction and movement of groundwater flow (2004). Case No. C01-4029.
- Trial (Bench) and deposition testimony as expert in hydrogeology: Cross

Petroleum v. United States (US Forest Service), U.S. Court of Federal Claims, groundwater remediation, groundwater movement, environmental forensics, chemical fate and transport of diesel and gasoline products, including MTBE, in sedimentary and fractured rock (2003). (Fed. Cl. No. 97-251C).