

APPENDIX H – REMAINING SUBSURFACE CONTAMINATION EAST WATERWAY OPERABLE UNIT FEASIBILITY STUDY

Prepared for

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1 INTRODUCTION

This appendix presents a series of figures depicting East Waterway (EW) Operable Unit (OU) subsurface sediment exceedances of the remedial action levels (RALs)¹. Also shown are the sediment quality standards (SQS) and the cleanup screening levels (CSL) exceedances for all Washington State Sediment Management Standards (SMS) chemicals to provide additional characterization of the subsurface sediments. Figures 1a-c through 6a-c provide a reference for each remedial alternative, illustrating the remedial technology selection, dredge depths, and the locations of subsurface contamination left in place after construction. This text describes the generation of the figures.

¹ For some risk driver COCs the RAL is equal to the SQS.

2 METHODS

For presentation purposes, the nine remedial alternatives are grouped into four groups. The No Action alternative, is unique and has its own set of figures (Figures 1a-c). Remedial Alternatives 1A(12), 1B(12), and 1C+(12) have the same remedial technologies for all areas except under piers and, therefore, are shown on the same set of figures (Figures 2a-c). Alternatives 2B(12) and 2C+(12) are also unique and have their own set of figures (Figures 3a-c). Alternatives 3B(12) and 3C+(12) have the same remedial technologies in open-water areas and share the same set of figures (Figures 4a-c). Finally, Alternatives 2C+(7.5) and 3E(7.5) are both unique and have their own sets of figures (Figures 5a-c and Figures 6a-c, respectively).

Core intervals representing sediment that has been dredged subsequent to sampling were not presented on figures. The rules and methods for data manipulation (e.g., determining exceedances, summing non-detects, etc.) are consistent with the EW SRI (Windward and Anchor QEA 2014). For core intervals with field duplicates, the average of the two results was used for RAL comparison, consistent with methods used in the SRI, and the parent sample is labeled on the figures.

The sampled core intervals on Figures 1a-c through 6a-c are coded based on RAL exceedances (yellow), and benthic CSL exceedances (red). RALs are presented in Section 6 of the Feasibility Study (FS) in Table 6-1, and consist of nine indicator SMS chemicals (for which the RAL is the SQS), and three other chemicals (dioxins/furans, carcinogenic polycyclic aromatic hydrocarbons [cPAHs], and tributyltin [TBT]). Although CSL is not an action level in subsurface sediments, CSL exceedances (considering all benthic contaminants of concern [COCs]) are shown on the figures to indicate locations with higher contaminant concentrations (CSL exceedances are also RAL exceedances²). If at least one RAL is exceeded

² With the exception of ICE-03 in the 0-1 foot interval, which does not exceed RALs for any of the nine indicator SMS chemicals, but does exceed the CSL for cadmium (which does not have a RAL). This exception does not affect the vertical extent of contamination because a deeper interval exceeds for PCBs (and thus drives remediation in this location). This exception does not affect the horizontal extent of contamination because of RAL exceedances in nearby surface sediment samples. All other sample intervals that exceed CSL for any COC also exceed for one or more of the indicator SMS chemicals with RALs.

in a core interval, that interval is labeled as greater than RALs and is identified as the depth of contamination for that core. Using the RALs, which include nine indicator SMS chemicals that represent all 29 risk driver COC SMS chemicals, to determine the depth of contamination does not exclude any exceedances of the SMS chemicals. Therefore, the RALs are appropriate for determining the depth of contamination.

A subset of RALs is based on SQS (see Section 6 of the FS). Many of these are based on carbon-normalized concentrations; however, carbon normalization is only considered valid within a specified range of total organic carbon (TOC) content. Sediment samples with TOC contents from 0.5% to 4% were TOC-normalized for comparison to SMS benthic criteria. The lower bound value of 0.5% TOC is provided by the Washington State Department of Ecology (Michelsen and Bragdon-Cook 1993), and the upper bound value of 4% is consistent with the value used in the LDW FS (AECOM 2012). For samples with TOC content outside of that range, the dry weight concentrations were compared to the lowest apparent effects threshold (LAET), which is functionally equivalent to the SQS, and the second lowest LAET (2LAET), which is functionally equivalent to the CSL.

cPAHs have one RAL site-wide and one RAL in intertidal clamming areas. For this analysis, cores with surface elevations above -4 feet mean lower low water (MLLW) were compared to the intertidal RAL (for potential clamming areas), and cores with surface elevations below -4 feet MLLW were compared to the site-wide RAL.

The dredging depths in removal areas were determined in a manner consistent with calculating the dredging volume in Appendix F, as follows:

- If the deepest RAL exceedance was just above an interval without a detected RAL exceedance, then the dredge depth was assumed to be at the contact between the two intervals.
- If the deepest RAL exceedance was just above an interval that was not analyzed, then the un-analyzed interval was assumed to be a RAL exceedance, and the dredge depth was assumed to be the top of the next interval without a detected RAL exceedance.
- If the deepest sample interval was a RAL exceedance, then the dredge depth was assumed to be the depth of the core plus an additional 1 foot.

- If the core had no RAL exceedances, then no dredging was assumed (note that the volume estimate in Appendix F assumes a 1-foot minimum dredging depth in removal areas with only surface sediment exceeding RALs).

The cores depicted in the figures were not compaction corrected, whereas the volumes in Appendix F included a compaction correction for cores with sampling percent recovery information available. In addition, the cores depicted in the figures do not include additional removal for overdredging or stable side slopes, and represent the neatline dredging depths.

The dredging depths in partial removal and capping areas were determined in a manner consistent with calculating the dredging volume in Appendix F as follows:

- In the Shallow Main Body Reach, the partial dredging depth was calculated to fit a 5-foot isolation cap and provide appropriate clearance for navigation. Partial dredging was assumed to extend to -38 feet MLLW in the Shallow Main Body – South, and -48 feet MLLW in the Shallow Main Body – North, as described in Section 7 of the FS. If the calculated partial dredging depth exceeded the depth of contamination, then the dredging depth was assumed to be the depth of contamination. Note that in some deep water locations, no partial dredging is needed, and capping without partial dredging would be specified during design.
- In the Mound Area, Slip 27 Head and Shoreline, and the Coast Guard Nearshore, the partial dredging depth was assumed to be 5 feet, to accommodate a 5-foot cap with the surface at original grade. If the calculated partial dredging depth of 5 feet exceeded the depth of contamination, then the dredging depth was assumed to be the depth of contamination.

The dredging depths in partial dredging and ENR-nav areas were determined in a manner consistent with calculating the dredging volume in Appendix F as follows:

- In the Deep Main Body Reach, Communication Cable Crossing area, and Deep Draft Berthing Areas, the partial dredging depth was calculated to fit an assumed 1.5-foot-thick ENR-nav layer. Partial dredging was assumed to extend to -54 feet MLLW, approximately 3 feet below the maintenance dredging depths. Where the partial

dredging depth is greater than the thickness of contamination, the thickness of contamination was considered the partial dredging depth.

3 DISCUSSION

The remediation area presented on each figure is based on the methodology described in Section 6 of the FS, by considering exceedances of RALs in surface sediment (including surface sediment toxicity) throughout the entire OU and the upper 2 feet of subsurface sediment for all areas north of the Spokane Street Bridge. The upper 2 feet in these areas are considered because of potential propwash forces that could expose subsurface sediments. These propwash forces do not occur under and south of the Spokane Street Bridge. In general, elevated subsurface contaminant concentrations are co-located with areas of elevated surface sediment concentrations, which are being actively remediated.

Relatively deeper deposits of contaminated sediment occur in the Mound Area and the Shallow Main Body Reach. These areas generally have subsurface sediment concentrations that are greater than the surface sediment concentrations (see FS Section 2.11.2.2), and have not been recently dredged for maintenance purposes (see FS Figure 2-22). In the Shallow Main Body Reach, some cores exceed RALs deeper than 2 feet below mudline, but do not exceed RALs in the upper 2 feet. Cores that were sampled in intervals larger than the upper 2 feet of sediment (e.g., sample intervals from 0 to 4 feet) were not used for establishing the remediation area. Eight of these cores (i.e., S01, S11, S13, S15, S16, S20, S30, and S47) contain a sample interval with concentrations above RALs within an unremediated area. These were not included in the remediation area because surface sediment concentrations are below RALs, and/or toxicity testing passed SQS criteria³. In addition, mixing depths from propeller wash (propwash) in the area of these cores is estimated to be 0.7 feet (with the exception of S30 and S47; see FS Figure 5-4), which suggests that mixing is not likely to occur across the full length of these intervals. Therefore, contamination present below the surface is unlikely to be exposed due to propwash.

Areas with relatively thin deposits of contaminated sediment are found in the Deep Main Body Reach and adjacent berths. These areas have been more recently dredged, resulting in

³ See FS Section 6 for more details on the development of the remediation footprints. For benthic risk-drivers, toxicity testing results trump chemistry results, except for polygons that exceed the SQS for PCBs and arsenic. PCBs and arsenic are also a human health COC and so RAL exceedances are always included in the remediation footprint.

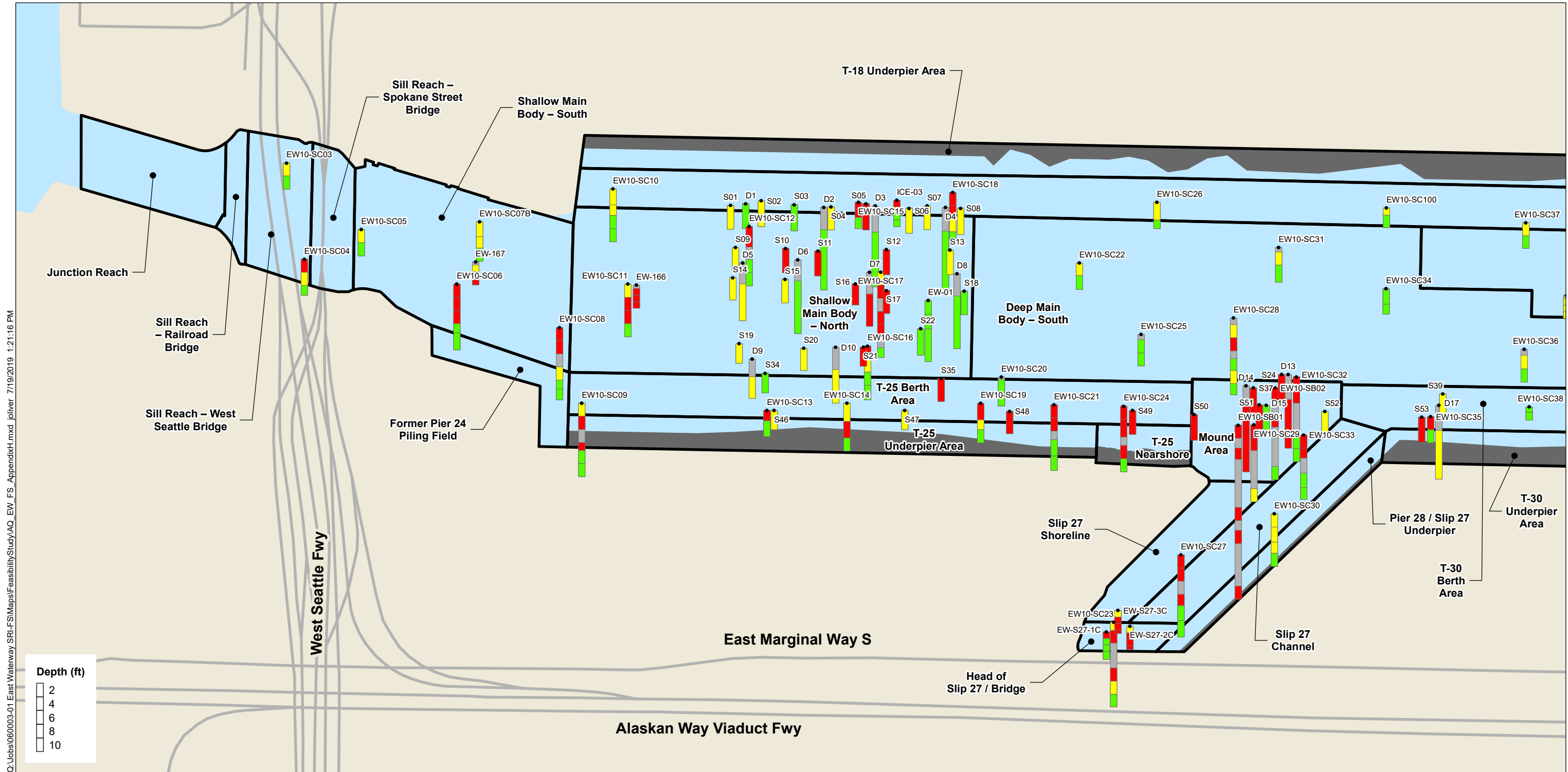
thinner depths of contaminated sediment. For example, RALs are exceeded in surface sediment, but not in any of the following cores: EW10-SC38, EW10-SC20, EW10-SC25, EW10-SC41, EW10-SC45, EW10-SC46, EW-164, EW10-SC101, EW-156, and EW10-SC56, indicating surficial contamination only.

The extent of remediation will be re-evaluated and modified as necessary during remedial design. Potential additional dredging volumes as a result of expansion of the dredging footprint are accounted for in the FS in the 50% dredging volume design factor described in Appendix F.

4 REFERENCES

- AECOM, 2012. Feasibility Study, Lower Duwamish Waterway, Seattle, Washington. Final Report. Prepared for Lower Duwamish Waterway Group. October 2012.
- Michelsen, T.C., and K. Bragdon-Cook, 1993. Technical Information Memorandum: Organic Carbon Normalization of Sediment Data. Washington State Department of Ecology, Olympia, WA.
- Windward and Anchor QEA, 2014. Supplemental Remedial Investigation. East Waterway Operable Unit Supplemental Remedial Investigation/Feasibility Study. Final. January 2014.

FIGURES



- Exceedance Status**
- No Action
 - Riprap (No Action)
 - ≤ RAL(12) and ≤ SQS
 - > RAL(12) or > SQS
 - > CSL
 - Interval not Analyzed
- CMA Boundaries**

NOTE:
1. RAL(12) denotes the RAL set that includes 12 mg/kg-OC for PCBs

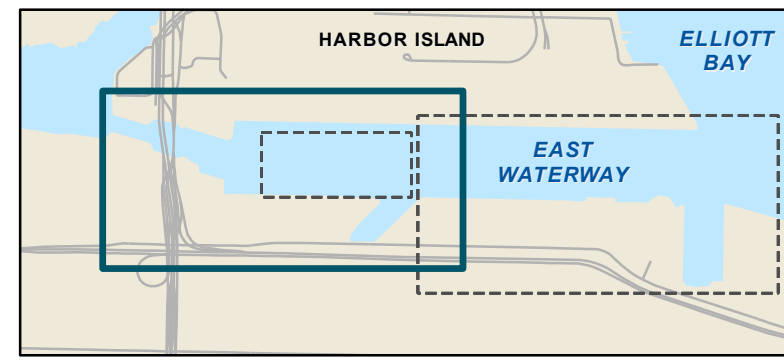
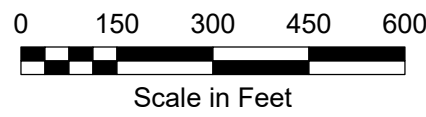
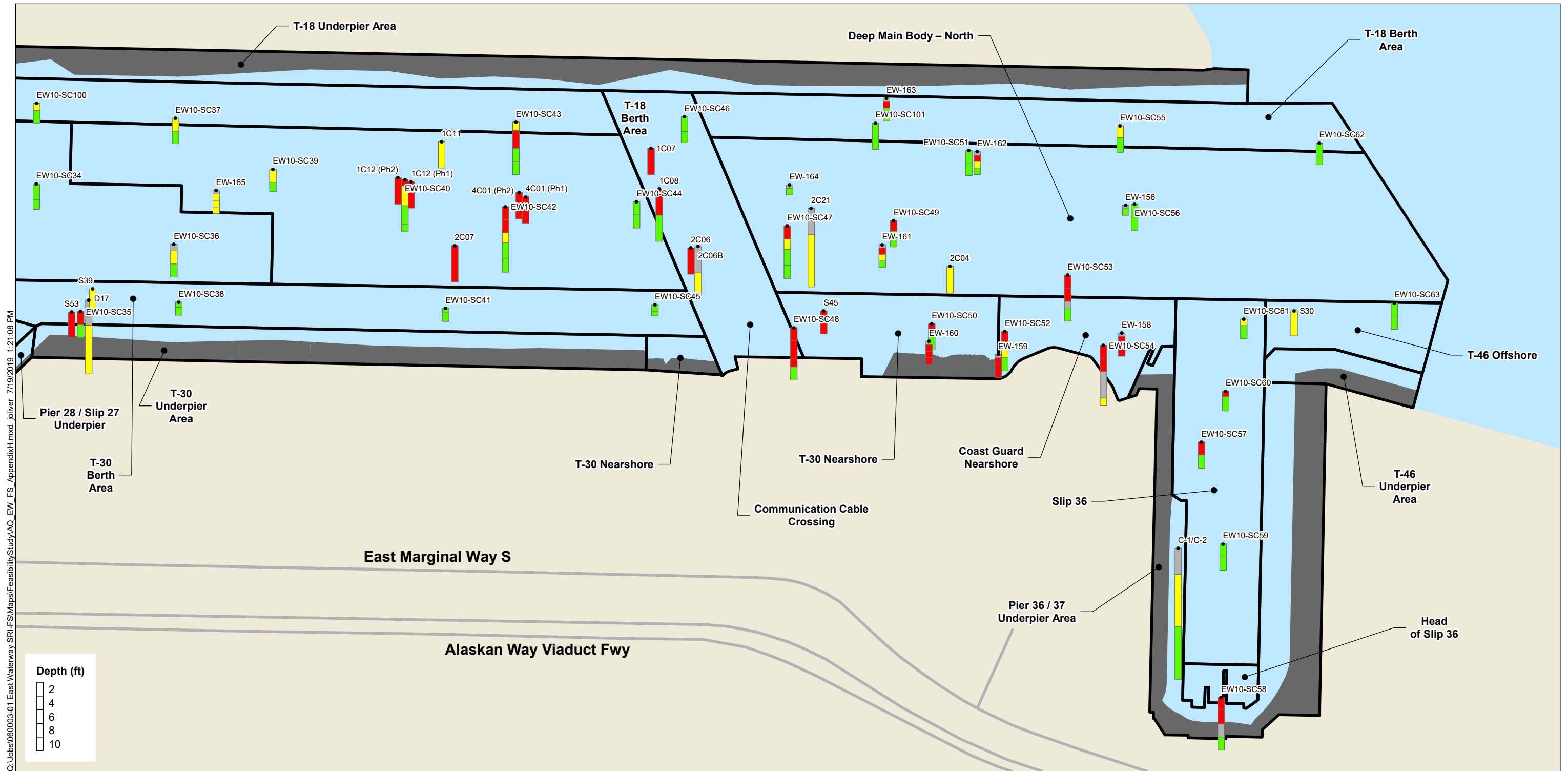


Figure 1a
Subsurface Contamination Remaining
No Action Alternative - South
Feasibility Study - Appendix H
East Waterway Study Area



- No Action

Riprap (No Action)
- Exceedance Status

≤ RAL(12) and ≤ SQS

> RAL(12) or > SQS

> CSL

Interval not Analyzed
- CMA Boundaries

NOTE:
1. RAL(12) denotes the RAL set that includes 12 mg/kg-OC for PCBs

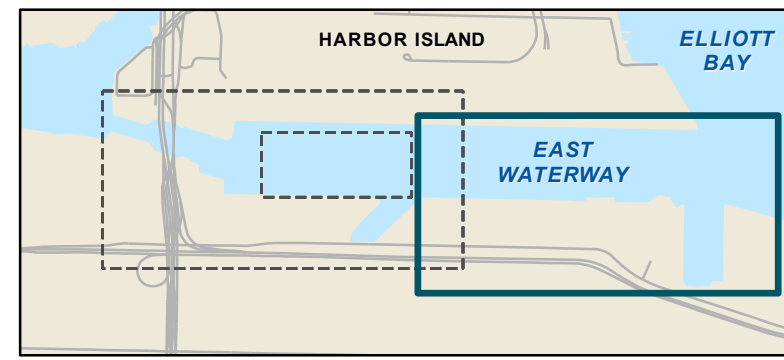
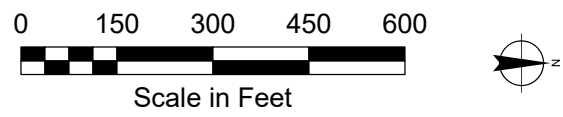
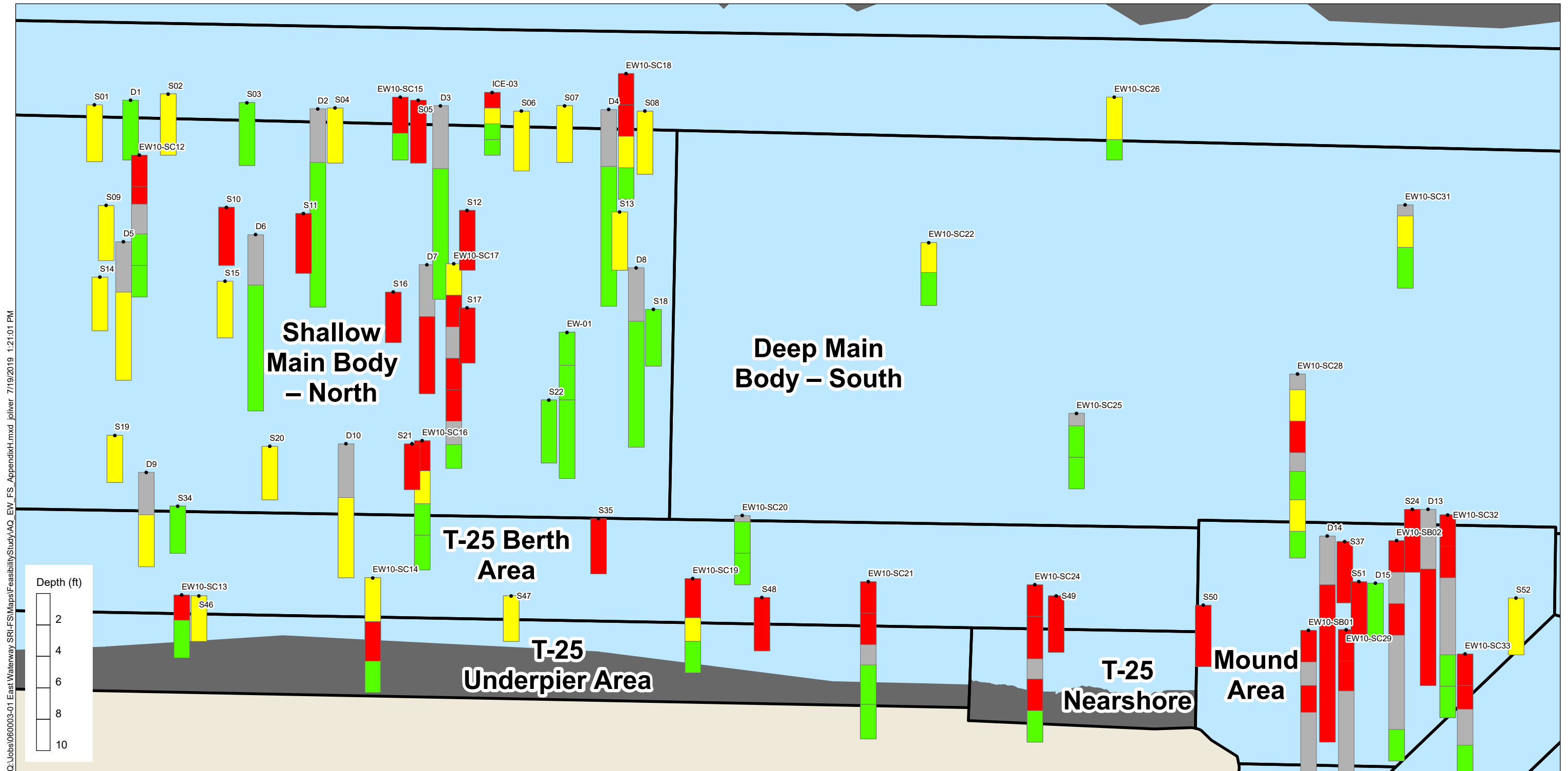


Figure 1b
Subsurface Contamination Remaining
No Action Alternative - North
Feasibility Study - Appendix H
East Waterway Study Area



- No Action
 Riprap (No Action)
 ≤ RAL(12) and ≤ SQS
 > RAL(12) or > SQS
 > CSL
 Interval not Analyzed
- CMA Boundaries

NOTE:
 1. RAL(12) denotes the RAL set that includes 12 mg/kg-OC for PCBs

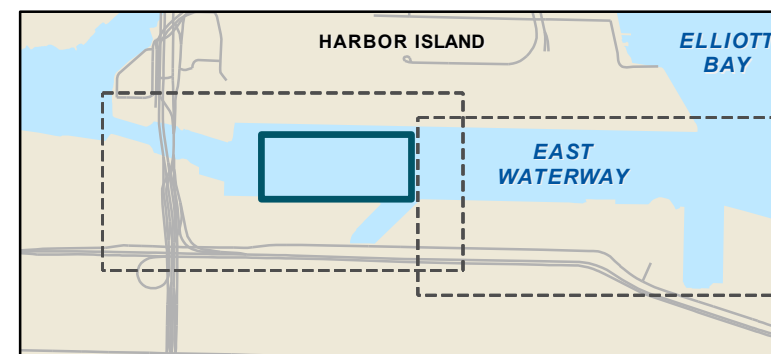
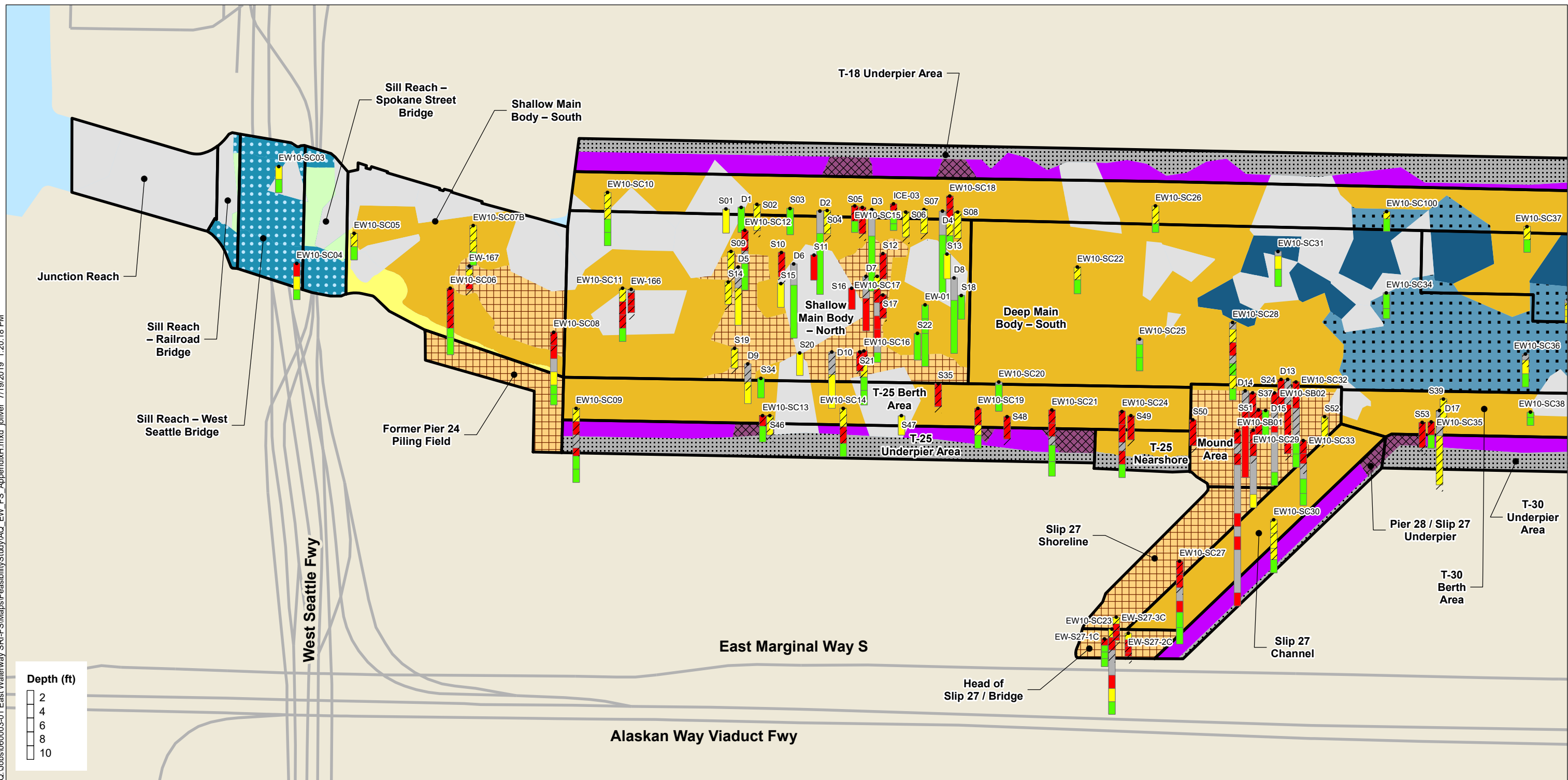


Figure 1c
 Subsurface Contamination Remaining
 No Action Alternative - Detail, South
 Feasibility Study - Appendix H
 East Waterway Study Area

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Technology Assignments

- Removal
- Removal and Backfill to Existing Contours
- Removal to the Extent Practicable and Backfill
- Partial Removal and Cap
- Partial Removal and ENR-nav
- ENR-sill
- ENR-nav

- Underpier: 1A(12): MNR; 1B(12): In Situ Treatment; 1C+(12): Hydraulic Dredging Followed by In Situ Treatment
- Underpier: 1A (12): MNR; 1B(12) and 1C+(12): In Situ Treatment
- Under Low Bridge: 1A(12): MNR; 1B(12) and 1C+(12): ENR-sill
- Riprap (No Action)
- No Action

Exceedance Status

- \leq RAL(12) and \leq SQS
- $>$ RAL(12) or $>$ SQS
- $>$ CSL
- Interval not Analyzed
- Dredging Depth

CMA Boundaries

NOTE:
1. RAL(12) denotes the RAL set that includes 12 mg/kg-OC for PCBs

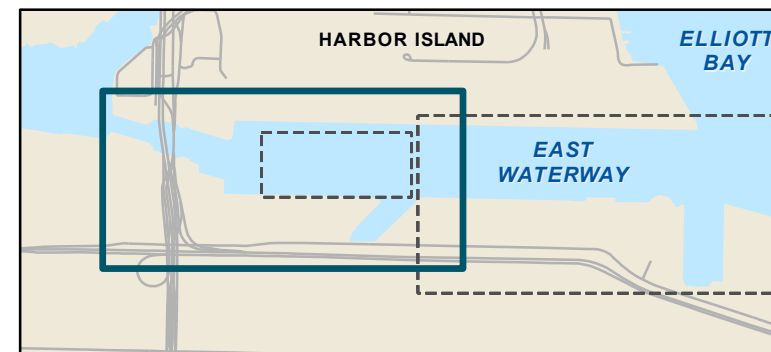
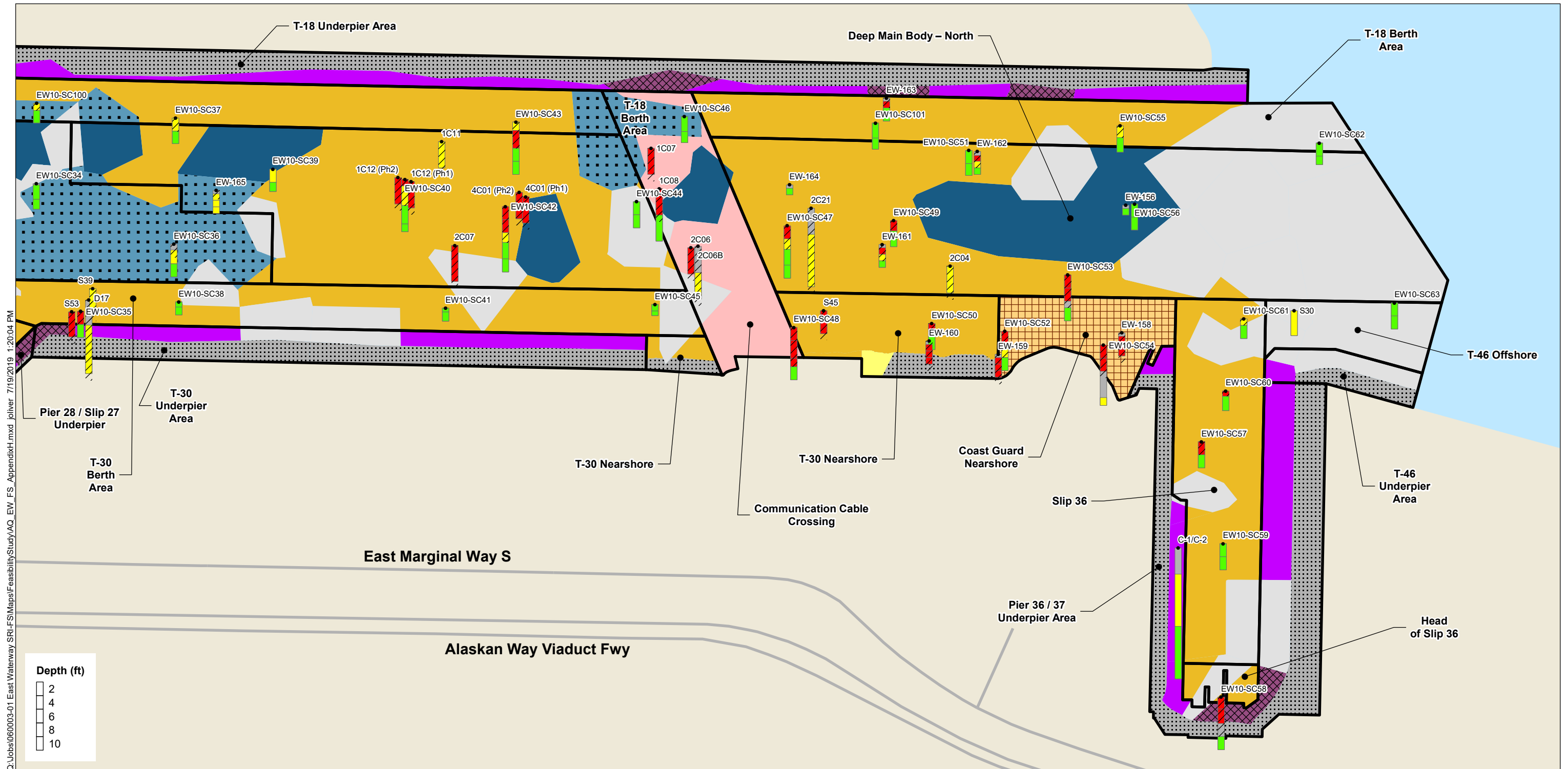


Figure 2a
Subsurface Contamination Remaining
Alternatives 1A(12), 1B(12), 1C+(12) - South
Feasibility Study - Appendix H
East Waterway Study Area



Technology Assignments

- Removal
- Removal and Backfill to Existing Contours
- Removal to the Extent Practicable and Backfill
- Partial Removal and Cap
- Partial Removal and ENR-nav
- ENR-sill
- ENR-nav

- Underpier: 1A(12): MNR; 1B(12): In Situ Treatment; 1C+(12): Hydraulic Dredging Followed by In Situ Treatment
- Underpier: 1A(12): MNR; 1B(12) and 1C+(12): In Situ Treatment
- Under Low Bridge: 1A(12): MNR; 1B(12) and 1C+(12): ENR-sill
- Riprap (No Action)
- No Action

Exceedance Status

- ≤ RAL(12) and ≤ SQS
- > RAL(12) or > SQS
- > CSL
- Interval not Analyzed
- Dredging Depth

CMA Boundaries

NOTE:
1. RAL(12) denotes the RAL set that includes 12 mg/kg-OC for PCBs

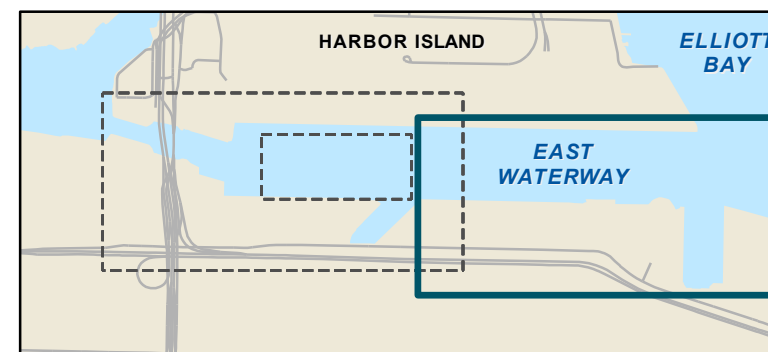
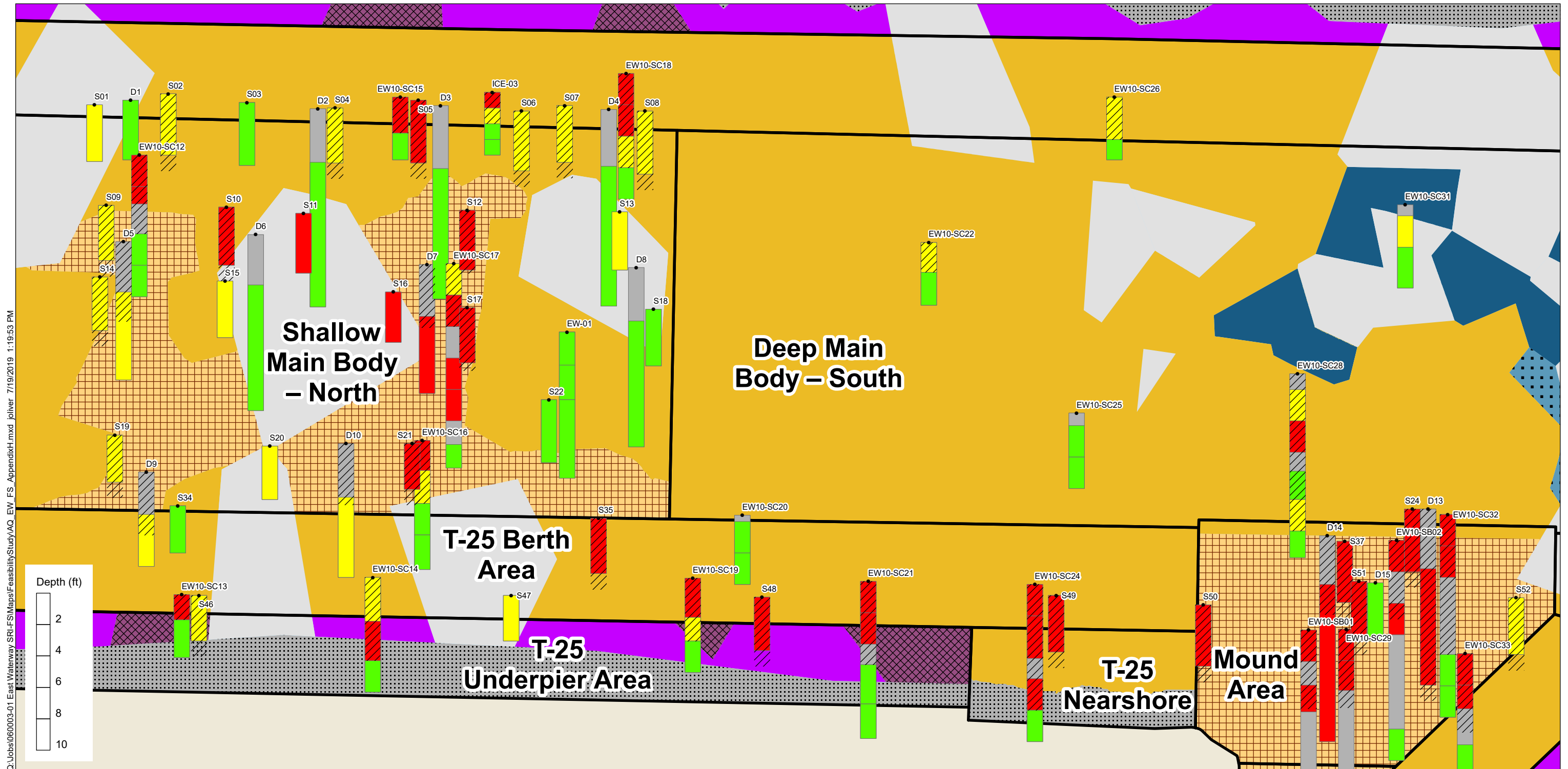


Figure 2b
Subsurface Contamination Remaining
Alternatives 1A(12), 1B(12), 1C+(12) - North
Feasibility Study - Appendix H
East Waterway Study Area



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Technology Assignments

- Removal
- Removal and Backfill to Existing Contours
- Removal to the Extent Practicable and Backfill
- Partial Removal and Cap
- Partial Removal and ENR-nav
- ENR-sill
- ENR-nav

- Underpier: 1A(12): MNR; 1B(12): In Situ Treatment; 1C+(12): Hydraulic Dredging Followed by In Situ Treatment
- Underpier: 1A(12): MNR; 1B(12) and 1C+(12): In Situ Treatment
- Under Low Bridge: 1A(12): MNR; 1B(12) and 1C+(12): ENR-sill
- Riprap (No Action)
- No Action

- Exceedance Status**
- ≤ RAL(12) and ≤ SQS
 - > RAL(12) or > SQS
 - > CSL
 - Interval not Analyzed
 - Dredging Depth

CMA Boundaries

NOTE:
1. RAL(12) denotes the RAL set that includes 12 mg/kg-OC for PCBs

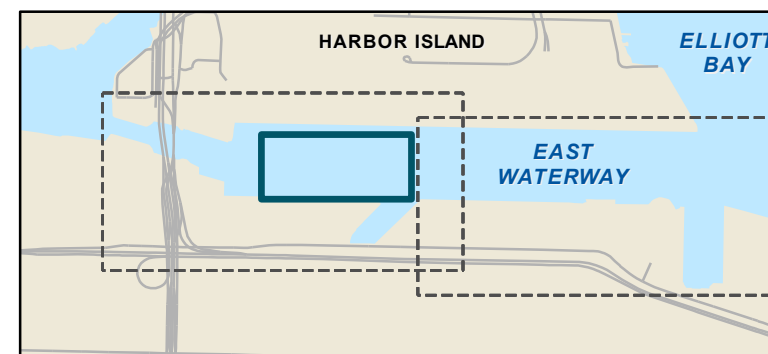
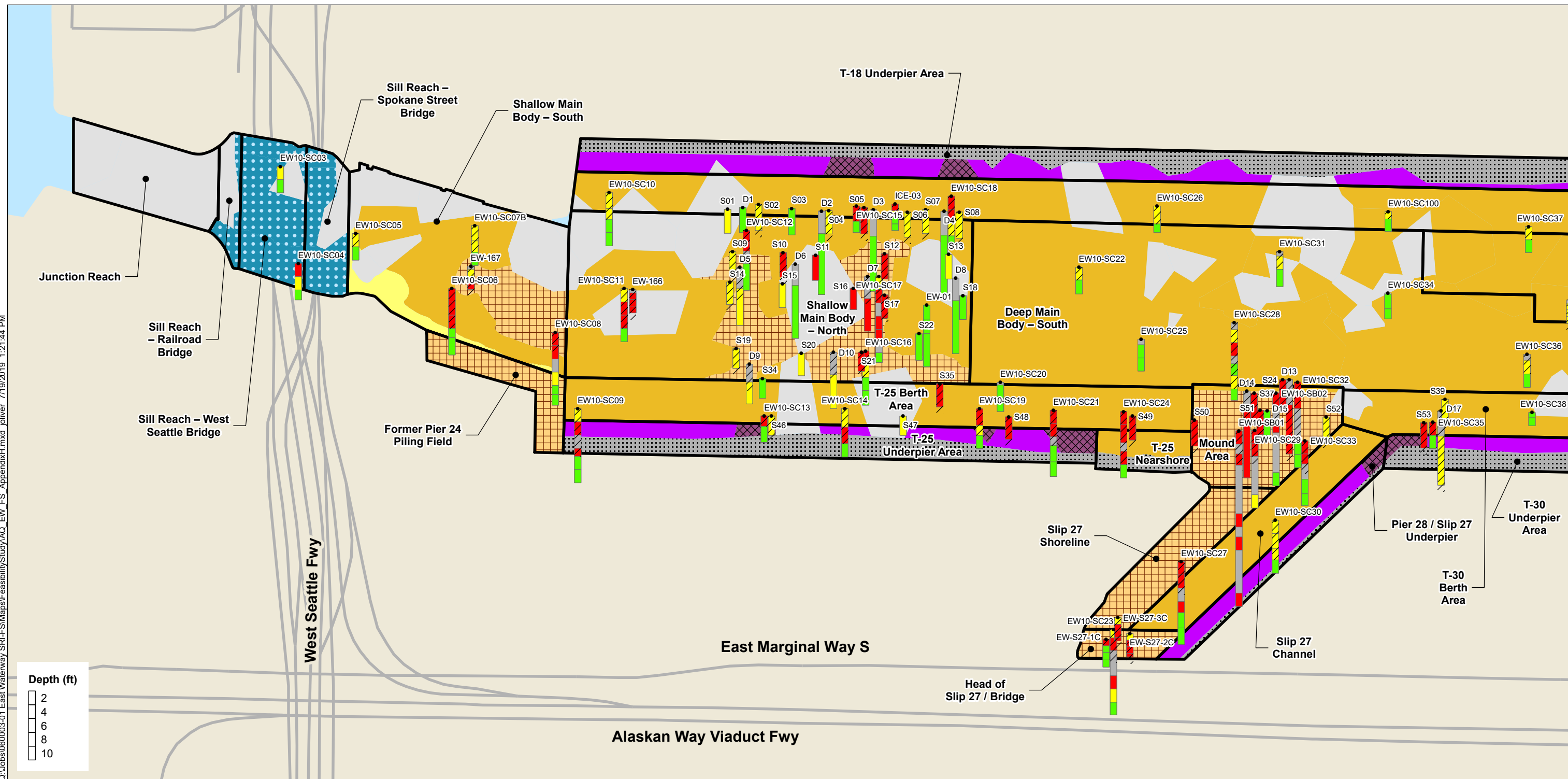


Figure 2c
Subsurface Contamination Remaining
Alternatives 1A(12), 1B(12), 1C+(12) - Detail, South
Feasibility Study - Appendix H
East Waterway Study Area

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Technology Assignments

- Removal
- Removal and Backfill to Existing Contours
- Removal to the Extent Practicable and Backfill
- Partial Removal and Cap
- ENR-sill
- Underpier: 2B(12): In Situ Treatment; 2C+(12): Hydraulic Dredging Followed by In Situ Treatment
- Underpier: In Situ Treatment
- Riprap (No Action)
- No Action

Exceedance Status

- \leq RAL(12) and \leq SQS
- $>$ RAL(12) or $>$ SQS
- $>$ CSL
- Interval not Analyzed
- Dredging Depth

CMA Boundaries

- CMA Boundaries

NOTE:
1. RAL(12) denotes the RAL set that includes 12 mg/kg-OC for PCBs

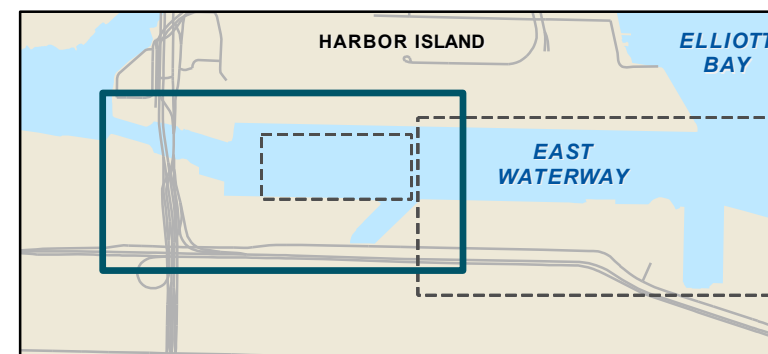


Figure 3a
Subsurface Contamination Remaining
Alternatives 2B(12), 2C+(12) - South
Feasibility Study - Appendix H
East Waterway Study Area

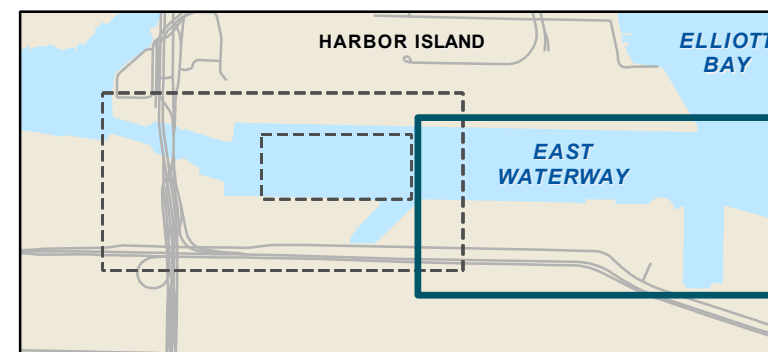
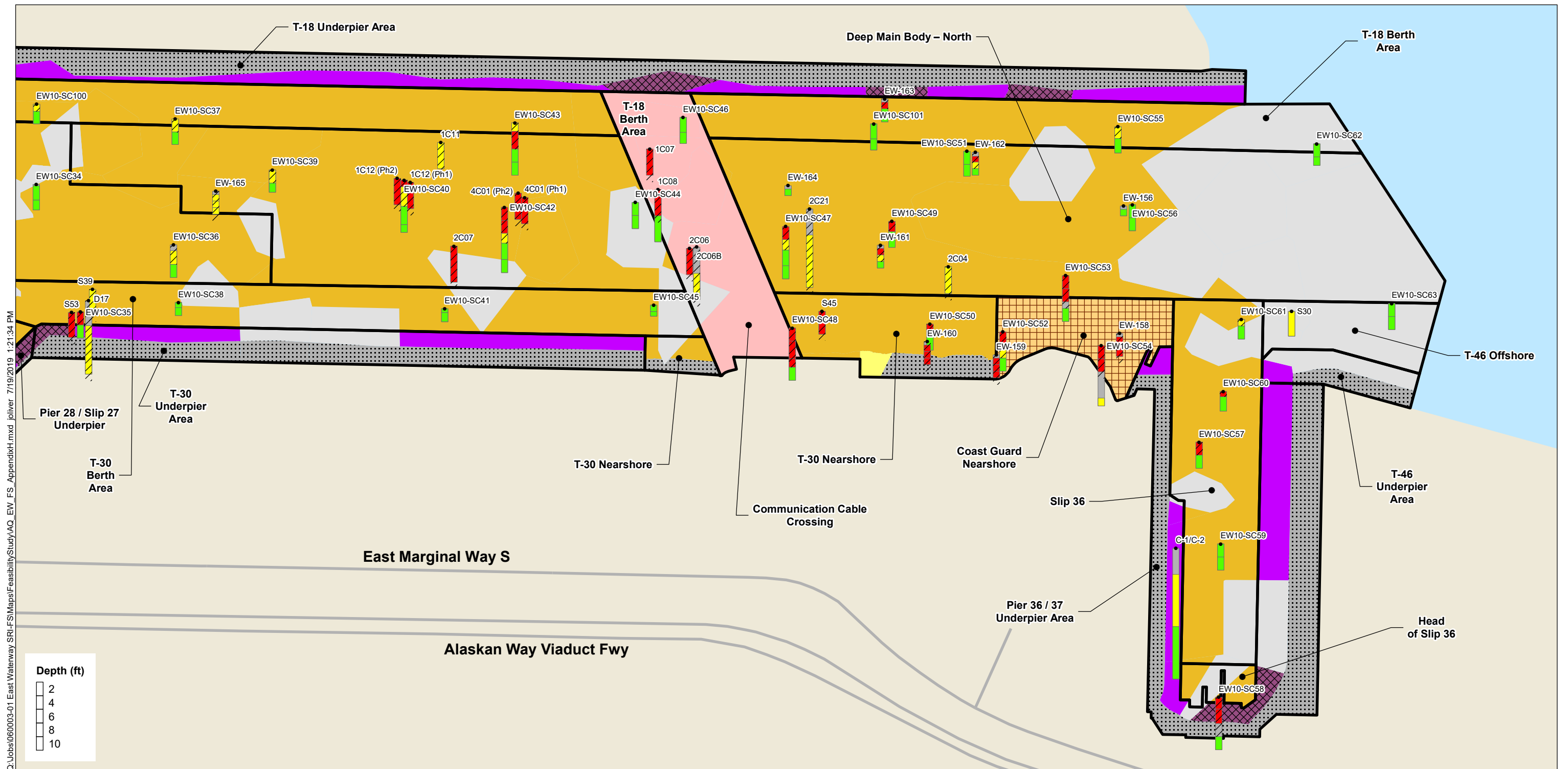
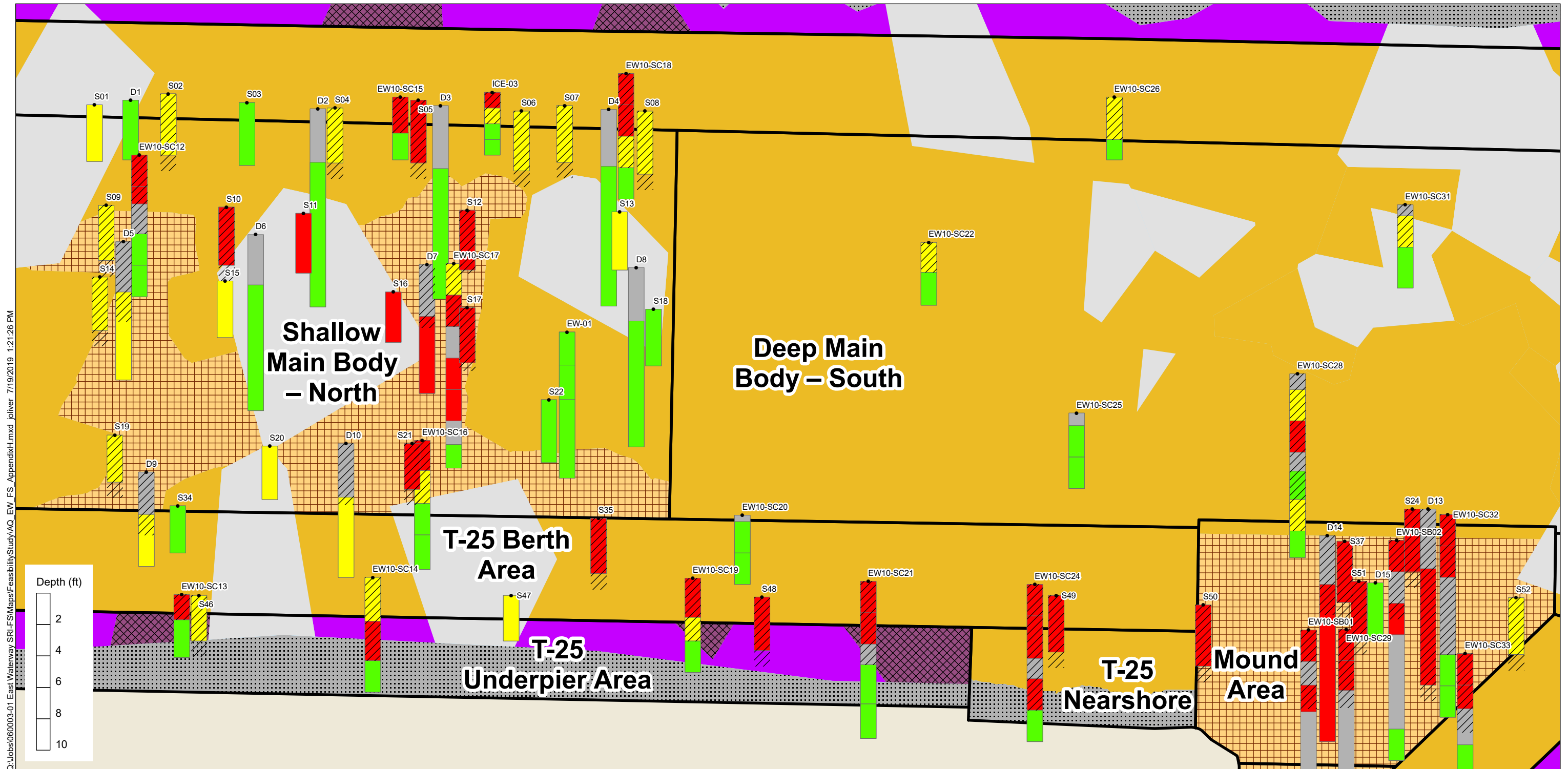


Figure 3b
Subsurface Contamination Remaining
Alternatives 2B(12), 2C+(12) - North
Feasibility Study - Appendix H
East Waterway Study Area



Technology Assignments

- Removal
- Removal and Backfill to Existing Contours
- Removal to the Extent Practicable and Backfill
- Partial Removal and Cap
- ENR-sill
- Underpier: 2B(12): In Situ Treatment;
2C+(12): Hydraulic Dredging Followed by In Situ Treatment
- Underpier: In Situ Treatment
- Riprap (No Action)
- No Action

Exceedance Status

- \leq RAL(12) and \leq SQS
- $>$ RAL(12) or $>$ SQS
- $>$ CSL
- Interval not Analyzed
- Dredging Depth

CMA Boundaries

NOTE:
1. RAL(12) denotes the RAL set that includes 12 mg/kg-OC for PCBs

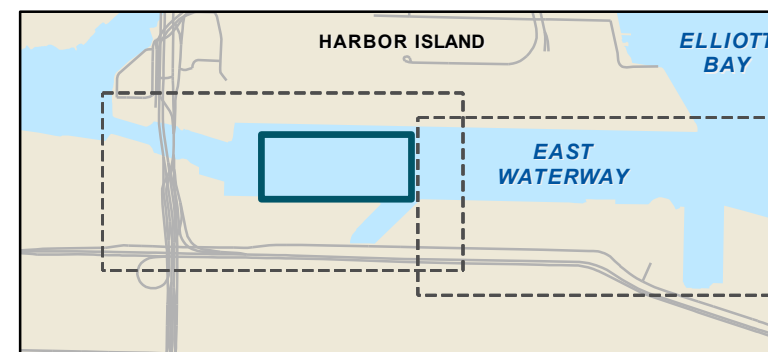
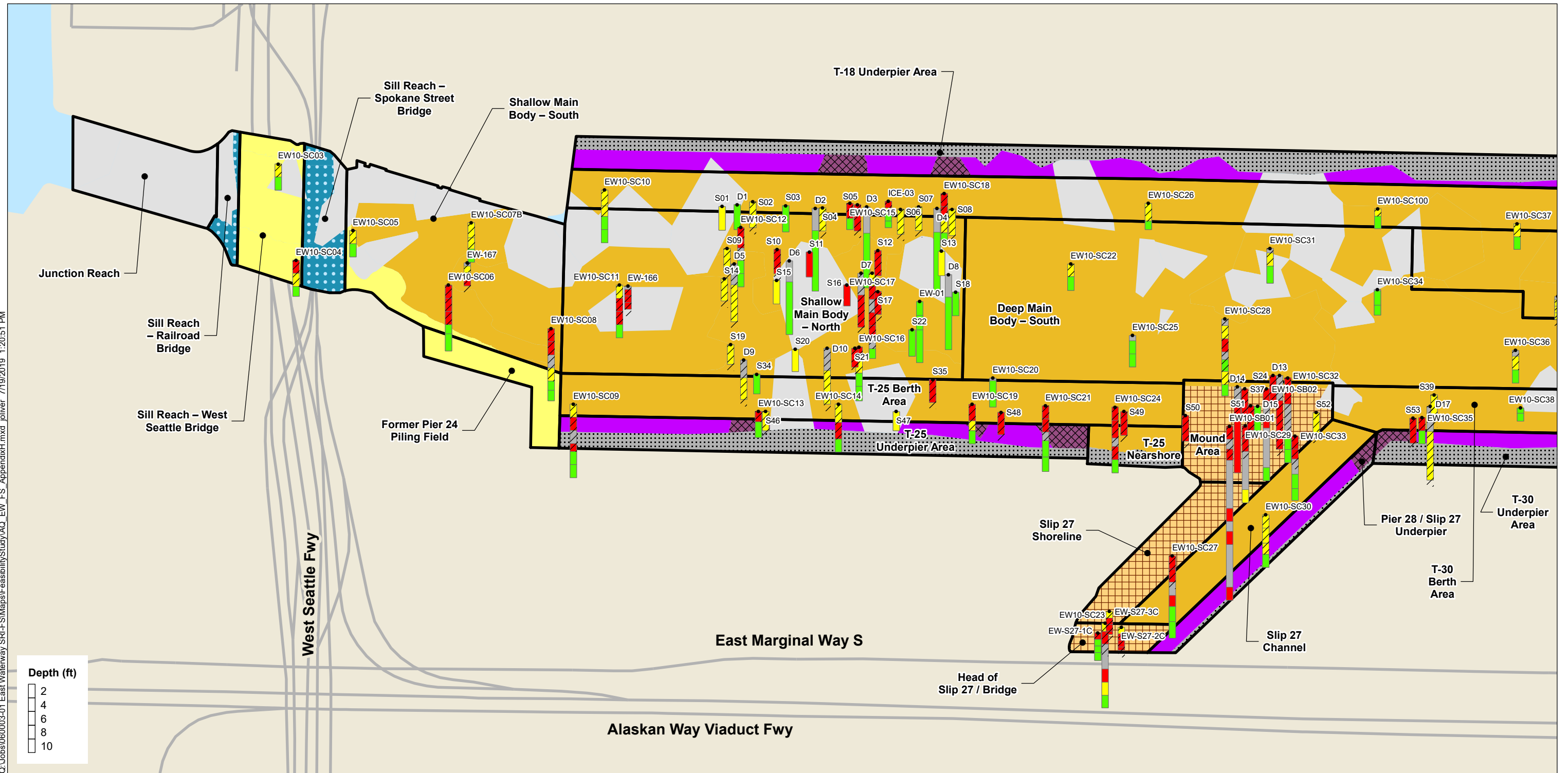


Figure 3c
Subsurface Contamination Remaining
Alternatives 2B(12), 2C+(12) - Detail, South
Feasibility Study - Appendix H
East Waterway Study Area

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Technology Assignments

- Removal
- Removal and Backfill to Existing Contours
- Removal to the Extent Practicable and Backfill
- Partial Removal and Cap
- ENR-sill
- Underpier: 3B(12): In Situ Treatment;
3C+(12): Hydraulic Dredging Followed by In Situ Treatment
- Underpier: In Situ Treatment
- Riprap (No Action)
- No Action

Exceedance Status

- \leq RAL(12) and \leq SQS
- $>$ RAL(12) or $>$ SQS
- $>$ CSL
- Interval not Analyzed
- Dredging Depth

CMA Boundaries

NOTE:
1. RAL(12) denotes the RAL set that includes 12 mg/kg-OC for PCBs

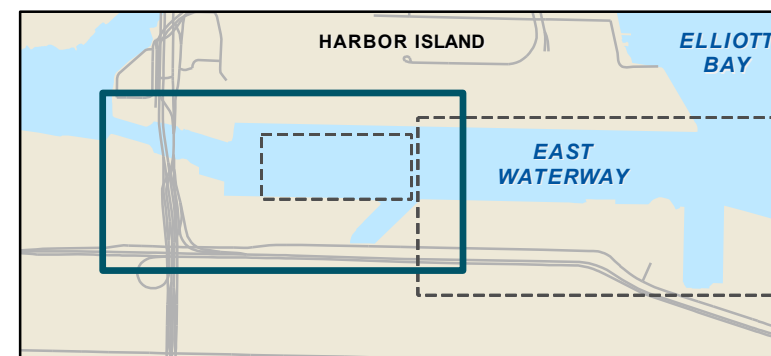


Figure 4a
Subsurface Contamination Remaining
Alternatives 3B(12), 3C+(12) - South
Feasibility Study - Appendix H
East Waterway Study Area

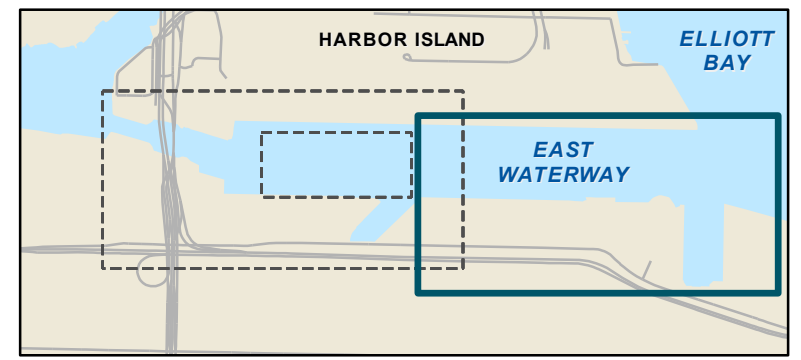
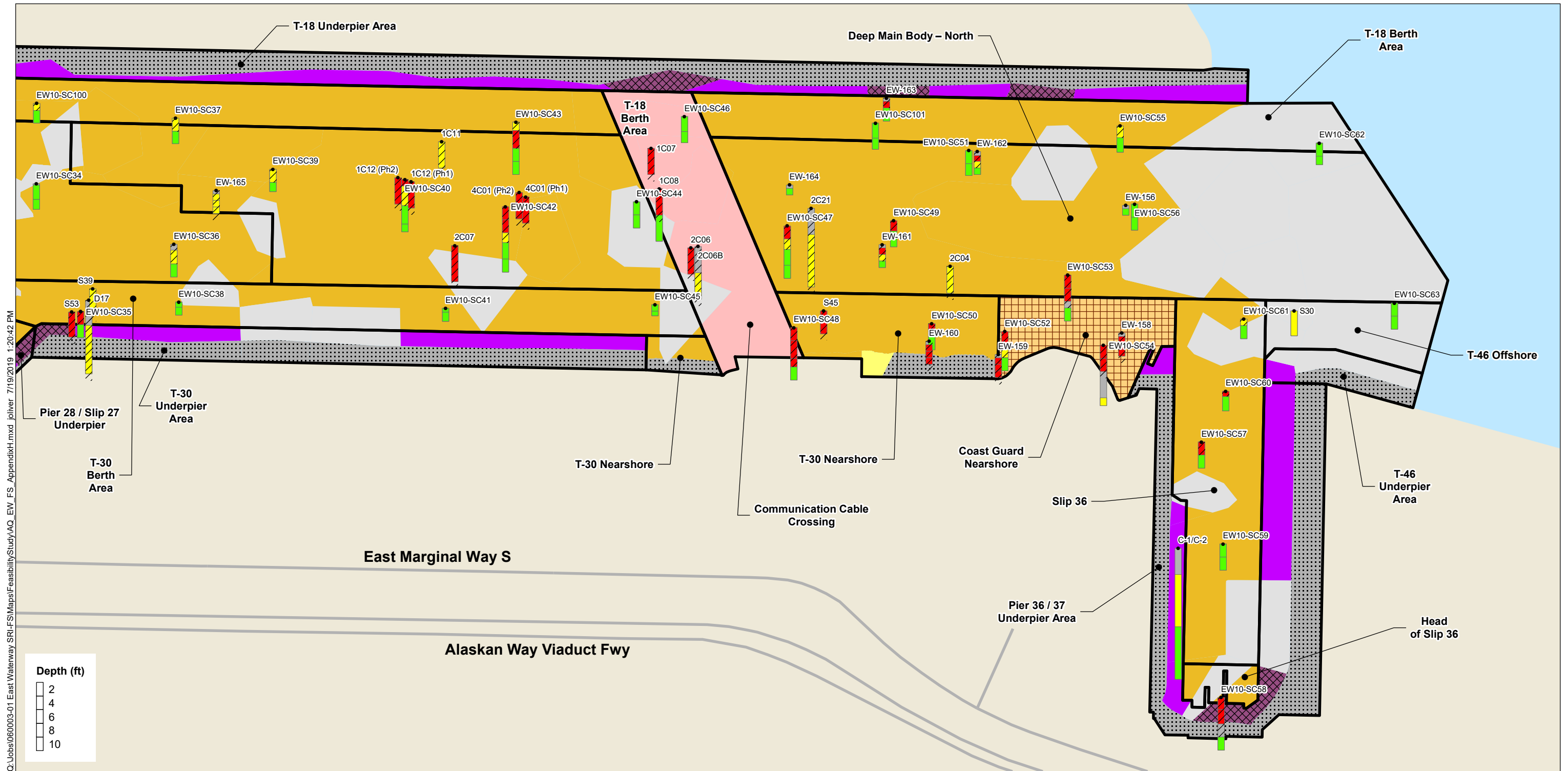
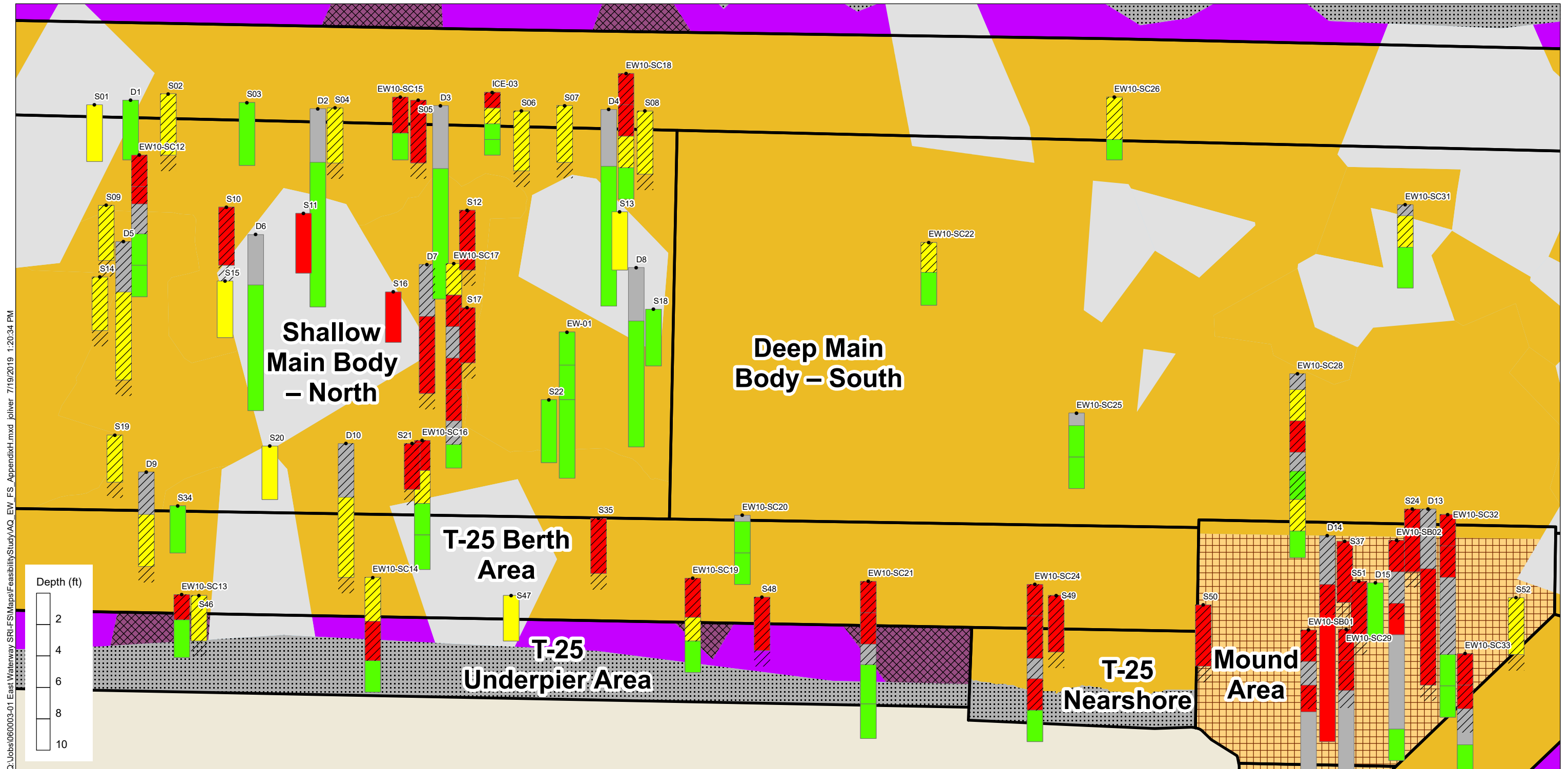


Figure 4b
Subsurface Contamination Remaining
Alternatives 3B(12), 3C+(12) - North
Feasibility Study - Appendix H
East Waterway Study Area



Technology Assignments

- Removal
- Removal and Backfill to Existing Contours
- Removal to the Extent Practicable and Backfill
- Partial Removal and Cap
- ENR-sill
- Underpier: 3B(12): In Situ Treatment;
3C+(12): Hydraulic Dredging Followed by In Situ Treatment
- Underpier: In Situ Treatment
- Riprap (No Action)
- No Action

Exceedance Status

- \leq RAL(12) and \leq SQS
- $>$ RAL(12) or $>$ SQS
- $>$ CSL
- Interval not Analyzed
- Dredging Depth

CMA Boundaries



NOTE:
1. RAL(12) denotes the RAL set that includes 12 mg/kg-OC for PCBs

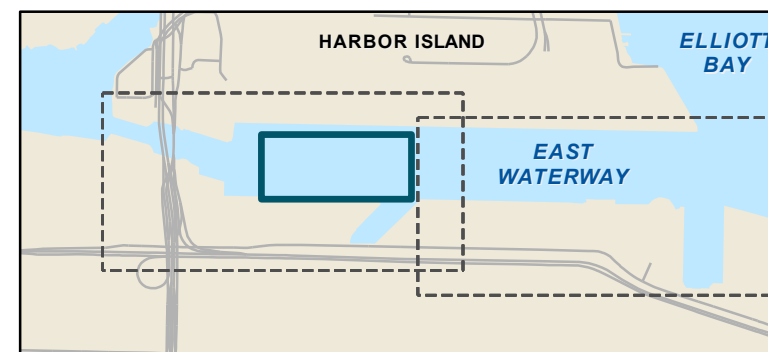
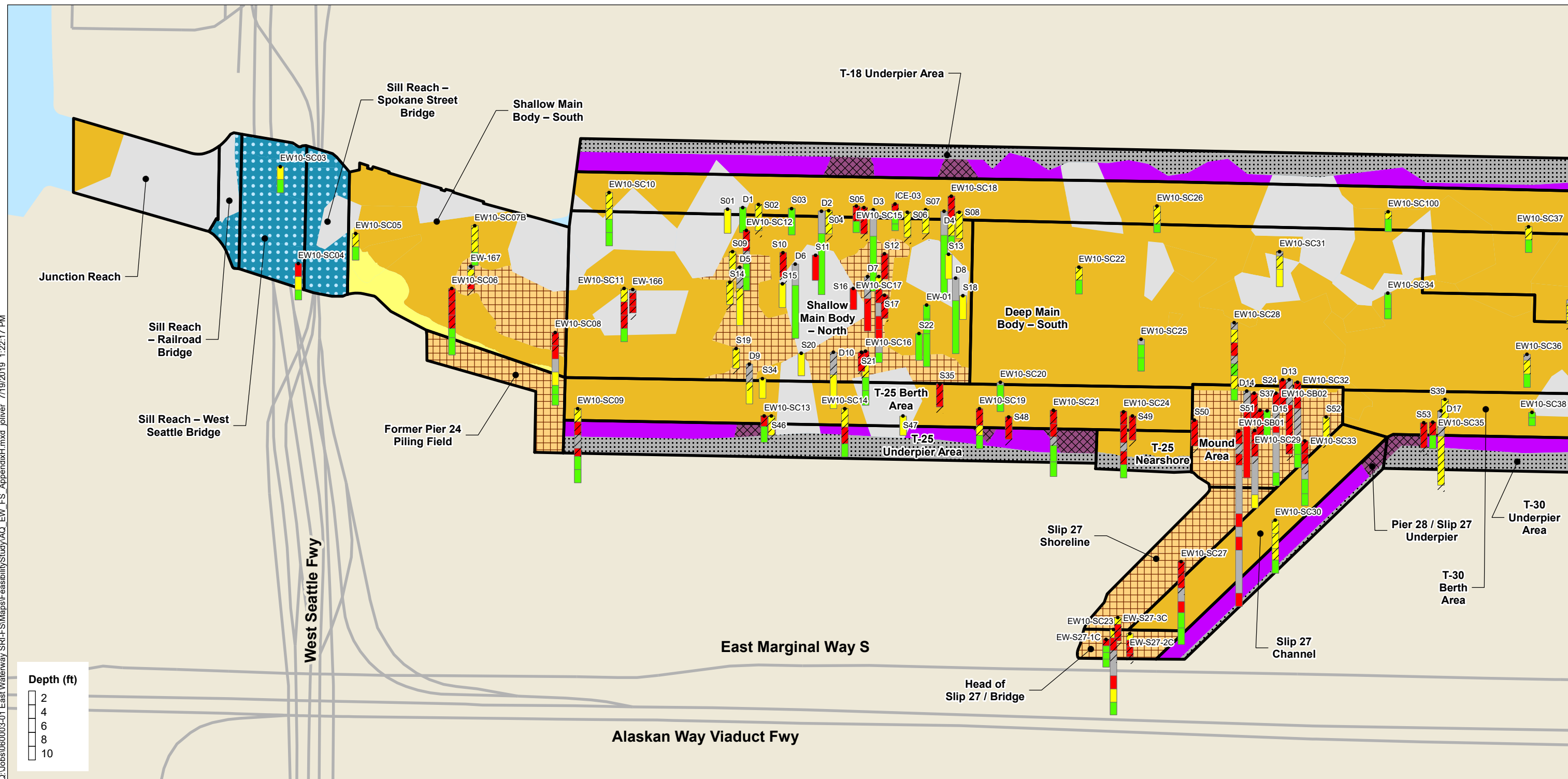


Figure 4c
Subsurface Contamination Remaining
Alternatives 3B(12), 3C+(12) - Detail, South
Feasibility Study - Appendix H
East Waterway Study Area

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Technology Assignments

- Removal
- Removal and Backfill to Existing Contours
- Removal to the Extent Practicable and Backfill
- Partial Removal and Cap
- ENR-sill
- Underpier: Hydraulic Dredging Followed by In Situ Treatment
- Underpier: In Situ Treatment
- Riprap (No Action)
- No Action

Exceedance Status

- \leq RAL(7.5) and \leq SQS
- $>$ RAL(7.5) or $>$ SQS
- $>$ CSL
- Interval not Analyzed
- Dredging Depth

CMA Boundaries

NOTE:
1. RAL(7.5) denotes the RAL set that includes 7.5 mg/kg-OC for PCBs

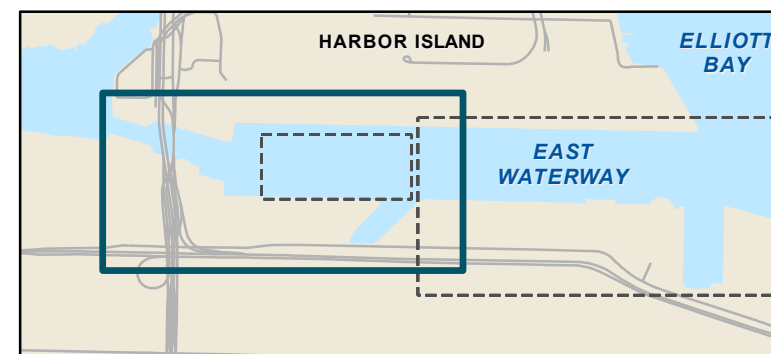
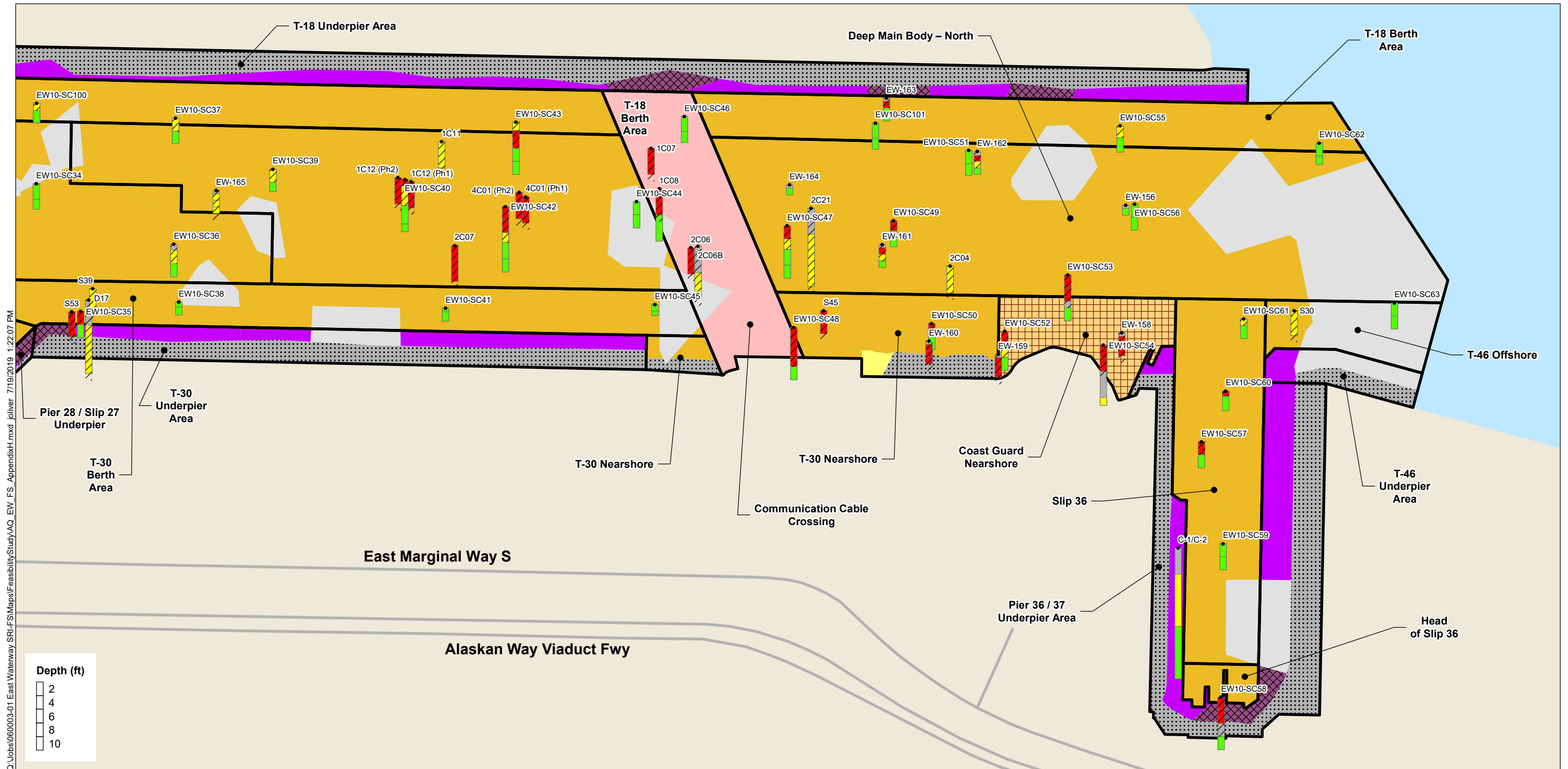


Figure 5a
Subsurface Contamination Remaining
Alternative 2C+(7.5) - South
Feasibility Study - Appendix H
East Waterway Study Area



- Technology Assignments**
- Removal
 - Removal and Backfill to Existing Contours
 - Removal to the Extent Practicable and Backfill
 - Partial Removal and Cap
 - ENR-sill
 - Underpier: Hydraulic Dredging Followed by In Situ Treatment
 - Underpier: In Situ Treatment
 - Riprap (No Action)
 - No Action
- Exceedance Status**
- \leq RAL(7.5) and \leq SQS
 - $>$ RAL(7.5) or $>$ SQS
 - $>$ CSL
 - Interval not Analyzed
 - Dredging Depth
- CMA Boundaries**

NOTE:
1. RAL(7.5) denotes the RAL set that includes 7.5 mg/kg-OC for PCBs

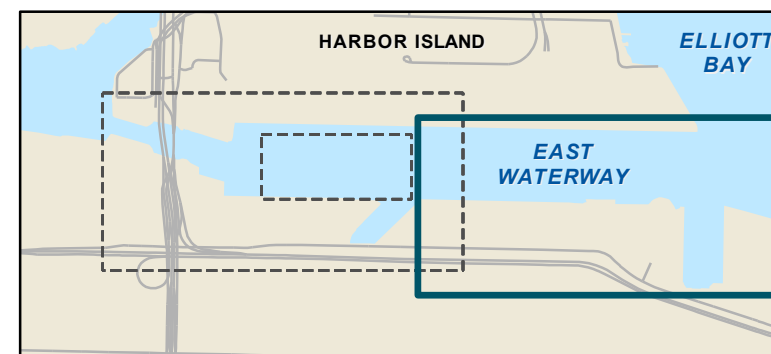
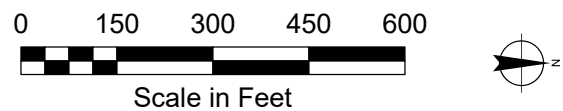
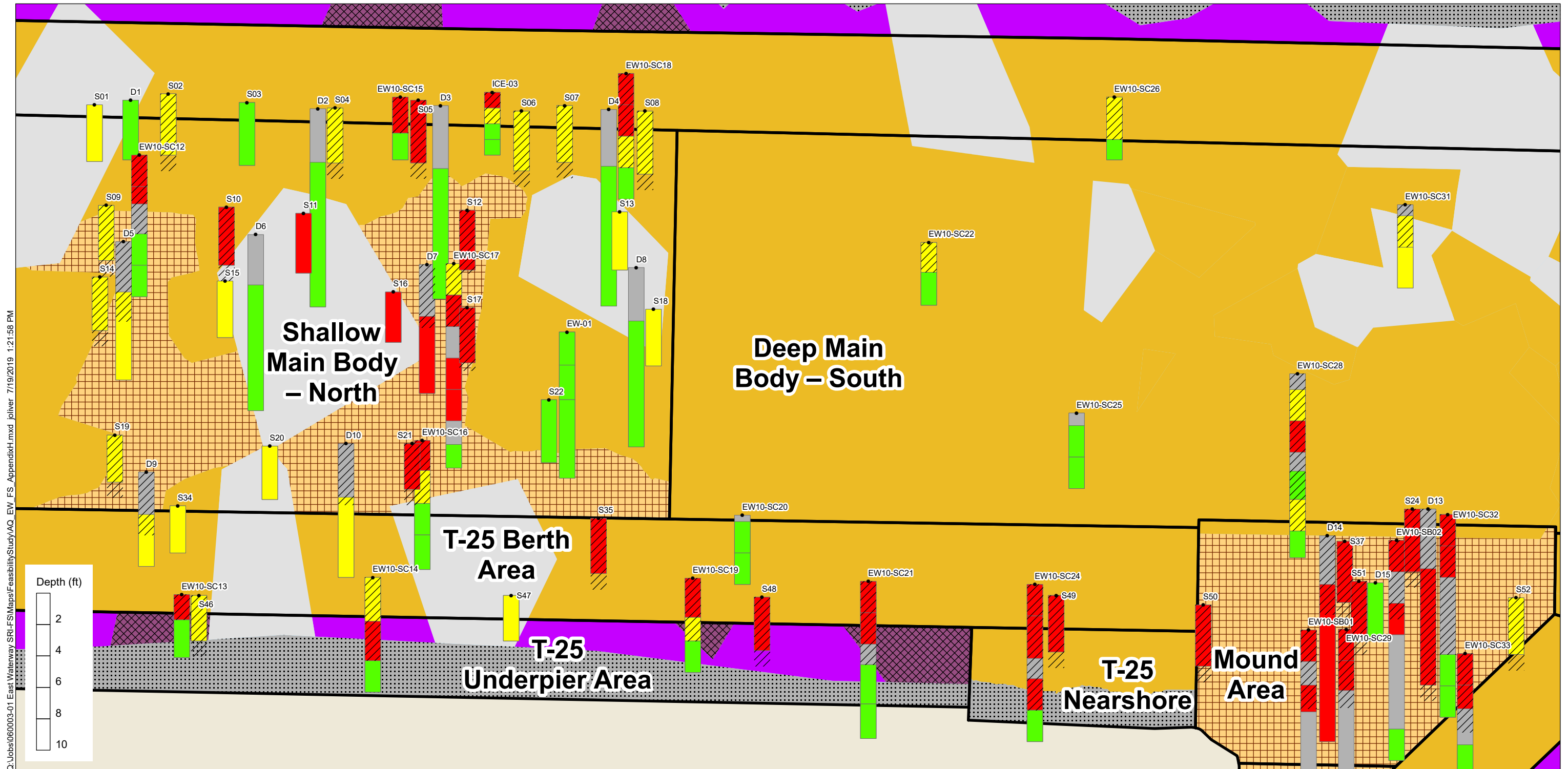


Figure 5b
Subsurface Contamination Remaining
Alternative 2C+(7.5) - North
Feasibility Study - Appendix H
East Waterway Study Area



Technology Assignments

- Removal
- Removal and Backfill to Existing Contours
- Removal to the Extent Practicable and Backfill
- Partial Removal and Cap
- ENR-sill
- Underpier: Hydraulic Dredging Followed by In Situ Treatment
- Underpier: In Situ Treatment
- Riprap (No Action)
- No Action

Exceedance Status

- \leq RAL(7.5) and \leq SQS
- $>$ RAL(7.5) or $>$ SQS
- $>$ CSL
- Interval not Analyzed
- Dredging Depth

CMA Boundaries

NOTE:
1. RAL(7.5) denotes the RAL set that includes 7.5 mg/kg-OC for PCBs

0 60 120 180 240
Scale in Feet

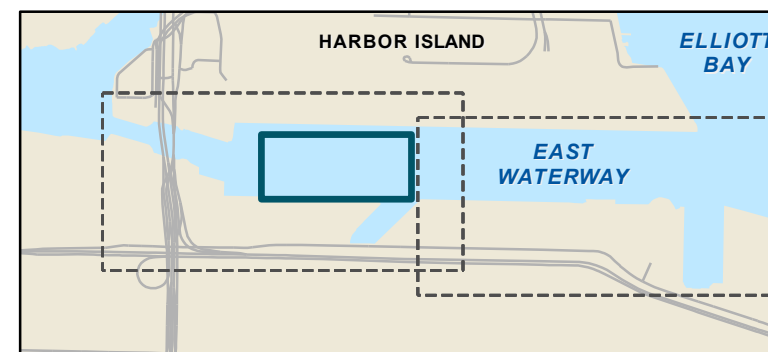
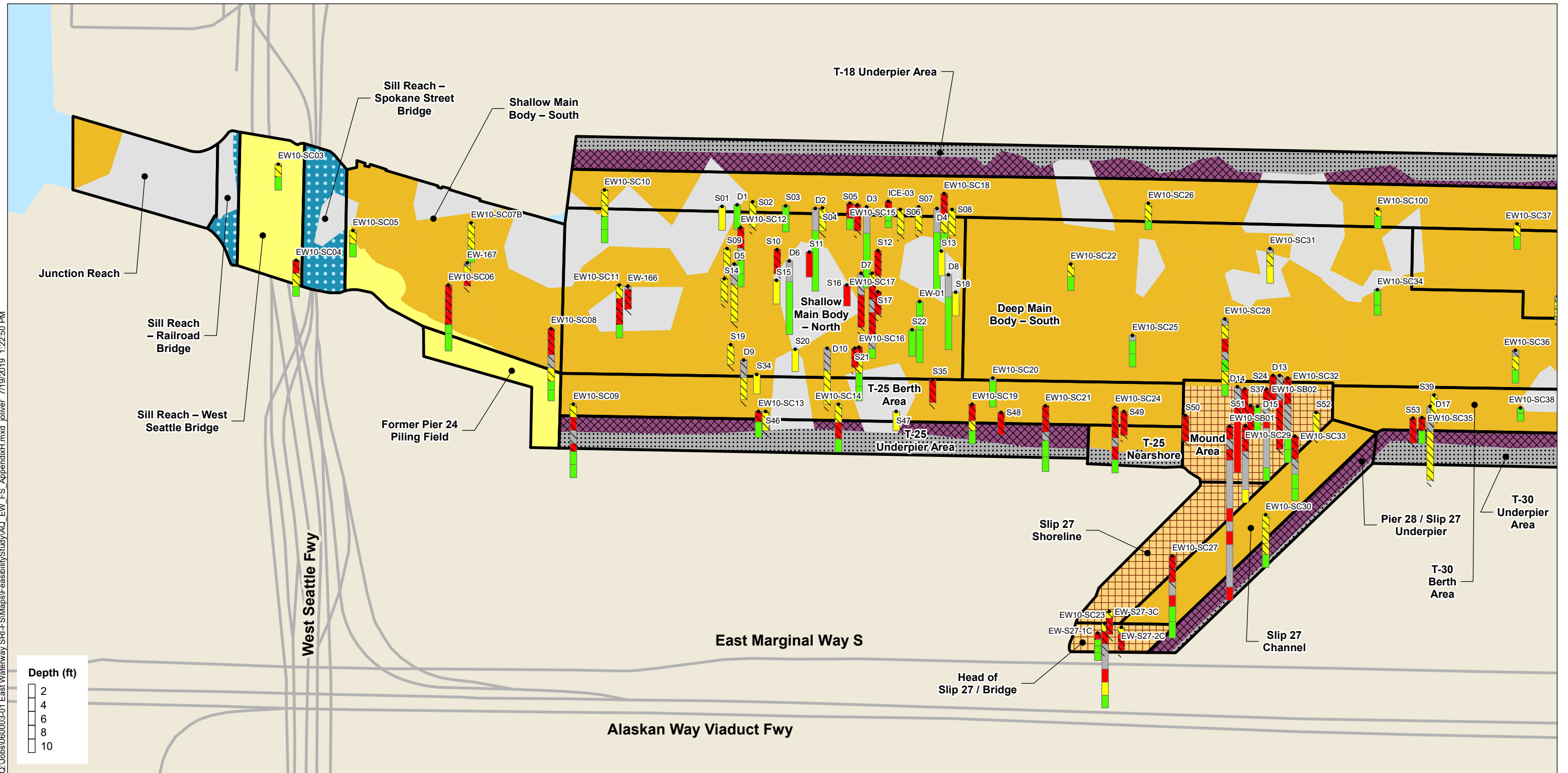


Figure 5c
Subsurface Contamination Remaining
Alternative 2C+(7.5) - Detail, South
Feasibility Study - Appendix H
East Waterway Study Area

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Technology Assignments

- Removal
- Removal and Backfill to Existing Contours
- Removal to the Extent Practicable and Backfill
- Partial Removal and Cap
- ENR-sill
- Underpier: Hydraulic Dredging Followed by In Situ Treatment
- Riprap (No Action)
- No Action

Exceedance Status

- \leq RAL(7.5) and \leq SQS
- $>$ RAL(7.5) or $>$ SQS
- $>$ CSL
- Interval not Analyzed
- Dredging Depth

CMA Boundaries

NOTE:
1. RAL(7.5) denotes the RAL set that includes 7.5 mg/kg-OC for PCBs

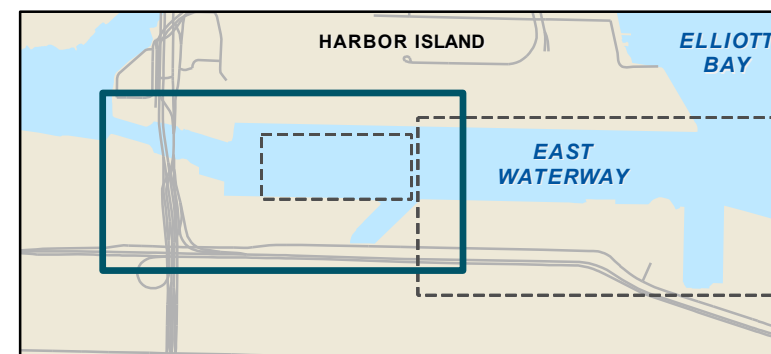
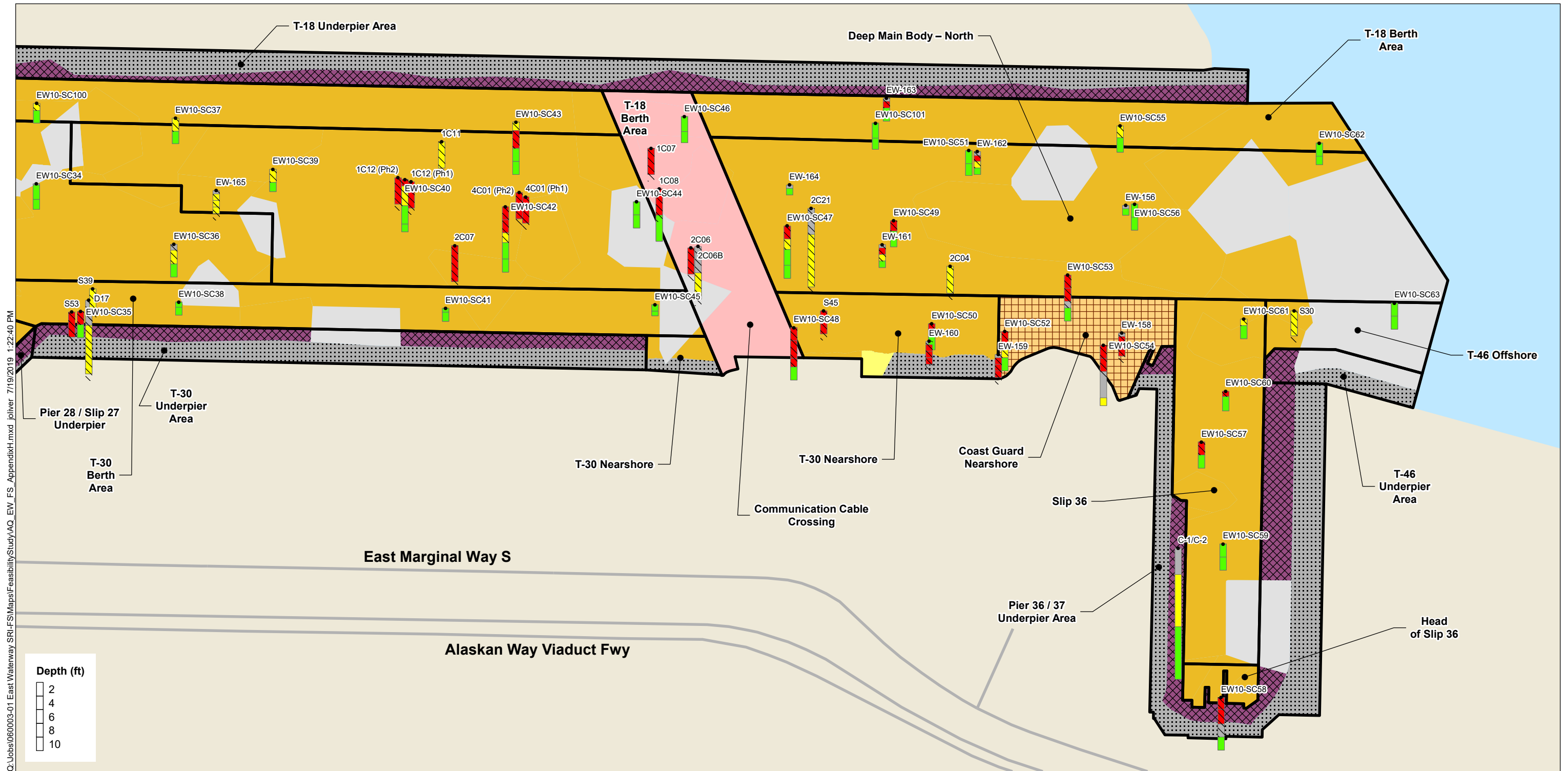


Figure 6a
Subsurface Contamination Remaining
Alternative 3E(7.5) - South
Feasibility Study - Appendix H
East Waterway Study Area



- Technology Assignments**
- Removal
 - Removal and Backfill to Existing Contours
 - Removal to the Extent Practicable and Backfill
 - Partial Removal and Cap
 - ENR-sill
 - Underpier: Hydraulic Dredging Followed by In Situ Treatment
 - Riprap (No Action)
 - No Action
- Exceedance Status**
- \leq RAL(7.5) and \leq SQS
 - $>$ RAL(7.5) or $>$ SQS
 - $>$ CSL
 - Interval not Analyzed
 - Dredging Depth
- CMA Boundaries**

NOTE:
1. RAL(7.5) denotes the RAL set that includes 7.5 mg/kg-OC for PCBs

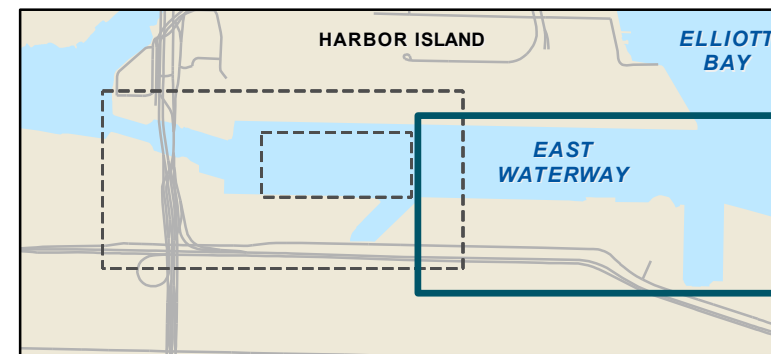
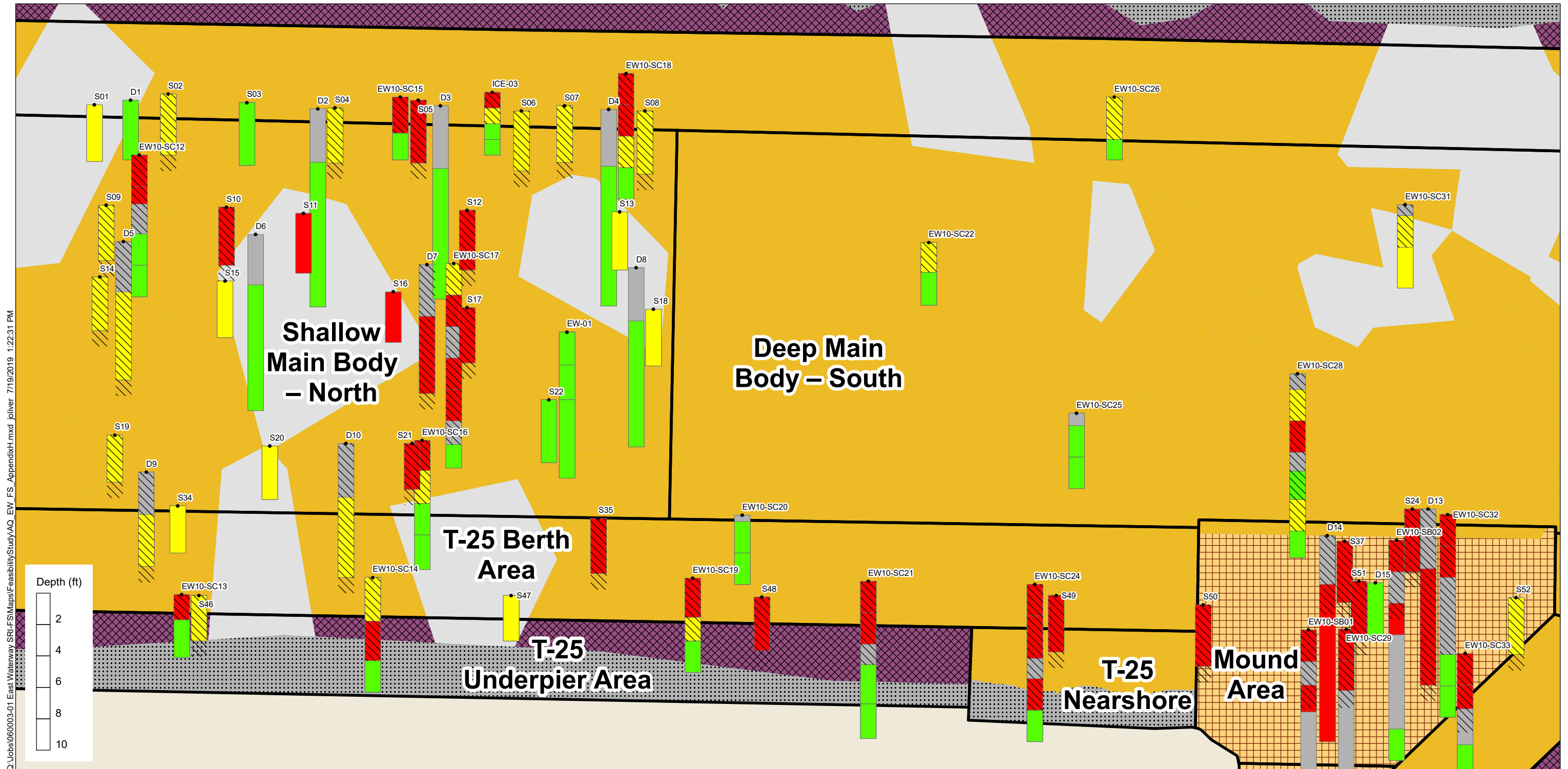


Figure 6b
Subsurface Contamination Remaining
Alternative 3E(7.5) - North
Feasibility Study - Appendix H
East Waterway Study Area



Technology Assignments

- Removal
- Removal and Backfill to Existing Contours
- Removal to the Extent Practicable and Backfill
- Partial Removal and Cap
- ENR-sill
- Underpier: Hydraulic Dredging Followed by In Situ Treatment
- Riprap (No Action)
- No Action

Exceedance Status

- \leq RAL(7.5) and \leq SQS
- $>$ RAL(7.5) or $>$ SQS
- $>$ CSL
- Interval not Analyzed
- Dredging Depth

CMA Boundaries

NOTE:
1. RAL(7.5) denotes the RAL set that includes 7.5 mg/kg-OC for PCBs

0 60 120 180 240
Scale in Feet

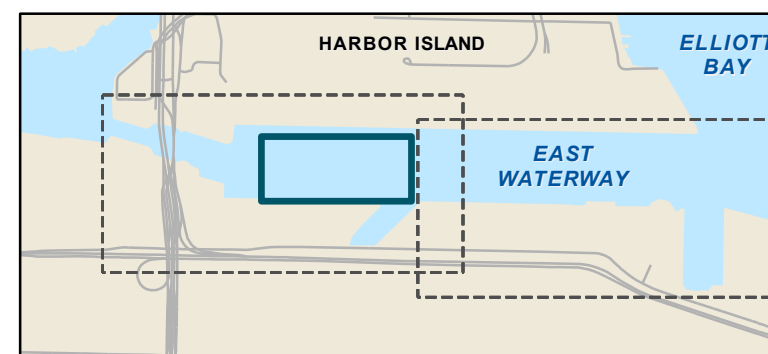


Figure 6c
Subsurface Contamination Remaining
Alternative 3E(7.5) - Detail, South
Feasibility Study - Appendix H
East Waterway Study Area