Cleanup Techniques Evaluation (Feasibility Study) - 2015 Update

Former New Gold House Site
Nome, Alaska

for

NOVAGOLD Resources, Inc.

July 10, 2015

GeoEngineers
Earth Science + Technology

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Table of Contents

LIST OF FIGURES

APPENDICES

EXECUTIVE SUMMARY

The purpose of the Cleanup Techniques Evaluation (Feasibility Study) report is to provide an analysis of remedial options for selecting the optimal cleanup approach for the Former New Gold House (FNGH) site located in Nome, Alaska, and to present the results of the analysis to the Alaska Department of Environmental Conservation (ADEC) to comply with the next step in the cleanup process. A Remedial Investigation has been completed for this site and is summarized in several Site Characterization and Monitoring reports prepared by GeoEngineers between 2011 and 2013 (see Section 5.0 References). These studies document the presence of mercury, arsenic and petroleum hydrocarbons at the site. The mercury is related to past gold processing activities. Arsenic is present at high background levels in the Nome area and has been concentrated around the FNGH. The petroleum hydrocarbons have migrated beneath the FNGH site from an upgradient source.

An Ecoscoping evaluation was included in GeoEngineers, Inc.'s (GeoEngineers) June 2, 2014 "Updated Cleanup Techniques Evaluation (Feasibility Study) and Ecoscoping Report." The Ecoscoping evaluation follows ADEC's March 2014 Ecoscoping Guidance. The ecological risk assessment (ERA) process in Alaska includes four steps: (1) Scoping Evaluation, (2) Preliminary Screening Evaluation (includes preparation of a preliminary conceptual site model [CSM]), (3) Screening-Level ERA, and (4) Baseline ERA. The Ecoscoping Form, along with the ecological CSM, makes up Steps 1 and 2 of the ERA process. The Scoping Evaluation (Step 1) determines whether potentially complete exposure pathways for ecological receptors are present at the site, while the Preliminary Screening Evaluation (Step 2) determines whether contaminants are present at concentrations greater than conservative ecological screening levels. According to ADEC's "Ecoscoping Guidance" dated March 2014, ADEC uses the completed Ecoscoping Form to determine whether a screening-level ERA or a baseline ERA is required (Steps 3 and 4 of the ecoscoping process). GeoEngineers prepared an ecological CSM (as well as a human health CSM) for the "Former New Gold House Supplemental Site Characterization Summary" report dated July 27, 2012. As part of preparing the ecological CSM, GeoEngineers identified sources, release mechanisms, transport mechanisms, exposure media, exposure routes and ecological receptors. The ecological CSM identified the FNGH operations as the primary source of mercury and arsenic contamination at the FNGH site and surface and subsurface soils as secondary sources. The recommended soil cover remedy outlined in the 2014 and now this 2015 Updated Cleanup Techniques Evaluation report (which includes additional groundwater, surface water and sediment testing results from 2014 sampling activities) addresses the mercury- and arsenic-contaminated soil sources by: (a) preventing direct contact exposure by humans and/or ecology and (b) reducing the physical movement of contaminated soil (via human and/or erosional processes) toward Dry Creek. Based on the site characterization data and CSMs, no additional ecological evaluation is necessary if the recommended remedial action (soil cover, environmental covenants and ongoing groundwater, surface water and Dry Creek sediment monitoring) is completed at the FNGH site. The soil cover remedy should be implemented as soon as possible.

This 2015 Update report includes data collected during the 2014 field season that further supports the recommendation of a soil cover for the FNGH. The 2014 supplemental groundwater, surface water and sediment testing results indicate that neither *groundwater, surface water, nor Dry Creek sediments* were impacted by mercury or arsenic at concentrations exceeding natural background. The site characterization results continue to point to a need to remediate mercury and arsenic contaminated soil located at the FNGH site.

The 2014 field efforts also included a hydrological study of streamflow and erosional characteristics within Dry Creek to evaluate stream erosion and flooding effects, if any, on a future soil cover. GeoEngineers' "Final Hydrographic Reconnaissance Summary of Findings" report dated July 2, 2015 indicates that the channel geomorphology is relatively stable and that implementation of a soil cover can be successfully implemented and maintained.

Considering the site characterization results, a total of eight possible remedial options for remediating mercury and arsenic contaminated soil were evaluated. These options can be grouped into three categories:

1. No Additional Action with Fencing and Monitoring,
2. Excavation with Off-site Disposal, or
3. Engineered Cover (soil cap).

The fencing/monitoring option is the current site condition. Fencing and site access restriction was previously approved by ADEC as an interim action.

The preferred remedy based on this analysis is to place an engineered cover (soil cap) over the mercury and arsenic contaminated soil, along with routine groundwater, surface water, and sediment and cover monitoring. A physical barrier of clean fill from local sources will be used to cover the contaminated soil. This layer will be compacted and graded and then covered with topsoil to facilitate growth of native vegetation and provide a non-hardscaped surface for water runoff and erosion protection. The 2014 hydrologic study concluded that rock particles greater than 6 inches in diameter are unlikely to erode and be transported within Dry Creek. As a result, areas of the cap that may be flooded by Dry Creek would be covered (armored) with rock greater than 6 inches in diameter.

The soil cover remedy will eliminate the direct contact exposure pathway and the physical mobility of contaminated soil towards Dry Creek. It is important to note that results obtained during site characterization show that surface water has not been impacted by mercury (or arsenic at concentrations above site background conditions). The vertical and horizontal extent of mercury and arsenic contamination present in soil at the site is well-defined, with several investigations characterizing the limits of the metals contamination that exceeds the proposed cleanup values. The original contributing source of this contamination—the FNGH facility itself—was removed in its entirety by 2005, so there is no residual contributing metals contamination source. Additionally, petroleum hydrocarbons present beneath the FNGH site that originated from historic sources at the adjacent (upgradient) 6th Avenue Property will be monitored through the groundwater and surface water monitoring program. Any disruption or removal of soil from the FNGH site would likely negatively affect the equilibrium conditions present at the site, and could result in mobilizing the petroleum hydrocarbons to move from the upgradient site through the FNGH and towards Dry Creek. Therefore, the preferred remedy, an engineered cover (soil cap) with institutional controls and groundwater, surface water and sediment monitoring, provides the overall highest level of environmental benefit for the cost. An evaluation of remedial alternatives and relative costs is provided in Appendix A.

1.0 INTRODUCTION AND SCOPE

This Cleanup Techniques evaluation and Feasibility Study examines mercury and arsenic contamination remediation options. The source of the metals contamination was gold processing activities conducted at the Former New Gold House (FNGH) site located in Nome, Alaska. Total petroleum hydrocarbons (TPH) documented in soil and groundwater during site investigations have been found to be generally from different sources (fuel tank systems related to historic power, maintenance, and ore processing activities at the 6th Avenue Property located up-gradient of the FNGH). Portions of the 6th Avenue Property are now owned by Bering Straits Native Corporation, and other portions are owned by the City of Nome (City). Figure 1 shows the respective property boundaries and ownership of the respective parcels.

The remedial options presented for the FNGH site acknowledge the TPH contamination with respect to whether potential remedies for the metals-contaminated soil would have a positive, negative, or neutral effect on future TPH contamination monitoring and/or cleanup. For the purpose of this report, TPH is defined as gasoline-, diesel-, oil-range (otherwise known as residual-range) hydrocarbons and associated volatiles; benzene, ethylbenzene, toluene and xylenes (BETX).

The FNGH site cleanup activities are governed by State of Alaska regulations. Regulation 18 AAC 75, Article 3, does not explicitly specify the preparation of a Feasibility Study as federal law under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) does. As a result, there are no formal regulatory procedures regarding the screening, evaluation and development of remedial alternative options for cleanup at a site. Specifically, 18 AAC 75.375(c)(5) states that the responsible party must "submit to the department [ADEC] for approval a site characterization report that…proposes cleanup techniques for the site." All other components of part (c) of the regulation were met in the final Supplemental Site Characterization Summary report (GeoEngineers, 2012) with the exception of the cleanup techniques component. Because the term "Feasibility Study" is commonly used throughout the environmental industry for the remedy selection step, this term is used in the title of this document in order to reduce possible confusion. Everywhere else in this document the ADEC terminology; Cleanup Techniques Evaluation is used. The Alaska Department of Environmental Conservation (ADEC) does not provide specific regulatory guidance regarding how to "propose" cleanup techniques, but does offer suggested elements in the selection of a cleanup technology, and these elements are used to evaluate the relative merits of alternative technologies. The criteria suggested by ADEC to evaluate proposed cleanup techniques in selecting a recommended remedy include:

- Protectiveness (or technical performance);
- Practicality (including maintenance);
- Effectiveness/permanence (including potentially adverse environmental impacts);
- Regulatory compliance;
- Public perception/input; and
- Comparative cost.

The following sections describe the approach used to screen and evaluate possible cleanup techniques for the metals contamination at the FNGH site.

2.0 CHARACTERIZATION RESULTS

As outlined in previous characterization reports, some mercury and arsenic soil contamination remains in the immediate vicinity of the FNGH. Establishing a remedy for soil is the focus of the Feasibility elements of this report. However, monitoring is another necessary element once the preferred remedy (a soil cover as described in the next sections of this report) is implemented. Monitoring of groundwater, surface water and Dry Creek sediment will be completed for evaluating contaminant trends and performance of the remedy.

Groundwater, surface water and sediment samples (from Dry Creek) have been collected from the FNGH and 6th Avenue sites annually by GeoEngineers since 2011. The most recent results, representing the most expansive dataset of groundwater (10 sample locations), surface water (5 sample locations), and sediment (13 sample locations) testing was completed during September 2014. The 2014 groundwater, sediment, and surface water sampling results are presented in GeoEngineers, Inc.'s (GeoEngineers) "2014 Groundwater, Surface Water and Sediment Monitoring Summary" report. The 2014 data were generally consistent with the 2013 data and previous monitoring events. The results indicate continued stability of the petroleum hydrocarbon groundwater plume, expected and consistent elevated background conditions for arsenic and no detectable mercury in groundwater. The results for each media is summarized as follows:

- **Groundwater.** Of the 10 wells sampled the three wells located on NOVAGOLD property are GMW2, GMW3, and GMW7R2. There are five wells on Bering Straits Native Corporation (BSNC) property (GMW1R, GMW4, GMW6, GMW8, and MW-10), and two on property owned by the City of Nome (GMW5 and MW-5). Mercury was not detected in any of the 10 groundwater samples, and arsenic contamination was consistent with previous monitoring events (background concentrations). Fuel hydrocarbons, specifically diesel-range organics (DRO), were the primary contaminants detected in groundwater. The highest detections were again reported at monitoring wells GMW4 and GMW5, located upgradient of the FNGH on the 6th Avenue property.
- **Surface Water.** Contaminants of concern were not observed at concentrations greater than drinking water criteria in samples obtained within Dry Creek (SW-2, 3 and 4). Two of the five surface water samples collected from areas of ponded water (not within the Dry Creek drainage, SW-5 and 6) had exceedances for arsenic, as well as DRO and RRO (residual range organics) in sample SW-6. Mercury was only detected at location SW-6, but at concentrations below cleanup standards. This surface water sample was collected south of the pond and north of the FNGH building footprint, and lies almost in the very center of the area proposed to be addressed with a soil cover.

- **Sediment.** Of the 13 sediment samples collected during September 2014, sediment sample SSD-25 had elevated concentrations of mercury, arsenic, DRO and methylmercury above the ADEC screening levels for soil. This sample was collected between the pond and pad of the FNGH site, within an area of previously confirmed mercury, arsenic and DRO soil contamination, and in the center of the area proposed to be remediated via soil cover. Mercury exceeded National Oceanic and Atmospheric Administration (NOAA) screening values in sample locations SSD-17 and SSD-24. Sample SSD-17 was collected from the tributary to Dry Creek closest to the FNGH site, and SSD-24 was collected to the west of the pond outside of the fenced area. Sample SSD-17 also had an exceedance for DRO. Arsenic was widespread, with all 13 sediment samples having concentrations in excess of the NOAA screening threshold, and six of the locations (SSD-13, SSD-16 through SSD-19, and SSD-25) having concentrations higher than the proposed background concentration of soil for the FNGH site. This result for arsenic is not surprising, given the high concentrations of naturally occurring arsenic throughout the greater Nome area.

During September 2014 surface water and sediment samples were tested for methylmercury. The highest concentration of methylmercury in surface water was reported at SW-6, but at a concentration more than three orders of magnitude below the ADEC cleanup standard for drinking water of 3.7 µg/L (micrograms per liter). Measurable concentrations of methylmercury were reported in 11 of the 13 sediment samples, with the highest value of 0.0933 mg/kg (milligrams per kilogram) occurring at SSD-25, collocated with SW-6, and located in the middle of the proposed soil cover footprint. The other ten samples had comparatively very low concentrations, ranging from 0.000040 mg/kg to 0.000822 mg/kg. Conditions for the formation of methylmercury vary, but the factors that generally affect the formation of methylmercury in the environment the most include temperature and the presence of stagnant water bodies (USFS, 2004). In the case of the 2014 event, water temperatures were consistently cold, ranging from 1^{o}C to 4.5^{o}C at a time considered to be the end of the summer season. The creek itself is frozen for the majority of the year. Surface water flow conditions are not stagnant (except at SW-6). A strong current was observed in each of the four sampling events conducted from 2011 to 2014.

One method to help understand the effect, if any, of methylmercury formation potential at the FNGH site is to compare observed concentrations of free mercury to methylmercury concentrations. Using a comparative ratio based on a methodology developed by California Environmental Protection Agency – State Water Resources Control Board, GeoEngineers compared the ratio of methylmercury to the concentration of free mercury found at a site. The 2014 FNGH results indicated an overall methylmercury to mercury ratio of 0.239 percent; the 2013 ratio was 0.189 percent; less than the 10 percent marker that represents a relationship. These low ratios of methylmercury to mercury offer additional empirical data that methylmercury formation at the FNGH Site is not a significant concern.

Continued monitoring of the FNGH site for long-term trend analysis is recommended for inclusion with the overall remedy addressing arsenic and mercury contamination.

3.0 SCREENING AND EVALUATION OF CLEANUP TECHNIQUES

With the exception of the “no action” option, each of the remedies evaluated in the subsequent sections of this report assume that the three monitoring wells on NOVAGOLD property will continue to be sampled and groundwater tested for arsenic, mercury, methylmercury, and TPH. Surface water sampling will continue at two locations in Dry Creek; (1) at the western edge of the FNGH property and (2) at the surface water drainage tributary flowing away from the FNGH site at its westernmost point of the property. Sediment will continue to be sampled at four locations in Dry Creek; one location upstream of the FNGH, between the old bridge and upper culvert and three locations between the old bridge and downstream culvert. Additional sampling of groundwater wells on BSNC and City of Nome properties would be dependent on future agreements with those parties.

The evaluation of arsenic and mercury-contaminated soil cleanup options is presented below. How each option could affect the off-site-sourced petroleum hydrocarbon plume that has migrated beneath the southern edge of the NOVAGOLD property is also briefly discussed.

3.1. Screening of Remediation Technologies

A screening evaluation of potentially applicable remediation technologies was completed for the FNGH site. Because there are a limited number of suitable technologies for the remediation of mercury and arsenic in soil, technologies such as (a) heating and vaporized recovery (retort of mercury) and (b) soil flushing and chemical extraction were screened out from further evaluation due to low effectiveness, difficulty to implement, and/or due to another technology being similarly effective and implementable and having a lower cost. For the purposes of comparability, options such as No Action/Continued Access Restriction with Fencing, and Institutional Controls/Monitoring were retained. The following remediation technologies were considered potentially effective and implementable and were retained for development into possible cleanup techniques:

- No action/access restriction with existing fencing;
- Institutional/engineering controls with monitoring;
- Solidification/stabilization of soil using sulfur polymer cement;
- Excavation and off-site disposal of contaminated soil;
- Combined limited “hot spot” (defined below) excavation/disposal and covering remaining soil with a soil cap;
- Covering soil with engineered soil cap and riprap cover;
- Covering soil with an impermeable geotextile cap; and
- Soil consolidation on-site with impermeable geotextile cap.

3.2. Description of Cleanup Technique Options

The cleanup techniques retained for further evaluation are summarized below. Each option focuses on addressing the contaminated soils at the FNGH Site.

3.2.1. No Action/Access Restriction with Existing Fencing (Option 1)

The no action/access restriction option is provided as a baseline. This is the current state of the site. The Alaska Gold Company (AGC) demolished the FNGH facility in 2004 and removed all debris, including 10 cubic yards of soil directly beneath the building, by 2005. The access restriction by fencing was an interim action approved by ADEC and completed by AGC (AGC was a subsidiary company of NOVAGOLD at that time) in 2007. The assumption for this option is that NOVAGOLD undertakes no further action beyond the submittal of this Cleanup Techniques Study. No cleanup activities beyond what has previously occurred at the FNGH would be undertaken.

3.2.2. Institutional/Engineering Controls (Fencing) with Groundwater, Surface Water and Dry Creek Sediment Monitoring (Option 2)

This option assumes that the fence surrounding the FNGH is repaired or replaced, and maintained to restrict access. Existing groundwater monitoring wells (3) on NOVAGOLD property and two surface water locations within Dry Creek would be sampled annually for mercury, arsenic and petroleum hydrocarbon contamination and four sediment locations within Dry Creek will be sampled annually for arsenic, mercury and methylmercury. An environmental covenant or Institutional Controls Management Plan (ICMP) would be prepared and assigned to the property deed in order to limit site use by the current or any future landowners. The purpose of groundwater and surface water monitoring is to provide groundwater quality information for validating that neither mercury nor arsenic exceeds natural background conditions (which is the current condition). Sediment testing would be used to establish trends and evaluate erosional effects and physical contaminant transport (if any). Additionally, this option uses the data collected from testing groundwater for TPH in the wells, to evaluate hydrocarbon migration and perform a degradation trend analysis to evaluate whether the TPH contamination is migrating toward Dry Creek, remaining stable, or retreating due to natural degradation. The groundwater and surface water monitoring portion of this remedy carries forward with the other cleanup techniques presented in Options 3 through 8.

3.2.3. Solidification/Stabilization of Contaminated Soil Using Sulfur Polymer Cement (Option 3)

Mercury does not typically respond well to conventional solidification/stabilization techniques, such as potash mixed with Portland cement, but based on GeoEngineers' 2010 bench scale testing at the site, the use of sulfur polymer cement in combination with a sodium sulfide catalyst was found to be technically feasible. The solidification/stabilization approach used during bench-scale testing resulted in the chemical alteration of free mercury into the mineral cinnabar (mercury sulfide), a compound that does not leach, which was then further encased in sulfur polymer cement. Sulfur polymer cement is heated and mixed on-site with a catalyst (sodium sulfide) and then tilled into the contaminated soil in an in situ process. In this remedial option, the entire FNGH area where contaminated soil exists would be encased in hardened cement, forming a monolith that could be covered with clean fill. The result is a remedy that is essentially impervious to leaching. However, the bench-scale tests showed that soils at the site did not leach mercury or arsenic contamination whether or not the soil was treated or stabilized by the sulfur polymer cement. The difference in leachability between the untreated and stabilized soil was almost negligible.

Sulfur polymer cement has far greater compressive strength and resistance to extremes in temperature than conventional Portland cement. As outlined in Option 2, this option includes periodic monitoring of the existing groundwater monitoring wells, surface water and sediment. It also assumes the repair/replacement of site fencing. Sulfur polymer cement does not have a stabilizing influence on TPH in soil, and so the overall effect of this technology on the TPH present at the FNGH Site is minimal.

3.2.4. Excavation and Off-Site Disposal of Metals Contaminated Soil (Option 4)

This option assumes excavation of arsenic- and mercury-contaminated soil from the FNGH area and approximately the upper 2 feet of contaminated soil located between the FNGH pad area and the manmade pond. Upon reaching the limits of the excavation, confirmation soil sampling would be conducted along the lateral and vertical limits of the excavation to verify the removal of contaminated soil exceeding the targeted cleanup concentrations (1.4 and 151 mg/kg for mercury and arsenic). The remedial action would be completed by placing clean fill throughout the site and re-grading it to a more natural slope, effectively covering the residual TPH-contaminated soil with a soil cap. This cover reduces exposure to residual hydrocarbons remaining in the soil. This option entails the removal of the fence surrounding the site since it eliminates the presence of metals-contaminated soil. However, monitoring wells remain in place, primarily for the purpose of monitoring hydrocarbons rather than mercury and arsenic. The excavated soil would be containerized and transported by barge for permitted disposal at a landfill in Washington State or Oregon. Although small amounts of TPH contamination would be removed concurrently with the metals-contaminated soil, the disturbance to the subsurface could have a significant negative effect on the current plume equilibrium by destabilizing the present subsurface conditions and thus cause contaminated groundwater to mobilize and migrate beneath the FNGH site toward Dry Creek.

3.2.5. Limited Hot Spot Excavation and Disposal Combined With an Engineered Cover of Remaining Soil with Groundwater, Surface Water and Dry Creek Sediment Monitoring (Option 5)

This scenario assumes a narrowly focused excavation of the most contaminated mercury and arsenic areas of the FNGH site, and soil disposal off-site in a permitted landfill, followed by covering and re-grading the site with clean, imported fill (a soil cap). Generally, the area of highest metal concentrations is located in the immediate vicinity of the historic FNGH facility. There are some locations in this immediate vicinity where contamination concentrations exceed the ADEC maximum direct contact of soil cleanup level for mercury, which is 30 mg/kg. Areas that exceed this value for mercury are defined as "hot spots" for this remedial option. Excavation of the mercury hot spots requires confirmation sampling to show removal of contaminated soil with the highest concentrations. In this option, lower concentrations of metals contamination remain in place, and the area would be covered with clean fill as described in Options 6 and 7 below. Under this scenario the fence is retained and groundwater, surface water and sediment monitoring activities are undertaken as described in Option 2. The remaining metals-contaminated soil areas could also contain TPH contamination, so monitoring is assumed to continue for both metals and petroleum hydrocarbons.

3.2.6. Covering Soil with Engineered Fill and 6-Inch-Minimum Riprap Cover with Groundwater, Surface Water and Dry Creek Sediment Monitoring (Option 6)

This option represents a conventional capping remedy for reducing the direct-contact pathway and erosional potential for the mercury, arsenic and petroleum hydrocarbon contamination at the FNGH. This remedy consists of placing up to 2-feet of a locally-sourced sand and gravel cover over contaminated soil (a soil cap). To protect the cover from seasonal flooding, an outer layer (an "armoring layer") of rock with a 6-inch-minimum diameter would be placed along the northern "sloped" portion of the soil cover to reduce exposure to erosive forces on the "sloped" sides of the cap exposed to the seasonal Dry Creek flooding. The spring melt that floods the Dry Creek valley is constrained by an undersized culvert on the downstream portion of Dry Creek which causes ponding in the low area below the FNGH site. As a result GeoEngineers' studies indicate that erosional effects of the soil cap (that is adequately designed and armored) will have little effect from the low energy backwater environment that develops in the topographic low area below the FNGH from spring flooding. Additional details regarding the hydrological flow mechanics are described in GeoEngineers' hydrology study (GeoEngineers 2015). It is also anticipated that the man-made pond would be filled to achieve a 1V:5H (vertical to horizontal) rise to run ratio. Additional elements of this cap and armoring design will be developed as part of an Engineering Design Report/Cleanup Action Plan.

This remedy would include removing the failing existing fence and replacing it with a new fence that matches the limits of the covered area. This option keeps all contaminated soil (metals and TPH) in place. This remedy does not directly inhibit rainwater infiltration at the site; which does not appear necessary considering that groundwater quality is not impacted from leaching chemicals of concern. Under this scenario the fence is retained and groundwater, surface water and sediment monitoring activities are undertaken as described in Option 2.

3.2.7. Capping Soil with an Impermeable Geosynthetic/Composite Cap with Groundwater, Surface Water and Dry Creek Sediment Monitoring (Option 7)

The principle difference between this option and the engineered fill cover option above (Option 6) is the introduction of an impermeable barrier that restricts water from infiltrating into the contaminated soil at the FNGH site, thus eliminating the soil to groundwater migration pathway (i.e., potential leaching pathway). This option includes a sand and gravel bedding layer that is graded to form a leveling layer. The thickness of the leveling layer would vary between one and four feet, except for the pond area, which would be completely filled and re-graded. In this remedial option, a 40 mil polyvinyl chloride (PVC) or high density polyethylene (HDPE) liner covers the leveling layer, on top of which a layer of compacted sand and gravel fill would be placed. Finally, a layer of uncompacted topsoil would be placed to encourage vegetation to grow over the cap. This remedy also assumes the removal of the existing fence and its replacement with the addition of signage warning visitors to not dig in the area of the cap. The prevention of infiltration could have a positive influence in reducing the potential for TPH migration beneath the site. However, as discussed in Option 6 above, leaching does not appear to be occurring within the metals-contaminated soils at the FNGH site, and the overall TPH plume appears to be stable. The footprint for the cap is the same as Option 6, as shown on Figure 5. As stated in the Option 6 discussion, the cap design details, such as dimensions and a grading plan, will be a component of the Engineering Design Report/Cleanup Action Plan prepared for the site. The preparation of environmental covenants documenting the future use restrictions at the site are also a component of this cleanup technique approach. Under this scenario, groundwater, surface water and sediment monitoring activities are undertaken as described in Option 2.

An asphaltic concrete cap was also considered for this option; however, the city of Nome lacks asphalt producing capability. Therefore, this approach was removed from further consideration.

3.2.8. Contaminated Soil Consolidation On-Site with an Impermeable Geosynthetic/Composite Cover (Option 8)

This option is a refinement of the impermeable cap option (Option 7) in that metals contaminated soil from the outer edges of the site (north and west of the FNGH pad) would be scraped and pulled back towards the FNGH pad, to be consolidated and covered at the FNGH location (the area of highest contaminant concentration). The purpose of this option is to reduce the surface extent of the metals-contaminated soil, decrease its proximity to Dry Creek and reduce the extent of the area to be covered, compared to the previous option. Excavation and relocation of the mercury and arsenic contamination would require confirmation sampling to verify (a) that the contaminated soil was actually removed and thus verifying the existing site characterization results and (b) that the remaining soil meets the proposed delineation concentrations. The concentrations proposed to delineate soils for removal and consolidation are the ADEC cleanup levels for mercury, and the calculated, site-specific background concentration for arsenic (1.4 and 151 mg/kg, respectively). This remedy backfills excavated areas with clean soil and grades the site to promote runoff, similar to Options 4 and 5. The remainder of the remedy follows the approach outlined in Option 7, although the amount of material required for the leveling layer is less under this option. The extent of the cover area shown on Figure 5 would be reduced by approximately half. However, this option would increase the overall thickness of the cover, and could require the installation of a retaining wall along the northern edge of the cover, or extending the cover further towards the western and eastern portions of the site. As with the options that include excavation, this option would cause considerable subsurface disturbance and could have a negative effect on the current hydrocarbon plume stability by disrupting the present subsurface conditions. This option similarly assumes that the fence would be removed and replaced with both a new fence and signage. In this option, the pond would remain intact, as draining and backfilling the feature would not be necessary to construct the cap. Under this scenario groundwater, surface water and sediment monitoring activities are undertaken as described in Option 2.

The last four options listed above assume the continuation of groundwater monitoring at the site and at two surface water locations within Dry Creek and sediment sampling within Dry Creek at four locations to evaluate remedy effectiveness, and periodic monitoring/inspection of the cover on an annual basis. These remedies as described need confirmation that the areas being affected are disturbed areas, and not classified as wetlands. A determination of whether these areas are classified as wetlands would need to be made and verified with the Anchorage District office of the U.S. Army Corps of Engineers (USACE). If the areas are determined to be wetlands, then the proposed action would likely need USACE authorization.

3.3. Cleanup Technique Evaluation Criteria

This section presents a description of the approach used to evaluate the cleanup technique options presented above. The criteria suggested by ADEC to evaluate proposed cleanup techniques for selecting a recommended remedy include: 1) protectiveness; 2) practicality; 3) effectiveness/permanence; 4) regulatory compliance; 5) public perception/input; and 6) comparative cost.

For the purpose of this cleanup technique evaluation, the criteria listed above are defined below, and these definitions were used as the basis for comparatively evaluating and selecting the preferred cleanup technique. The comparison and scoring of each criterion is included in the “Cleanup Techniques Options Evaluation” spreadsheet presented in Appendix A. This spreadsheet uses the threshold criteria and elements listed in the subsections below and scores each element for each remedial option. The higher the score the more feasible and appropriate the remedy for the specific conditions at this site. This scoring system is commonly used in Feasibility Studies as a selection technique to rank alternatives relative to one another. The numerical scoring is not a qualitative measure, except in the context of a relative comparison.

3.3.1. Protectiveness

The overall protectiveness of a cleanup technique is evaluated based on several factors, such as the extent to which human health and the environment are protected and the degree to which overall on- and off-site risk is reduced.

3.3.2. Practicality

Practicality is defined as an overall measurement of the relative difficulty and uncertainty of implementing a given cleanup technique. Evaluation of practicality includes consideration of technical factors such as the availability of proven technologies to accomplish the cleanup work, and also includes administrative factors associated with permitting and completing the cleanup. Another key aspect of this criterion is the remote nature of the site’s location in Nome, and the limited amount of resources available to implement a given remedy. Nome’s challenging location and climate present practical limitations on certain remedies. There is a narrow window to bring in materials and equipment needed to perform the work, as well as performing the work itself. Any applicable remedy must be implementable within a compressed construction timeframe and account for extreme weather conditions. Remedies that require extensive logistical support or the shipment in (or out) of large quantities of materials or supplies would not be favorably ranked in this portion of the evaluation. Additionally, non-natural materials (geotextiles, impermeable barriers/liners, tie-down bars, fences, etc.) are subject to frost-jacking and heave during freeze-thaw conditions. These elements also would not be favorably ranked in this portion of the evaluation.

3.3.3. Effectiveness/Permanence

This criterion includes the degree to which the cleanup technique permanently reduces the toxicity, mobility or mass of the contamination, the effectiveness of a given cleanup option in destroying the contamination, the reduction or elimination of the release source, and the degree of irreversibility of the technique. Because elemental mercury and arsenic cannot be 'destroyed,' this evaluation factored in the ability of a given technology to change the form of the metals contamination, and whether there would be any tangible benefit towards addressing petroleum contamination. Although petroleum cleanup is not the focus of this analysis, it is important to consider whether the preferred mercury and arsenic cleanup option, increases or decreases the potential for mobilizing petroleum contamination beneath the FNGH. As a result, the effect of the remedy on petroleum mobility is factored into the evaluation.

3.3.4. Regulatory Compliance

This criterion evaluates whether the technique complies with all appropriate, relevant and applicable requirements specified by the Alaska Administrative Code (18 AAC 75 section 340 – 360), federal requirements (USACE General Permit 2006-214-M1), and City of Nome statutes. This criterion also considers the magnitude of permitting required for implementing a given technique, and the extent of regulatory input required in order to obtain the necessary permits.

3.3.5. Public Perception/Input

Public input is a requirement for ADEC's cleanup process, and this criterion looks to establish the likelihood of the public accepting or preferring one proposed remedy over another one. It also factors into how a given cleanup technique may or may not affect the behavior of the public regarding the FNGH site. As specified under 18 AAC 75.325(j) for site cleanup ADEC can seek public input from the citizens of Nome and any other applicable stakeholders regarding the proposed cleanup, using whatever method ADEC determines to be appropriate for seeking public participation.

3.3.6. Comparative Cost

The cost comparisons are based on a set of assumptions that were applied equally to each of the options. They are preliminary engineering estimates and have been prepared to assist in the selection of a preferred remedy related to cost-benefit. Actual cleanup cost estimates will need to be obtained from contractors before proceeding with the cleanup action. The cost evaluation is intended for relative comparative purposes among the different cleanup techniques to assist in the overall analysis of relative costs, benefits and disadvantages of the options. The cost to implement a cleanup technique includes transportation and disposition of materials and equipment, the cost of construction, and long-term costs. Long-term costs include operation and maintenance costs, monitoring costs, equipment replacement costs and the cost of maintaining institutional controls. Unit costs used to develop overall remediation costs were derived using a combination of published engineering reference manuals (i.e., R.S. Means); construction cost estimates solicited from contractors familiar with working in Nome; and review of actual costs incurred during similar applicable projects.

Some states weight cleanup alternative criteria in order to consider the relative importance of a certain aspect of the selection process. Because there are no standards associated with the development of cleanup techniques for contaminated sites in Alaska, each of the criteria listed above were given equal weighting for the purpose of ranking the eight proposed cleanup options. However, the protectiveness factor was given more emphasis in selecting the preferred cleanup option, as the chosen remedy has to address the reduction of risk to the environment first and foremost among the evaluation criteria.

3.4. Evaluation and Comparison of Cleanup Techniques

This section summarizes the comparative analysis of the cleanup options developed for the FNGH site. Each option was evaluated with respect to the criteria described in Section 3.3 and then compared to the other options relative to its expected performance under each criterion. Each cleanup technique was ranked comparatively against the other techniques on the basis of each evaluation criterion. The components of the eight cleanup techniques are described in Section 3.2. The evaluation of the options and the results of the qualitative evaluation are summarized below as well as presented in a table in Appendix A.

3.4.1. Cleanup Technique Categorization

The eight cleanup techniques described in Section 3.2 fall into three distinct categories:

A. No action or Institutional Controls and Monitoring Only (Options 1 and 2);

B. Soil removal and/or Treatment (Options 3, 4 and 5); and

C. Soil Contamination Cover/Cap (Options 6, 7 and 8).

Option 5 (limited excavation and capping) and Option 8 (soil consolidation and capping) have components of both soil excavation and capping as part of their remedy.

Although the cleanup technique that is ultimately chosen will specifically address mercury and arsenic contamination, the presence of petroleum hydrocarbons in the subsurface soil and groundwater needs to also be considered in the final selection. Soil and groundwater data collected in 2011, and groundwater and surface water sampling performed in 2012, 2013 and 2014 indicate that TPH contamination is relatively stable beneath the FNGH site, with some potential to migrate towards Dry Creek to the west of the site. Therefore, it is possible that any type of significant soil disturbance or excavation activities could potentially affect the current conditions and route petroleum contamination migration underneath the FNGH site. Options 3, 4, 5, and 8 (the soil excavation options) were removed from further consideration in part because excavation would affect the stability of the TPH plume. For example, (1) exposing petroleum contaminated soil to rainwater, infiltration and flood waters, (2) exposing petroleum to direct contact by human and/or environmental receptors (whereas the current soil cover reduces or eliminates direct contact) and/or (3) the possibility of disrupting the currently stable eco-habitat and hydrogeologic regime (groundwater flow pattern, plume extent/mobility and permafrost conditions). This is especially important because the data generally show that water and sediment chemistry is sufficient to support positive aquatic life conditions in Dry Creek.

In contrast, the no action or limited action options (Options 1 and 2) described in Section 3.2 present the best scenarios for the site to maintain the present subsurface stability and plume equilibrium conditions. However, with respect to the mercury and arsenic contamination, neither of these options offers exposure protection for potential receptors, either human or ecological, that might possibly come in contact with the site's contaminated soil. As discussed in the "hot spot" remediation approach in section 3.2.5, there are locations within the immediate vicinity of the FNGH site where contamination concentrations exceed the ADEC maximum direct contact of soil cleanup level for mercury, suggesting that a bias for action to more permanently restrict possible direct contact exposure, is warranted.

Table 1 below summarizes the options removed from further evaluation as a result of this analysis (scoring table in Appendix A) and includes a summary rationale for their exclusion from further consideration. Remedial options that resulted in an increased risk of destabilizing the TPH plume, or conversely, did not reduce the potential for physical transport of mercury- and arsenic-contaminated soils due to extensive soil disturbance did not score high. Likewise, cleanup options that did not provide any reduction in direct exposure pathways to the metals contamination also fared poorly in the evaluation.

The following section discusses the options that scored highest in this evaluation (Options 6 and 7) in greater detail.

TABLE 1. CLEANUP TECHNIQUES ELIMINATED OR RETAINED FOR IMPLEMENTATION AT THE FNGH SITE

Option Number	Cleanup Technique Description	Total Cost[a, c]	Rationale for Elimination or Retention and Primary Reasons for Elimination
Option 1	No Action	**$0**	**Eliminated.** Does not address exposure pathways of direct contact and inhalation risk for contaminated soil, does not comply with 1987 Compliance Order by Consent issued by ADEC.
Option 2	Groundwater monitoring, Institutional controls, and Limiting Site Access (i.e., fencing)	**$510,000***	**Eliminated.** Offers modest improvement in reducing the exposure pathway, but does not provide sufficient protection for potential receptors,
Option 3	Solidification/Stabilization Using Sulfur Polymer Cement	**$4,350,000**	**Eliminated.** Requires extensive disturbance of soil and could potentially mobilize subsurface TPH contamination. Untreated soils also show very low leachability. Most costly option to implement.
Option 4	Excavation and Off-Site Disposal	**$3,540,000**	**Eliminated.** This option also disturbs much of the FNGH site soils, and could mobilize subsurface TPH contamination. Work would need to be completed in a very short work window and work would be extremely difficult in very wet, lowland conditions. Second most expensive option to implement.
Option 5	Limited "hot spot"[b] excavation/disposal and cover remaining soil	**$1,780,000**	**Eliminated.** Excavation and removal of soil could mobilize TPH contamination in the subsurface. Work would need to be completed in a very short work window and work would be extremely difficult in very wet, lowland conditions. May not capture and contain contamination sufficiently.

Option Number	Cleanup Technique Description	Total Cost[a, c]	Rationale for Elimination or Retention and Primary Reasons for Elimination
Option 6	Covering Soil with Engineered Fill Soil and Rip-Rap Cover	**$1,175,000**	**Retained.** See discussion in Section 3.4.2
Option 7	Capping Soil with an Impermeable Geo-textile Liner	**$1,325,000**	**Retained.** See discussion in Section 3.4.2
Option 8	Contaminated soil consolidation on-site with capping	**$1,380,000**	**Eliminated.** Requires extensive excavation and soil movement on the site. Work would need to be completed in a very short work window. Work would be extremely difficult in very wet, lowland conditions. Could possibly mobilize subsurface TPH contamination. Also requires confirmation sampling to verify targeted extent of soil has been pulled back for covering.

[a] Total cost includes plans, design, construction, monitoring and contractor overhead. The listed costs do not assume any contingency.

[b] The reference to "hot-spot" soils refers to the respective concentrations of mercury and arsenic, not to any difference in soils with respect to their leaching potential, which has been determined site-wide to be very low.

[c] Assumes a five year period of monitoring and reporting activities. Costs from Option 2 included in Options 3 through 8.

3.4.2. Cleanup Techniques Evaluation (Comparison of Two Retained Remedies)

Based on the comparative and scoring analysis spreadsheet in Appendix A and the summary in Section 3.4.1, two remedies were retained for further consideration; (1) Engineered Fill and Riprap Cover (Option 6) and (2) Capping of Soil with an Impermeable Geosynthetic/Composite Cap (Option 7). In order to compare each remaining option, they were evaluated against one another using the six evaluation criteria described in Section 3.3. The principle difference between these two options is that Option 7 adds an impermeable liner to the engineered fill covering the contaminated soil. The comparison of the two options for each of the evaluation criteria is summarized below:

- **Protectiveness.** Both options protect potential receptors from possible exposure to soil contamination. The cap with the liner (Option 7) offers slightly more protection by reducing the potential for precipitation runoff to come into direct contact with mercury, arsenic and petroleum hydrocarbon soil contamination. However, even though there is sand, gravel and topsoil overlying the liner, the impermeability of the liner will increase surface water runoff from water that infiltrates the cover soil and encounters the liner. Therefore the design will need to consider stormwater management elements to reduce erosional effects and high runoff from the impermeable liner surface (as opposed to natural drainage through soil).
- **Practicality.** Both options are feasible to install. For Option 7, however, a synthetic liner requires more maintenance and monitoring under the arctic conditions prevalent in Nome; frost heave could damage the liner. The engineered soil fill cover (Option 6) uses local materials (sand and gravel and larger-sized riprap rock cover), and would be more adaptable and robust relative to the harsh freeze-thaw and arctic conditions. It also would require considerably less maintenance and monitoring oversight.
- **Effectiveness/Permanence.** Both options offer effective remedies. The lined cover option offers slightly greater effectiveness in reducing the potential for precipitation infiltration to come into contact

with mercury, arsenic and TPH-contaminated soil. However, the leaching potential for site soils has been demonstrated to be very low, so an impermeable liner does not offer any significant advantage in addressing leaching potential at this site. However, as outlined in the "Practicality" section, the freeze-thaw effects could result in the need for significant maintenance for the geosynthetic liner, and therefore, it has a lower permanence rating than the soil-only cover.

- **Regulatory Compliance.** Both options comply with 18 AAC 75.325(f) as permanent remedies that meet applicable cleanup requirements.
- **Public Perception.** Both options are similar in appearance and neither option is considered to have a particular advantage over the other. It is our view that public concern is very limited related to the potential environmental contamination and past proposed actions at the FNGH property. However, any remedial actions that negatively affect the adjacent 6th Avenue property's museum or other development projects would likely create a negative perception of the action. In this instance, neither option has a likely negative impact on nearby development, so there is little appreciable difference in the two remedies.
- **Cost.** The cost of installing a cap with a liner (Option 7) is more expensive than installing an engineered fill cover (Option 6). In addition to materials costs being greater, installation time is longer and specialized labor is not available in Nome that is necessary to install the liner correctly. Furthermore, maintenance of a synthetic cap over the very long term is costlier than the engineered fill cover option.

When compared using the criteria outlined in this section, the two options are similar. Although Option 7 (Liner Option) offers a slight advantage regarding Protectiveness, Option 6 (Engineered Fill and Riprap Cover) offers an advantage with respect to Practicality, Permanence and Cost. The other screening criteria were equal between the two remedies.

3.4.3. Preferred Cleanup Technique – Option 6 Engineered Soil Cover

The preferred cleanup option is a soil cover (Engineered Fill and Riprap Cover [Option 6]). This option represents a conventional capping remedy for reducing the direct-contact pathway threat and erosional potential for the mercury and arsenic contamination at the FNGH. The soil cover will eliminate both the direct contact pathway and physical movement of contaminated soil toward Dry Creek (the soil to surface water pathway); thus addressing the pathways of concern outlined in both the human health and ecological conceptual site models.

This option is the most flexible, adaptable and maintainable. It is less disruptive and results in less exposure than the excavation options. In this option, the soil cover remedy consists of re-grading the site and placing a locally-sourced sand and gravel cover. To protect the cover from seasonal flooding, an outer layer (an "armoring layer") of rock with a 6-inch-minimum diameter would be placed along the sloped, northern portion of the soil cover to reduce exposure to erosive forces on the sides of the cap that may be exposed to seasonal flooding. The spring melt that floods the Dry Creek valley is constrained by an undersized culvert on the downstream portion of Dry Creek which causes ponding in the low area below the FNGH site. As a result, GeoEngineers' studies indicate that erosional effects of the soil cover (that is adequately designed and armored) will have little effects from the low energy backwater environment that develops in the topographic low area below the FNGH from spring flooding. Additional details regarding the hydrological flow mechanics are described in GeoEngineers' hydrology study (GeoEngineers 2015). It is also anticipated that the man-made pond would be filled to achieve a 1V:5H (vertical to horizontal) rise to run ratio. Additional elements of this cap and armoring design will be developed as part of an Engineering Design Report/Cleanup Action Plan. The engineering design would use additional data from a site bathymetric survey to conduct a hydraulic analysis to accurately determine potential shear stress on the soil cover, along with likely maximum flood heights and water flow velocities to ensure a stable cover. This remedy would include removing the failing existing fence and replacing it with a new fence that matches the limits of the covered area. This option keeps all contaminated soil (metals and TPH) in place. This remedy does not directly inhibit water infiltration at the site. This remedy also includes groundwater, surface water and Dry Creek sediment monitoring.

GeoEngineers obtained and reviewed historic aerial photos from the 1940s, 1950s and 1960s. The historic photos show that the pond present on the site is man-made and not a natural feature, as previously believed. Understanding that the pond is man-made is important for providing re-grading flexibility. For example, because of the undulating and steep site grades it will be difficult to complete any remedy (re-grade, excavate or cover) at this site without impacting or filling the manmade pond. Historic documentation indicates that the pond was created sometime between 1951 and 1962. The aerial photo shown in Figure 1 is from 1951 and the pond is clearly absent in the photo and the area below the bluff is largely undisturbed with the exception of the road leading from the bluff. In 1962, the pond appears in the aerial photo (Figure 2), and more site disturbance is present, including the apparent creation of a channel to the pond and water intake structures. By 1977, as Figure 3 shows, the FNGH structure is present and the pond is clearly visible and very similar in size and shape to its present configuration. It appears that the man-made pond may have been excavated so that soil could be used to create the pad where the FNGH facilities were constructed or as a water supply feature for activities at either the FNGH or 6th Avenue Property. For completeness of comparison, Figure 4 presents an aerial photograph taken in 2010, and also shows the property boundary of the land owned by NOVAGOLD. Figure 5 shows the approximate footprint of the cover area to address the arsenic and mercury contamination, including proposed monitoring points for surface water and existing groundwater monitoring wells. The cover design details, such as dimensions and a grading plan will be a component of the Cleanup Action Plan prepared for the site.

Based on the knowledge that the pond is man-made, and the complexity of the existing site grades relative to existing contamination, options 6 and 7 assume that the engineered fill will extend into the pond area. As a result the pond area will be returned to its natural (pre-1962) state of a broad, lowland floodplain adjacent to Dry Creek. GeoEngineers' hydrologic/hydrographic study (GeoEngineers 2015) concluded that the additional surface area of the soil cover would not appreciably change the channel dynamics of Dry Creek, or increase the potential for flooding of the expanded surface area the cap would presumably cover. Additionally, if Alaska DOT or Nome Public Facilities resizes and realigns the culvert underneath Bering Street, it would significantly reduce the existing flooding hazard potential associated with the FNGH site.

This remedy was proposed as a remedy for the FNGH site twice previously (in 1990 and again in 1999) and was rejected by ADEC both times as an inadequate response to the mercury contamination. The initial rejection of the cap option was because the option did not present the same conditions for long-term protection offered by the nearby Steadman Field cap remedy. ADEC at the time stated "we are not opposed to the concept of capping at the New Gold House Site, but…we will require conditions for the New Gold House that are equivalent to those for Steadman Field." The specific conditions alluded to in the ADEC letter included deeding the property to the City of Nome and recording protective covenants limiting future development at that site. As discussed in Section 3.2.2 above, all potential cleanup techniques that would leave the contamination in place include the preparation of environmental covenants that would restrict future use of the site and preclude any activities that would disturb the engineered fill cover, and include monitoring to measure effectiveness.

In 1999, ADEC responded to the re-submittal of the capping remedial option by stating that "it is unlikely a cap will be approved, given the site's close proximity to water." However, since 1999, four significant investigations of mercury and arsenic contamination occurred at the FNGH site to define the extent of contaminant migration. These investigations cumulatively provided evidence that mercury does not readily leach to groundwater at this site and very little arsenic contaminant migration has occurred, even with the proximity of the site to surface water (Dry Creek). Gold ore processing activities ceased at the FNGH site before 1990, and the source of the mercury contamination was removed in 2004. All four of the site investigations were completed subsequent to 2005. The results of these studies support the engineered fill cover option as an appropriate remedy for arsenic and mercury to protect Dry Creek.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Based on this evaluation, the most effective means for addressing mercury and arsenic-contaminated soil at the FNGH site is to cover it beneath an engineered sand/gravel soil cover with institutional controls providing environmental covenants limiting future land use and continued groundwater, surface water, and Dry Creek sediment monitoring (Option 6). The purpose of this remedial approach is to physically separate mercury and arsenic-contaminated soil from human and ecological direct contact exposure and reduce erosion of exposed contaminated soil.

Although ADEC was unsure about a capping or covered fill remedy for the FNGH site in the 1990s, actions taken since then provide confidence that an engineered fill cover solution is an appropriate remedy today. This conclusion is based on the following:

- Interim actions were completed at the FNGH site (removal of the source facilities and installation of fencing) in 2004.
- Four site characterization studies that have been completed since 2005, coupled with three consecutive annual monitoring events provide strong evidence that the mercury and arsenic contaminated soil does not represent a threat to groundwater or surface water at this site (through leaching). The primary mechanism for potential mercury and arsenic mobility from the FNGH site is through physical movement of contaminated soil, therefore a soil fill cover prevents this physical action of plume expansion or exposure (though erosion or human activity).
- Further understanding of the TPH plume that emanates from an upgradient source on the 6th Avenue Property site, based on three monitoring events conducted over a two year period (2012 through2014), indicates that this plume is generally stable. The preferred remedy for the FNGH mercury and arsenic contaminated soil (engineered fill cover) would not disrupt the equilibrium of this plume, nor would it conflict with future actions or monitoring that may be necessary for this plume. An engineered fill cover will address and limit long-term erosion potential, and will provide a stable environment to provide greater long-term protection against potential contaminant migration, principally through human activity.

The preferred remedy (Engineered Fill and Riprap Cover [Option 6]) entails import of over 5,000 cubic yards of clean locally sourced sand and gravel backfill that in part will be placed within the manmade pond to restore it to its natural (pre-1962) undisturbed condition. This also allows the backfill to be graded back toward the FNGH site and the lower part of the bluff in order to cover the contaminated soil area in a more natural configuration. The extent of the area to be covered in this remedy is approximately one acre (Figure 5). The volume and area values are estimates only and will be refined and included in a Cleanup Action Plan to be prepared in the future.

The footprint of the proposed cover may lie within an area classified as uplands, but will require consultation with the Alaska District of the USACE, as well as ADEC and the City of Nome prior to covering areas that could be considered as wetlands and subject to permitting requirements under Section 404 of the Clean Water Act. However, there is visual and historic aerial photo evidence to support the fact that the area proposed for covering was extensively disturbed for historic ore processing activities at the site and, as stated previously, this remedy would restore site conditions to the more natural pre-1962 conditions. Remediation installation activities would need to take place in the late summer or early autumn prior to winter weather affecting remedial operations.

In order to address the effectiveness of this remedy and to monitor existing TPH contamination, NOVAGOLD proposes to also continue a groundwater and surface water monitoring program consisting of the three groundwater monitoring wells installed on the FNGH (NOVAGOLD) property along with two surface water locations, one in Dry Creek, and one at the western drainage boundary of the property and Dry Creek sediment sampling at four locations. Data collected from the wells and Dry Creek will be used for trend analysis to evaluate the effectiveness of the cleanup action. NOVAGOLD would consider conducting additional monitoring at the remaining 7 wells that are not on NOVAGOLD property. This will, however, require the continued cooperation of BSNC and the City of Nome, as these wells are part of their property and outside of NOVAGOLD's control.

5.0 LIMITATIONS

GeoEngineers, Inc. prepared this report for the exclusive use of NOVAGOLD Resources, Inc. and their authorized agents for the FNGH project in Nome, Alaska. Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted environmental science practices in this area at the time this report was prepared. The conclusions and opinions presented in this report are based on our professional knowledge, judgment and experience. No warranty or other conditions, express or implied, should be understood.

Any electronic form, facsimile or hard copy of the original document (email, text, table and/or figure), if provided, and any attachments should be considered a copy of the original document. The original document is stored by GeoEngineers, Inc. and will serve as the official document of record.

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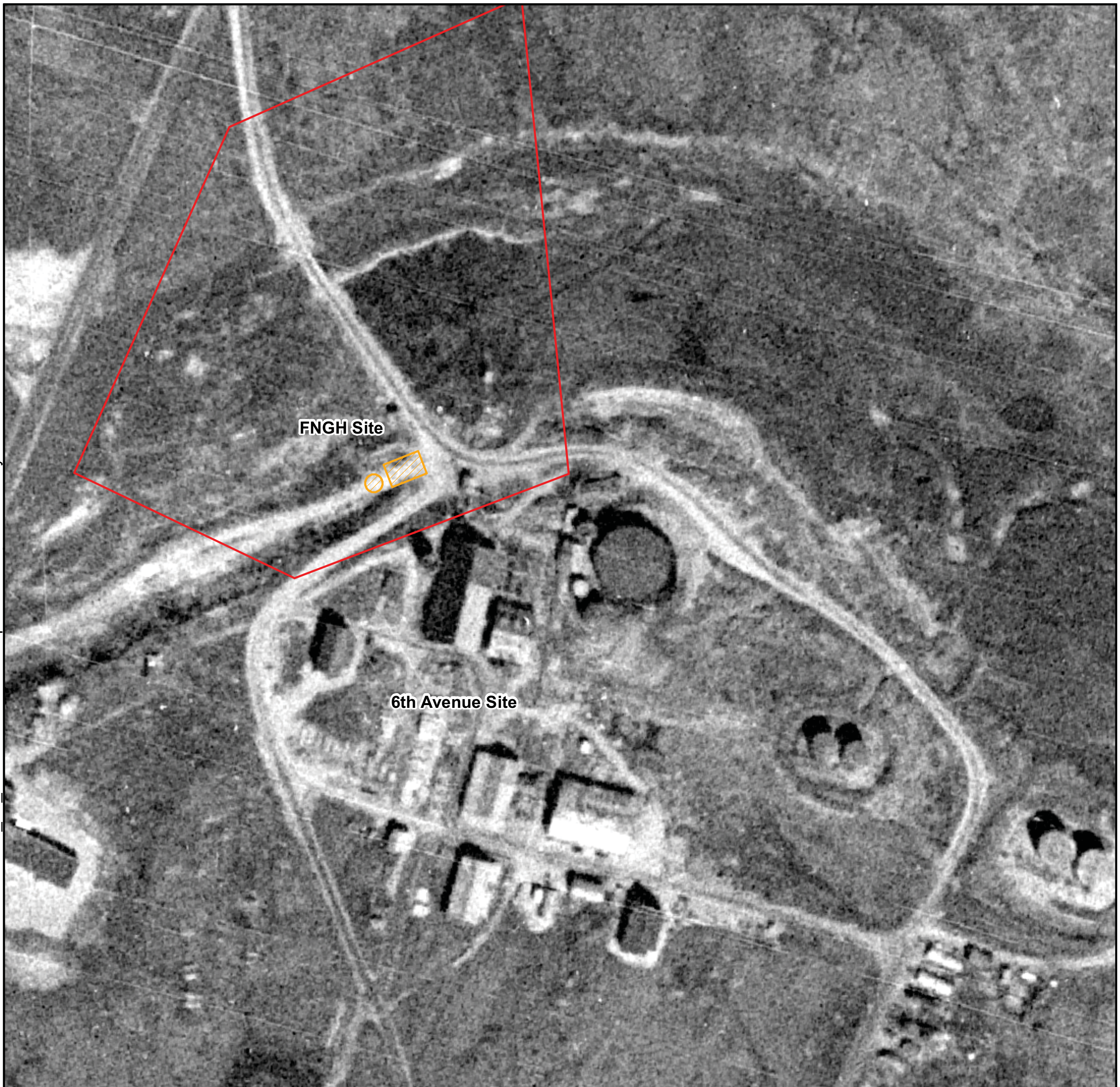
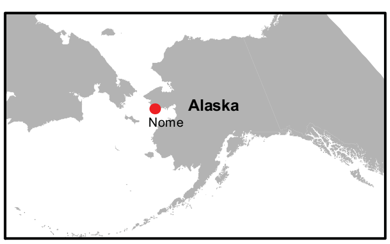
FIGURES





Approximate location of Former New Gold House and Settling Tank (removed in 2004/05)

Extent of Property Owned by NOVAGOLD Resources, Inc.

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Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
3. It is unlawful to copy or reproduce all or any part thereof, whether for personal use or resale, without permission.
4. Property Boundary limits of '15 Below Dry Creek USMS 1122' provided by NOVAGOLD Resources, Inc., November, 2012.

Aerial from AeroMetric (1951)

Transverse Mercator, Zone 3 N North, North American Datum 1983
North arrow oriented to grid north

Nome, Alaska
Aerial Photo, FNGH Site and 6th Avenue, June 1951

Former New Gold House and 6th Avenue Sites
Nome, Alaska

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Figure 1

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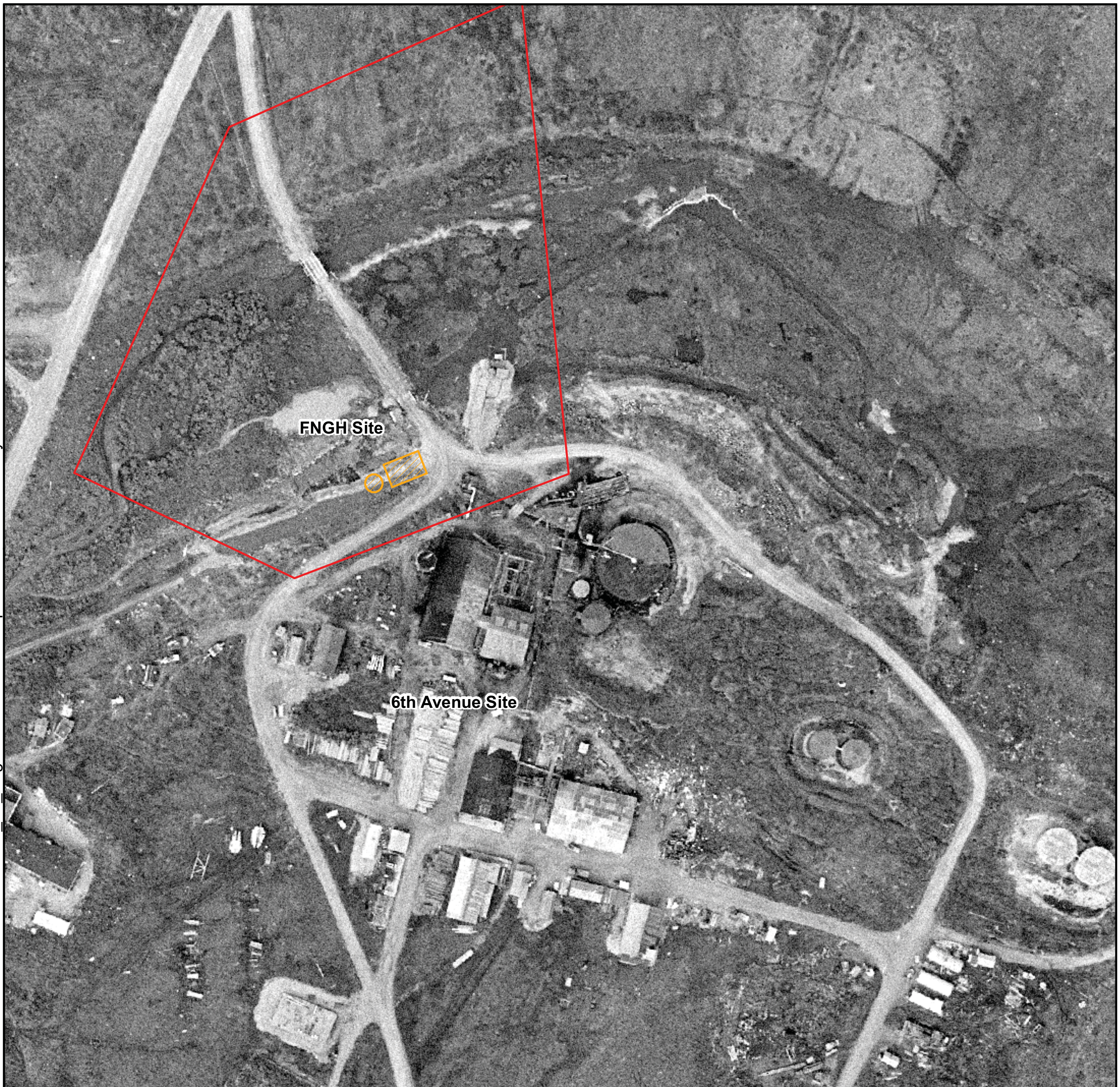
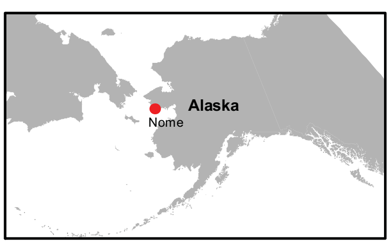
Office: Sacramento





Approximate location of Former New Gold House and Settling Tank (removed in 2004/05)

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Aerial from AeroMetric (1962)

Transverse Mercator, Zone 3 N North, North American Datum 1983
North arrow oriented to grid north

Nome, Alaska
Aerial Photo, FNGH Site and 6th Avenue, August 1962

Former New Gold House and 6th Avenue Sites
Nome, Alaska

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Figure 2

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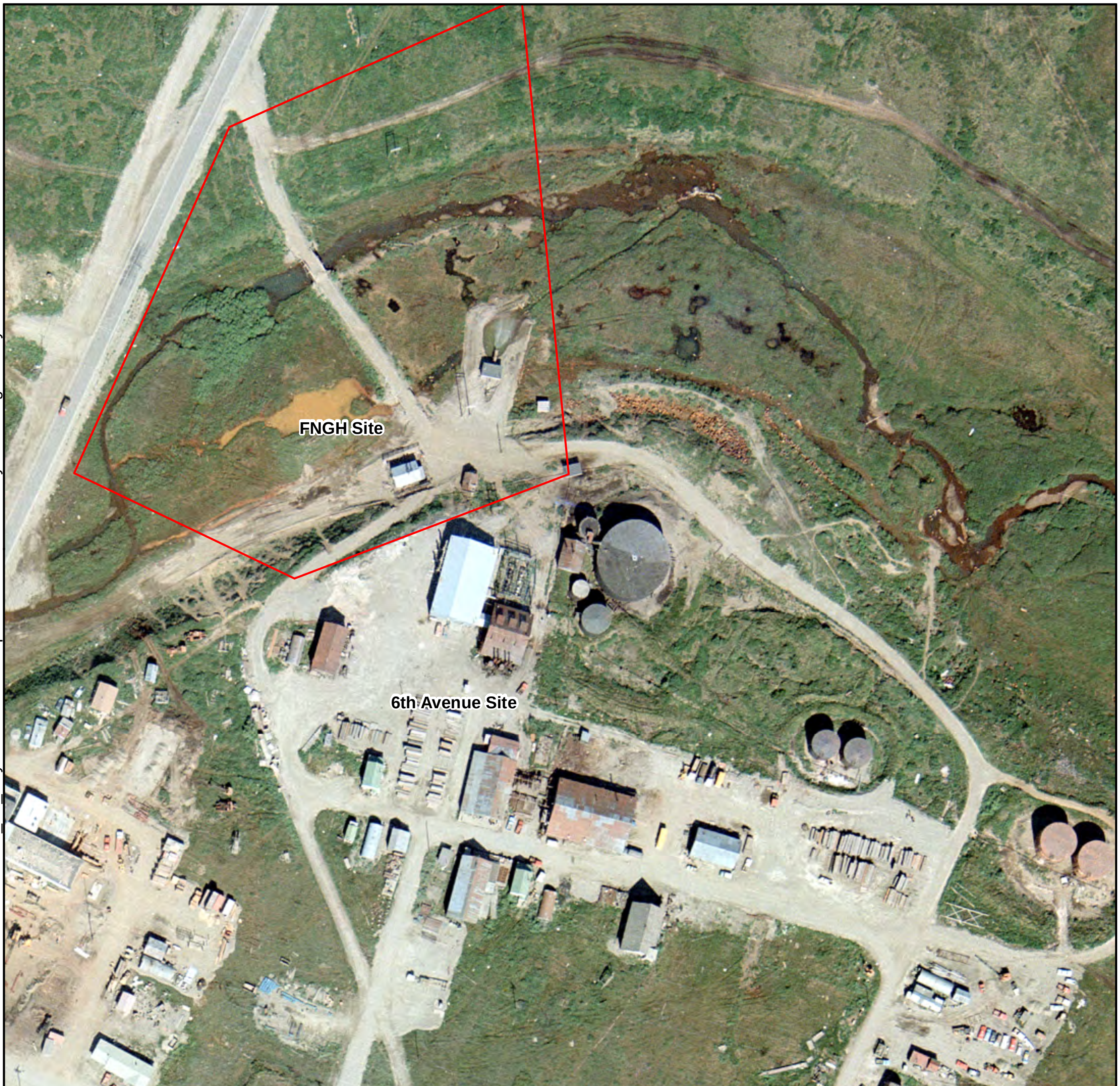
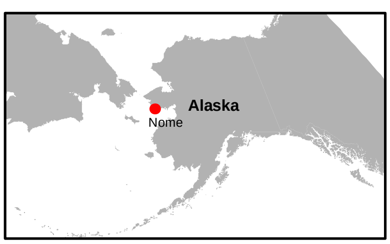
Office: Sacramento





Extent of Property Owned by NOVAGOLD Resources, Inc.

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4. Property Boundary limits of '15 Below Dry Creek USMS 1122' provided by NOVAGOLD Resources, Inc., November, 2012.

Aerial from AeroMetric (1977)

Transverse Mercator, Zone 3 N North, North American Datum 1983
North arrow oriented to grid north

Nome, Alaska
Aerial Photo, FNGH Site and 6th Avenue, July 1977

Former New Gold House and 6th Avenue Sites
Nome, Alaska

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Figure 3

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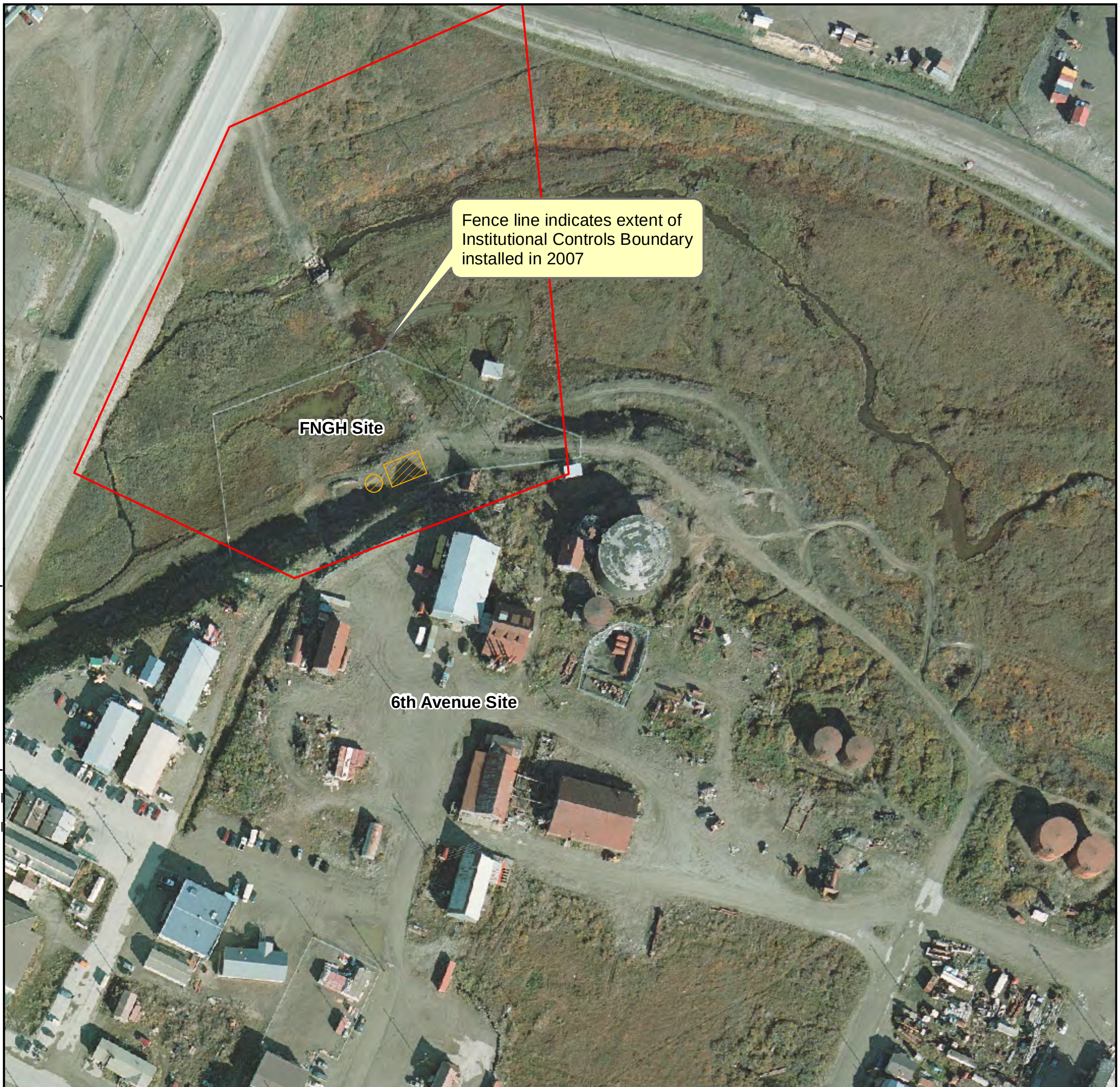

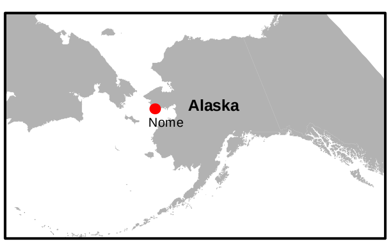

Approximate location of Former New Gold House and Settling Tank (removed in 2004/05)

Extent of Property Owned by NOVAGOLD Resources, Inc.

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Notes:
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Aerial from AeroMetric (2010)

Transverse Mercator, Zone 3 N North, North American Datum 1983
North arrow oriented to grid north

Nome, Alaska
Aerial Photo, FNGH site and 6th Ave, September 2010

Former New Gold House and 6th Avenue Sites
Nome, Alaska

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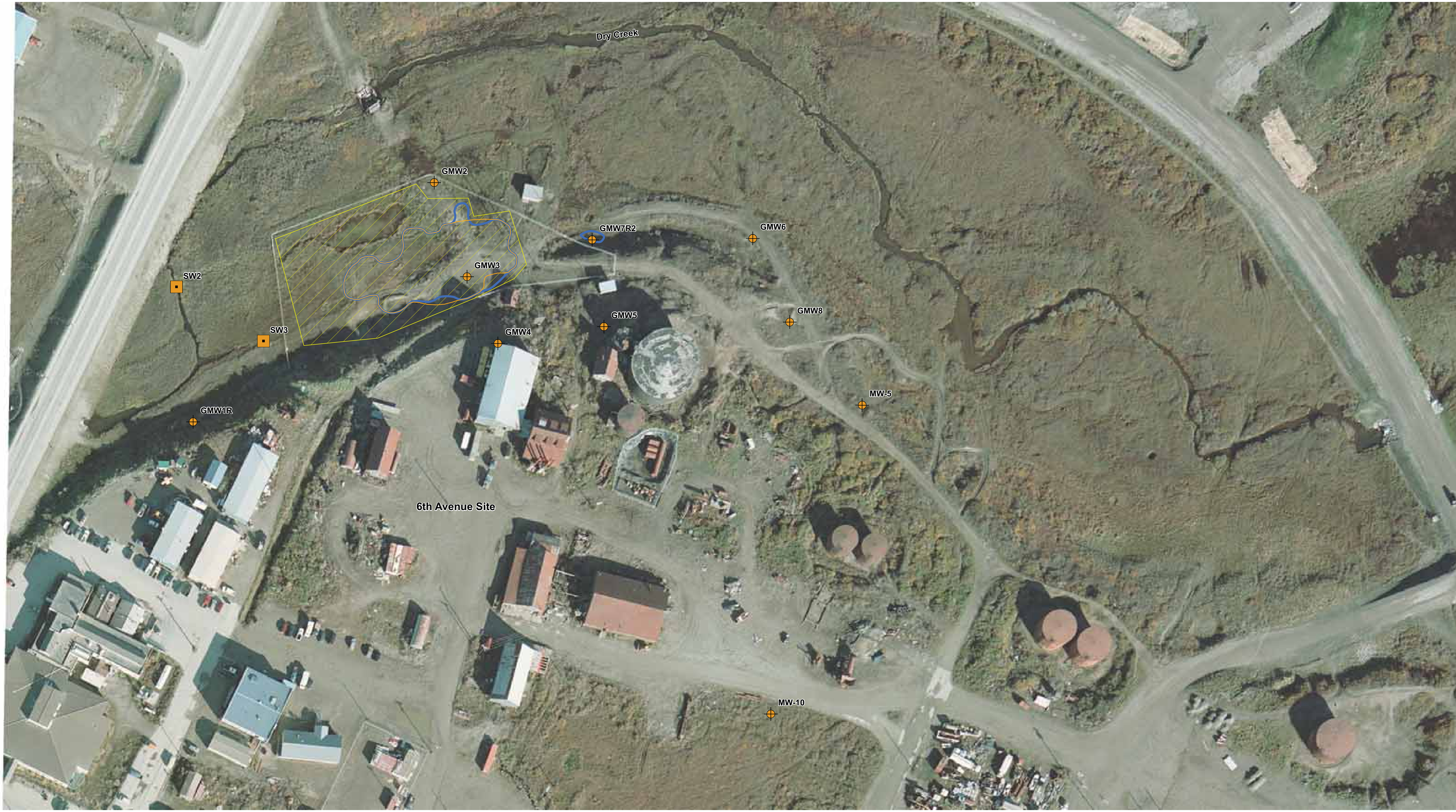
Figure 4

Office: Sacramento Path: W:\Sacramento\Projects\19\1972600100_F4_September2010.mxd Map Revised: 26 February 2013 ccabrera



Proposed Surface water monitoring points

Groundwater Monitoring Well Locations

Proposed Extent of Capped Area

Maximum areal extent of mercury contamination

Maximum areal extent of arsenic contamination

*The extent of mercury and arsenic contamination shown in this figure is from Figures 5 and 8 of the Final Supplemental Site Characterization Summary Report, FNGH, Nome Alaska, July 2012, GeoEngineers.

Reference: Aerial from AeroMetric (2010).

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
3. Property Boundary limits from map titled 'No. 15 Below Dry Creek Claim – USMS 1122' and provided by NovaGold Resources Inc., November, 2012.

N W E S

60 0 60 120 180
Feet

Proposed Cover and Monitoring Station Locations

Former New Gold House and 6th Avenue Sites
Nome, Alaska

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Figure 5

Path: W:\Sacramento\Projects\19\1972600\GIS\1972600100_ProposedCap_MonitoringStations_F5.mxd Map Revised: 05 March 2013 ccabrera

APPENDICES

APPENDIX A
Remedial Alternatives Evaluation

Appendix A

Remedial Alternatives Evaluation - Mercury and Arsenic Soil Contamination

Cleanup Options Comparison Summary

Former New Gold House
Nome, Alaska

Note: Numerical rankings are for the purpose of relative comparisons only.

Cleanup Technique Option	Description	Protectiveness	Practicality	Effectiveness/Permanence	Regulatory Compliance	Public Perception/Input	Relative Estimated Cost (contractor estimates advised)
No Action	No institutional controls or treatment.	Not effective for protecting human health and environment. **Score = 1**	Does not address remaining contamination on the site. **Score = 1**	Not effective, nor permanent for addressing remaining contamination present at the site. **Score = 1**	Would not comply with the 1987 Compliance Order by Consent. **Score = 1**	Implementable but likely not acceptable to the general public. **Score = 1**	None **Cost = $0** **Score = 8**
Institutional Controls/Engineering Controls	Implement deed notification to inform future owners of the presence of potentially hazardous substances at the site and /or implement deed restriction to restrict certain specific future site activities. Continued maintenance of existing fencing and existing groundwater monitoring wells. Routine groundwater surface water and sediment (in Dry Creek) monitoring.	Effectiveness for protection of human health would depend on enforcement of and compliance with deed restrictions and maintenance of fence. **Score = 2**	Readily implementable, as fence is already in place, and restrictive covenants can be developed. Groundwater monitoring wells already installed. **Score = 3**	Does nothing to permanently reduce the mobility (by physical/erosional soil transport), mass, or toxicity of the contamination present. Only effective if controls are in place and enforced. Can be reversed readily. **Score = 2**	Offers only limited compliance with Order, as remaining contamination is not addressed, although protectiveness is increased. **Score = 2**	Implementable but may not be acceptable to the general public. **Score = 3**	Low capital cost, low long-term cost. **Total Cost (10 years) = $510K** **Score = 7**
Solidification/Stabilization of soil using sulfur polymer cement	Treat soil with sodium sulfide to form cinnabar in situ; encase contaminated soils in stabilized mass of sulfur polymer cement mixed and applied on-site. New fence required; groundwater monitoring continues. Routine groundwater surface water and sediment (in Dry Creek) monitoring.	Effective for containing contaminant mass and effectively immobilizing potential for transport. Eliminates migration pathways to both human and ecological receptors and groundwater. Some residual mass could remain allowing for possible exposure to receptors. **Score = 3**	Requires considerable coordination and logistical support to implement on site, including transport of specialized equipment to a remote site. Has never been performed in Alaska before, so may require additional permitting and review before being accepted. **Score = 2**	Provides excellent reduction in contaminant mobility and toxicity, but contamination would remain on site. Some monitoring/maintenance would be necessary, if only to reduce potential for vandalism. Disturbance of soil could mobilize petroleum hydrocarbon contamination upgradient of the site. **Score = 3**	Acceptance of a technology not widely applied in Alaska could be problematic. May require extensive monitoring to verify remedy success and satisfy permitting requirements. **Score = 3**	Due to very technical aspects of this remedy, may be the hardest approach to successfully convince the public of its feasibility. **Score = 2**	Very High capital cost, low to moderate long-term cost. **Total Cost (10 years) = $4,350K** **Score = 1**
Excavation and off-site disposal of contaminated soil	Remove and dispose of contaminated soil off-site using typical excavation methods for soil removal.; place clean fill and compact/re-grade to reduce exposure to hydrocarbon contamination. No fence installation necessary; continue groundwater monitoring. Routine groundwater surface water and sediment (in Dry Creek) monitoring.	Eliminates pathways by removing contamination from site. Most protective scenario for arsenic and mercury. However, could mobilize upgradient hydrocarbon contamination, which could then threaten Dry Creek. **Score = 4**	Straight-forward to implement on-site, but logistical concerns with transport of material on barges for disposal in Washington or Oregon. Will require considerable advance coordination and acquisition of enough transport vehicles to keep production rates moving sufficiently quickly during excavation activities. Local climate means a narrow window for implementation and off-site out of state disposal. Working in very wet conditions would add to complexity and likely would create increased potential for hydrocarbon mobility. **Score = 4**	Eliminates arsenic/mercury contaminant mobility and mass by removing it entirely from the site. But, could also mobilize upgradient petroleum hydrocarbon contamination. Most permanent remedy for metals, would still require monitoring for hydrocarbons. **Score = 4**	Would successfully address regulatory requirements for source removal, but may have additional permitting requirements due to proximity to Dry Creek, as well as excavation and equipment use in the Dry Creek floodplain. No long term monitoring for arsenic and mercury required. However, possible petroleum contamination mobilization could make this remedy non-compliant. **Score = 4**	The permanence and potential to turn the property over for re-use without restriction could be appealing to the public. Transportation of contaminated fill through town and unknowns related to mobilization of hydrocarbons toward Dry Creek could be negatives. Additionally the public could be concerned with disruption and/or destruction of existing Dry Creek floodplain area. **Score = 7**	Very High capital cost, very low long-term cost. **Total Cost = $3,540K** **Score = 2**
Combined limited hot spot excavation/disposal and covering remaining soil	Excavate and dispose of soils at of-site landfill; fill excavated areas with clean fill; compact/grade and install engineered fill cover with geotextile fabric. No fence installation. Routine groundwater surface water and sediment (in Dry Creek) monitoring.	Reduces presence of contaminant mass and provides protection by reducing or eliminating migration pathways to receptors and groundwater. Excavation activities could possibly mobilize upgradient hydrocarbon contamination towards Dry Creek. **Score = 5**	Straight-forward to implement, but some logistical challenges with identification of extent of hot spots to remove and obtaining analytical confirmation could cause stand-by issues. Same transport and disposal issues as Option 4 above, only smaller in magnitude. Working in very wet conditions would add to complexity and could create increased hydrocarbon mobility. **Score = 5**	Offers some mass removal combined with reducing metals contamination, but could mobilize petroleum hydrocarbons. Has a considerable monitoring and maintenance component like the other soil cover options. **Score = 5**	Would address some regulatory requirements, as it includes mass removal from the site, but would require considerable verification soil sampling and testing. Does not address regulatory compliance with possible petroleum hydrocarbon contamination mobility increasing as a result of excavation activity. **Score = 5**	Excavation and engineered fill soil covers are an easily understood remedy but the combination of the two elements could be difficult to convey the benefits and disadvantages to the public. This option is less permanent than full excavation and there likely would not be the benefit of turning the property over for re-use without restriction. Transportation of contaminated fill through town and unknowns related to mobilization of hydrocarbons toward Dry Creek could be negatives. Additionally the public could be concerned with disruption and/or destruction of existing Dry Creek floodplain area. **Score = 7**	High capital cost, moderate long-term cost. **Total Cost (10 years) = $1,780K** **Score = 3**
Covering soil with engineered fill	Grade and cover site with clean backfill; cover site with locally sourced native sand and gravel fill material. Install new fence. Routine groundwater surface water and sediment (in Dry Creek) monitoring.	Effective for eliminating migration pathway from soil to human/eco receptors. Leaching not a concern at the site. Will not mobilize hydrocarbon contamination that is upgradient. **Score = 8**	Comparatively easy to implement, some logistical challenges with sourcing clean fill and riprap. **Score = 8**	Eliminates physical mobility of contaminated soil. Does not remove mass or toxicity of the contamination. Remedy requires long term monitoring and maintenance under a range of environmental conditions, but needs less monitoring/maintenance than a synthetic cover. Remedy does not disturb subgrade soil. **Score = 8**	Does not disturb subgrade soils, thus eliminating contamination mobility, but does require some long term cover monitoring and deed restriction to be put in place. **Score = 8**	Easy to understand remedy for the public, but limitations on access and possible use/re-use could be a negative. **Score = 5**	Moderate capital cost, moderate long-term cost. **Total Cost (10 years) = $1,175K** **Score = 6**
Soil cover with impermeable geotextile layer	Grade and cover site with clean backfill and impermeable geotextile fabric; cover site with fill and compact/grade. Install new fence. Routine groundwater surface water and sediment (in Dry Creek) monitoring.	Effective for eliminating migration pathway from soil to human/eco receptors and for migration to groundwater, but leaching potential is extremely unlikely whether there is a liner or not. Makes cover more complex to maintain. **Score = 7**	Also relatively easy to implement, some additional specialized equipment required for compacting, grading and preparing site for geotextile line placement on graded clean fill. Would need some specialized labor to install liner correctly. **Score = 7**	Provides essentially the reduction of contaminant mobility and direct contact, but does not reduce mass or toxicity. Requires even greater monitoring and maintenance program to ensure integrity of the synthetic liner; which could be problematic in harsh arctic (freeze-thaw) conditions. **Score = 7**	Similar remedy as soil cover, but additional monitoring requirements to verify liner integrity. **Score = 7**	Very similar to Soil Cover option, only with impermeable synthetic liner. Likely similar feedback from the public; easy to understand and appreciate the benefit, but would like to have more accessibility. **Score = 5**	High capital cost, moderate long-term cost. **Total Cost (10 years) = $1,325K** **Score = 5**
Contaminated soil consolidation on-site with impermeable geotextile geomembrane liner	Excavate contamination along edges of contaminant area or in isolated spots, and consolidate in central area where highest concentrations of contaminated soil are present. Cover with fill, regrade site, line with geotextile and impermeable cover layer. Install cutoff/retaining wall along northern side. New fence required. Routine groundwater surface water and sediment (in Dry Creek) monitoring.	Effective for eliminating migration pathway from soil to human/eco receptors and for migration to groundwater, but excavation/movement of soil could mobilize upgradient hydrocarbon contamination. Consolidation does reduce the site's surface area for potential exposure. **Score = 6**	Easy to implement; equipment available to excavate, transport and re-place soil on the site. Challenge will be associated with identifying hot spots and limits of soil extent that is being pulled in for the consolidation, in addition to those listed for the engineered fill options above. **Score = 6**	Consolidates mass and controls contamination on the site, reduces contaminant mobility and direct contact, but does not reduce mass or toxicity. Could mobilize upgradient petroleum contamination. Still requires monitoring and maintenance program to ensure integrity of the cover. **Score = 6**	This option gives greater flexibility in placement of contamination on site that will be covered, but would still require excavation permitting with follow-up confirmation soil sampling and testing, cover monitoring and reporting to verify remedy compliance/success. **Score = 6**	May seem too complicated and too hard to maintain. **Score = 6**	Moderate capital cost, moderate long-term cost. **Total Cost (10 years) = $1,380K** **Score = 4**

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