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Draft Final
Conceptual Site Model and Data Gaps Evaluation
Technical Memorandum
Technical Support Services
Rolling Knolls Superfund Site

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1. CONCEPTUAL SITE MODEL AND DATA GAPS EVALUATION

This section presents the information used to develop a conceptual site model (CSM) for the study area, which is used to develop an understanding of what is known about the Site, to assist with the identification of data gaps, and to support development of DQOs for the study.

1.1 Site History

1.1.1 Site Description and History

The Rolling Knolls Landfill Superfund Site (the Site) is located in Chatham Township, New Jersey at the south end of Britten Road in the Green Village community (Figure 1). The Site consists of an approximately 140 acre landfill with an approximately 30 acre area of additional surface debris (i.e., waste was not observed below ground) spread along its western edge (Figure 2). The official National Priorities List (NPL) Site boundaries were delineated based on the extent of observable waste material across the Landfill's footprint; however, previous studies (e.g., Geosyntec 2018a) have documented Site-related contaminants outside of the Landfill footprint (i.e., outside of the currently designated Site boundaries). The Site is bordered on the north by a ballfield and shooting range owned by the Green Village Fire Department. The central and western portions of the Landfill are owned by a Trust created by the last will and testament of Angelo J. Miele, who was the former landfill operator. The current Trustee is Paul J. Miele (Geosyntec 2018b). The Refuge (Figure 1), owned by the United States Government and managed by the FWS, covers 7,768 acres. The Refuge boarders the Site to the east, south, and southwest (Figure 2) and approximately 35 acres of the Site (as the Site is currently defined) lies within the Refuge (Figure 2). The Refuge-portions of the Site and the Refuge area east and south of the Site are designated as Wilderness Area.

The Landfill received municipal and industrial wastes from Chatham Township and surrounding communities from the 1930s to approximately 1968 (Geosyntec 2018b). Previous investigations revealed that much of the waste consists of municipal solid wastes along with smaller areas of industrial waste. Foster Wheeler (2000) reported that Township of Chatham Board of Health (TCBH) records indicated that the municipal wastes included household refuse, residential septage wastes, construction and demolition debris, landscaping wastes, scrap metal, and tires. Homeowners and private trash haulers also reportedly brought household wastes to the Landfill. Further documentation by Foster Wheeler (2000) indicates that municipalities were disposing of sewage on top of the Landfill, which was restricted to the Township of Chatham by the mid-1960s.

Between 1955 and 1975 the TCBH required mosquito and rodent control measures, including surface water drainage and applications of minimal daily cover, which consisted of “swamp muck” obtained from the edges of the Landfill (Foster Wheeler 2000). TCBH records from 1962 indicate that landfill management also required the application of herbicides for weed control, the application of oil on the Landfill roads for dust suppression, and that dead animals were also disposed of in the Landfill. Geosyntec (2018b) reports that the Refuge-portion of the Landfill was never properly covered after the Landfill was closed in 1968. Empirical reports (Geosyntec 2018a) indicate that much of the waste is still exposed at the surface and only a thin layer of soil covers other portions of the Landfill, which confirms that the entire landfill was never properly abandoned. Accessibility concerns raised after a 1974 wildfire at the Site prompted the Landfill owner (the Trust) to construct a series of raised fire roads. The fire roads were constructed between 1979 and 1982 and the Trust was issued a citation in 1979 for using unpermitted waste materials (reported as construction and demolition debris) in the road’s construction.

1.1.2 Previous Investigations

This section describes the previous environmental investigations that have been conducted at the Site. For details regarding the investigation activities and results, refer to the relevant, cited reports.

A CERCLA Site Inspection (SI) was initiated in 1985 by USEPA Region II in response to reports of uncharacterized process wastes at the Site. Under that investigation, one surface soil and four sediment samples were collected on the Landfill and on Refuge property where landfill material reportedly did not exist (Foster Wheeler 2000). The samples were analyzed for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), organochlorine pesticides (OCPs), and metals. USEPA conducted a follow up investigation in 1986, during which they sought to define the Landfill depth, nature of soil contamination, and evaluate potential dioxin soil contamination. Eight borings were advanced and environmental samples were collected from multiple depths and analyzed for VOCs, SVOCs, PCBs, OCPs, metals, and dioxin (NUS Corporation 1986).

The FWS conducted a fish tissue and sediment survey in 1988 (FWS 1991). The study evaluated metals and polycyclic aromatic hydrocarbons (PAHs) present in fish tissue, and metals, OCPs, and PAHs present in sediment. The sampling locations were reportedly biased around potential source areas and roadways.

In 1989, the FWS and U.S. Geological Survey conducted a joint investigation of Loantaka Brook and the perimeter of the Landfill (the location of the perimeter investigation has not been verified). Surface water, sediment, and groundwater samples were collected and analyzed for metals, VOCs, and SVOCs. Sediment samples were collected and analyzed for metals.

USEPA conducted a current conditions investigation in 1999 (Foster Wheeler 2000). Seven soil borings were advanced and two monitoring wells were installed. Additionally, 21 surface water, 10 groundwater, 21 sediment, and 15 soil samples were collected and analyzed for VOCs, SVOCs, PCBs, OCPs, and metals. A follow up sampling event was conducted in 2000 to collect additional data.

The FWS conducted a 10-year follow-up investigation in 1999 relative to its 1988 investigation (FWS 2005). The objectives of this investigation were to:

- Quantify the concentrations of metals, OCPs, and PAHs in Refuge sediment, and metals and OCP concentrations in fish tissue;
- Compare those data to the data from 1988; and,
- Identify the potential change in sediment and fish tissue concentrations between the two sampling events.

All of the samples were collected within the Refuge boundaries because FWS was not granted access by surrounding property owners. Samples were also not collected within the Refuge portion of the Site.

During two field events in 2003, the USEPA Region II Site Assessment Team (SAT) conducted phased investigations at the Site:

- Phase I involved the collection of soil and sediment samples, which were screened for PCBs;
- Phase II involved the collection of soil and sediment samples for laboratory confirmation of the Phase I screening results; and
- Additional sediment and soil samples were collected from locations where drums or other visual indications of possible source material were observed.

The additional samples were analyzed for Target Compound List and Target Analyte List (TAL) (excluding cyanide) constituents. Additional sample volumes were collected at the sediment sampling locations and analyzed for total organic carbon (TOC) and particle size (Weston Solutions Inc. 2003a, 2003b and 2003c). Subsequently, the SAT issued a Hazard Ranking System package in April 2003 and on September 29 of the same year, the Site was listed on the NPL - Site ID NJD980505192.

Subsequent to a potentially responsible party (PRP) search, a number of PRPs were identified as contributors to the hazardous substances found in the Landfill. The USEPA signed an Administrative Settlement Agreement and Order on Consent (Agreement; CERCLA-02-2005-2034) with Chevron Environmental Management Company, Alcatel Lucent USA Inc., and Novartis Pharmaceuticals Corporation (collectively, the Group) on September 30, 2005. Subsequent to the Agreement, the Group conducted investigations under USEPA oversight.

A Phase I Remedial Investigation (RI) was initiated by the Group in 2005 with a second phase conducted in 2014 and 2015. The objectives of Phase I RI included:

- Characterizing the Site’s geology and hydrogeology;
- Characterizing landfill waste;
- Defining chemicals of potential concern (COPCs) and environmental media; and,
- Providing data to support risk assessments and remedy selection.

The results of the Phase I RI were reported in the Site Characterization Summary Report (Arcadis 2012) and the results were used to generate a Baseline Human Health Risk Assessment (BHHRA; CDM 2014) for the Site. A number of data gaps were identified after the Phase I RI was completed and a data gaps investigation was conducted between November 2014 and January 2015 to further define the nature and extent of contamination at the Site, and to provide additional data to support a Baseline Ecological Risk Assessment (BERA) and remedial alternative evaluations for the Feasibility Study (FS). The data gaps analysis investigation results were reported in the Data Gaps Technical Memorandum (Geosyntec 2016). The data gaps investigation also involved the collection of data used to evaluate the efficacy of monitored natural attenuation (MNA) at the Site, which was reported in the Supplemental Groundwater and Baseline Monitored Natural Attenuation Investigation Report (Geosyntec 2017).

The 2016 Baseline Ecological Risk Assessment (BERA) was prepared by Integral Consulting Inc. (Integral) for the RP group, The Rolling Knolls Group. The BERA is over 1800 pages long and includes eight appendices that are reports unto themselves, including Derivation of Toxicity Reference Values (TRVs), Ecological Habitat Assessment, Derivation of Biota Transfer Factors, and risk calculations, among others. The BERA also relied upon and referred back to many other reports including the Screening-Level Ecological Risk Assessment (SLERA) (ARCADIS, 2012), Ecological Habitat Survey, Sampling and Analysis of Site-Specific Background Soil (Arcadis, 2008), and the Work Plan for the Baseline Ecological Risk Assessment (Integral, 2016).

The BERA relied on the analytical results for soil, sediment, and surface water collected over the period from 2007 through 2015 as part of the RI, and sampling conducted in May/June 2016 specifically to support the BERA. The BERA sampling included collection of earthworms and/or other soil invertebrates and co-located surface soil (0-6 inches) samples, small mammals, forage fish or tadpoles, aquatic vegetation, sediment toxicity testing, sediment for acid volatile sulfide and simultaneously extracted metals (AVS/SEM) analysis, and surface sediment (0-6 inches) and surface water from onsite and reference locations.
Forty acres of Refuge property were included as a BERA exposure unit. BERA sampling on the Refuge was limited to:

- Three earthworm/soil invertebrate samples,
- Five surface soil samples (three co-located with the invertebrate samples),
- Four small mammal samples,
- Four surface water samples from Black Brook,
- Six sediment samples (one from Loantaka Brook at the Refuge boundary and five from Black Brook), two of the samples from Black Brook were included for toxicity testing and four from Black Brook were analyzed for AVS/SEM for bioavailability assessment.

The very sparse sampling coverage on the Refuge illustrates gaps in data for biota, surface soil, and sediment. Furthermore, no aquatic vegetation, forage fish or tadpole samples, and only a few incomplete invertebrate samples (two millipede samples and a partial earthworm sample) were collected from locations within the Refuge, which are data gaps.

The BERA data were used to support exposure, toxicity, and bioavailability (AVS/SEM) assessments including food chain modeling to estimate exposure by wildlife receptors. Additionally, literature uptake factors (sediment or soil to biota) were used to estimate contaminant concentrations in aquatic invertebrates, emergent insects, and terrestrial vegetation for the wildlife exposure models.

Risks were evaluated on a Site-wide basis, by basic habitat types (i.e., terrestrial, wetland or aquatic), and by sub-habitat areas: Loantaka and Black Brooks (including some locations on the Refuge/at the Refuge boundary), landfill perimeter (including locations on the Refuge), terrestrial within and outside GSNWR (includes 40 acres within the Refuge), wetlands (North Ponds area, west, east, and south wetlands; onsite ponds (West Pond #1, North Ponds), and reference areas. Background threshold values (BTVs) were calculated for comparisons to background for metals, Aroclor-1254, and total PCBs as either the maximum (limited sample sizes) or 95% upper tolerance limits (UTLs) using the sediment and soil data collected from reference areas and for metals only using sediment data from the USGS National Uranium Resource Evaluation (NURE) database for New Jersey Streams.

Thirteen assessment endpoints were evaluated. The measurement endpoints and BERA results and data gaps that are important for the Refuge are summarized for each endpoint:

- Terrestrial vegetation. Measurement endpoints included abundance and structure of terrestrial and wetland plant communities and observations of plant health from the ecological habitat survey, and comparison of contaminant concentrations in soils to plant screening benchmarks. Some plant benchmarks were exceeded, but there were no observations of adverse effects on plant heath. Elevated lead (maximum >6000 mg/kg) was measured in Refuge soils. The average lead concentration from samples collected on the Refuge was highly elevated (1600 mg/kg) and exceeds the EPA Ecological Soil Screening Level (EcoSSL) for plants (120 mg/kg). Lead is known to inhibit seed germination, growth, transpiration, and chlorophyll production in plants. This indicates some potential for risk to plants from exposure to lead in Refuge soils.

- Benthic invertebrates. Measurement endpoints included surface water concentration comparisons to NJDEP acute and chronic surface water quality benchmarks/criteria, and sediment concentration comparisons to NJDEP sediment benchmarks. Also, sediment AVS/SEM and total organic carbon (TOC) analyses were used to evaluate bioavailability, benthic acute sediment toxicity testing was conducted, and correlations between toxicity and contaminant concentrations were evaluated. Only six sediment samples were collected from within the GSNWR, including two for toxicity testing. Dissolved barium concentrations from Black Brook surface water samples collected at the landfill perimeter (SWA006 and SWA007, on the Refuge) exceeded acute and chronic water quality criteria. Sediment samples collected at these same Refuge locations (SED006 and SED007) exceeded sediment benchmarks for DDT and metabolites, total PCBs, and eight metals. The AVS/SEM analysis for one of the sediment samples from this location (SED007) also indicated some potential for toxicity from metals, most likely due to lead and zinc. This suggests some potential for risk to aquatic organisms on the Refuge, though no toxicity was observed for Refuge samples in the acute sediment toxicity tests. Loantaka and Black Brooks within GSNWR are designated as Outstanding Resource Waters of the State and, as such, are protected under NJDEP antidegradation polices.

- Amphibians. Measurement endpoints included surface water and sediment concentrations compared to toxicity benchmarks, tadpole tissue concentrations compared to tissue benchmarks, sediment concentrations compared to the polychlorinated biphenyl (PCB) effects literature, and qualitative observations of amphibian abundance. No amphibians were observed in the segment of Black Brook that is at the Refuge boundary (though they were abundant at upstream locations) and no amphibians were sampled from locations that are on the Refuge, which is a data gap. Amphibians are known to be sensitive receptors and a state endangered species, the blue spotted salamander, occurs at the Site. Dissolved barium concentrations from Black Brook surface water samples collected on the Refuge at the landfill perimeter (SWA006 and SWA007) exceeded acute and chronic water quality criteria indicating some potential for risk to amphibians and other aquatic organisms from exposure to barium in surface water at the Refuge.

- Herbivorous birds. Mallard duck was the representative receptor. Contaminant concentrations were measured in sediment, surface water, and aquatic vegetation, though no vegetation samples were collected from within GSNWR, which is a data gap. Food chain exposure modeling results were compared to no-observed- and low-observed-adverse-effect-level (NOAEL/LOAEL) based TRVs derived from the literature. No contaminants had HQs greater than one indicating no risk to herbivorous birds.

- Piscivorous birds. Great blue heron was the representative receptor. Contaminant concentrations were measured in sediment, surface water, and forage fish, though no fish samples were collected from within GSNWR, which is a data gap. Food chain exposure modeling results were compared to NOAEL/LOAEL based TRVs. No contaminants had HQs greater than one indicating no risk to piscivorous birds.

- Herbivorous mammals. Meadow vole was used as the representative receptor. Contaminant concentrations were measured in surface soil/sediment and were estimated using uptake factors for terrestrial vegetation. Food chain exposure modeling results were compared to NOAEL/LOAEL based TRVs. LOAEL, HQs were greater than one for dioxin on a toxic equivalency basis (TEQ), methyl mercury, and selenium; the highest HQs were from estimated exposures within the Refuge indicating some potential for risk to herbivorous mammals.

- Vermivorous (worm-eating) mammals. Short-tailed shrew was the representative receptor. Contaminants were measured in sediment/soil and soil invertebrates and were estimated using uptake factors for terrestrial plants. Only three earthworm/soil invertebrate samples, five surface soil, and six sediment samples were collected from the 40-acre exposure unit within the Refuge. Food chain exposure modeling results were compared to NOAEL/LOAEL based TRVs. LOAEL HQs were greater than one for total PCBs, PCB TEQ, and ten metals; HQs were generally highest for terrestrial habitat within GSNWR indicating risks to vermivorous mammals, with some exceptions for individual contaminants.

- Vermivorous birds. American robin was the representative receptor. Food chain exposure modeling results were compared to NOAEL/LOAEL based TRVs. Only three earthworm/soil invertebrate samples, five surface soil, and six sediment samples were collected from the 40-acre exposure unit within the Refuge. LOAEL HQs were greater than one for dioxin TEQ, cyanide, and ten metals (including cadmium, lead, selenium, copper, and methyl mercury, which are known to bioaccumulate) for estimated exposures within GSNWR terrestrial habitats. HQs were generally highest for terrestrial habitat within GSNWR indicating risks to vermivorous birds, with some exceptions for individual contaminants.

- Carnivorous mammals. Red fox was the representative receptor. Contaminant concentrations were measured in soil/sediment and small mammals, and were estimated for terrestrial vegetation using uptake factors. Four small mammal samples were collected from the 40-acre exposure unit that is on the Refuge. Food chain exposure modeling results were compared to NOAEL/LOAEL based TRVs. There were no contaminants with LOAEL HQs greater than one for exposures within GSNWR.

- Insectivorous mammals. Little brown bat was the representative receptor. Contaminant concentrations were estimated in emergent insects using uptake factors. Food chain exposure modeling results were compared to NOAEL/LOAEL based TRVs. Potential habitat exists at the Site and Refuge for the federally endangered Indiana bat. LOAEL HQs were greater than five for estimated bat exposures to selenium in Black Brook, all wetland, and wetland south exposure units (which include Refuge property); however, there were some elevated HQs for reference site exposures as well. HQs were greater than one for arsenic, barium, copper, methyl mercury, selenium, Aroclor 1242, and PCB TEQ. Some of these include HQs>1 for exposure units that include Refuge property indicating some risk to insectivorous mammals. The total PCB concentrations in soil/sediment from samples collected on GSNWR also potentially represent a risk to terrestrial insectivorous wildlife. The average total PCB concentration from samples within the Refuge is 3.1 mg/kg and the maximum exceeds 12 mg/kg. The NJDEP Wildlife Preliminary Remediation Goal (PRG) for total PCBs is 0.371 mg/kg based on a shrew study.

- Insectivorous birds. Tree swallow was the representative receptor. Contaminant concentrations were estimated in emergent insects using uptake factors. Food chain exposure modeling results were compared to NOAEL/LOAEL based TRVs. LOAEL HQs were greater than two for tree swallow estimated exposure to selenium within the Black Brook exposure unit (includes Refuge property), though the reference site HQ also exceeded one (HQ=1.3) suggesting some uncertainty and a low likelihood of risks to insectivorous birds.

- Carnivorous birds. Red-tailed hawk was the representative receptor. Contaminant concentrations were measured in small mammals, though only four small mammal samples were collected on the Refuge. Food chain exposure modeling results were compared to NOAEL/LOAEL based TRVs. There were no contaminants with LOAEL HQs greater than one for exposures within GSNWR or sitewide, suggesting no risk to carnivorous birds.

- Piscivorous mammals. Mink was the representative receptor. Contaminants were measured in sediments, surface water, forage fish, and aquatic vegetation, and were estimated for aquatic invertebrates. No forage fish or aquatic vegetation samples were collected on the Refuge and surface water and sediment samples were limited. Food chain exposure modeling results were compared to NOAEL/LOAEL based TRVs. LOAEL HQs were greater than one for copper and selenium for estimated sitewide exposures in aquatic and wetland habitats; no HQs were greater than one for exposures on GSNWR indicating no risk to piscivorous mammals at the Refuge.

To evaluate Site-specific, reuse-related considerations for the identification of reasonably anticipated future Site uses, the Group conducted a reuse assessment. The results were provided in the Reuse Assessment Report (TRC 2017a) and supplemented in a Reuse Assessment Addendum (TRC 2017b). The conclusions of the Reuse Assessment Addendum were that "the potential reuse of the Site is limited by:

1. The presence of extensive and state- and federally-regulated areas that limit development;
2. The environmentally-sensitive nature of the surrounding area;
3. State, county, and local planning documents that discourage development in environmentally-sensitive areas away from established centers and focus on protection of the [Refuge];
4. The lack of available infrastructure and associated Site accessibility issues; and
5. The presence of buried waste which complicates construction and makes it costlier."

A Draft RI Report was submitted in January of 2018 (Geosyntec 2018a) and a Revised Final FS Report was submitted in July 2018 (Geosyntec 2018b). The sample locations from the RI and BERA are illustrated on Figure 3.

A summary of the Revised Draft FS alternatives with their key feature(s) relative to the impacts on the Refuge portion of the Site is provided below:

Alternative	**Key Features Relative to Impacts on the Refuge [a]**

Landfill 1[b]	No Action
Landfill 2	Site controls (i.e., Institutional Controls, Fencing and Signage);
Landfill 3	Capping of selected areas to reduce overall risk, remediation of “Areas of Particular Concern (APCs)”, and remediation of non-vegetated areas of soil contamination above remediation goals. (Note: only one APC was identified in the Refuge, associated with soil sample SS-118 in the south part of the Landfill.)
Landfill 4	Excavation and off-site disposal of selected areas to reduce overall risk, remediation of APCs, and remediation of non-vegetated areas of soil contamination above remediation goals. (Note: only one APC was identified in the Refuge, associated with soil sample SS-118.)
Landfill 5	Capping of all landfill material (including the Refuge portion of the Site).
Groundwater 1	No Action with naturally occurring constituent of concern reductions.
Groundwater 2	Source control, institutional controls, constituent of concern reduction by ongoing natural processes, long term monitoring with potential need to make adjustments to the remedy in the future.
Groundwater 3	Source control, institutional controls, constituent of concern reduction by ongoing natural processes, long term monitoring with implementation of a contingent remedy.

[a] To address the area of the Refuge significantly impacted by the Site/landfill, and to comply with the Refuge Comprehensive Conservation Plan, the DOI ECM, and all other applicable or relevant and appropriate requirements.
[b] The Revised Draft FS refers to these alternatives as “Soil” alternatives; however, they address the source landfill waste as well as the soils contaminated by the Landfill waste and are more appropriately labeled as “Landfill” alternatives.

A critical review of the FS conducted by KMPower (2019) on behalf of FWS concluded that significant areas of the Refuge contain contaminated surface soils resulting from Landfill waste activities that pose an elevated risk to wildlife and recreational users. KMPower (2019) concluded that the preliminary remediation goals (PRGs) proposed in the Revised Draft FS (Geosyntec 2018b) were not adequate to protect wildlife or recreational visitors, including children, at the Refuge.

KMPower (2019) concluded that a comprehensive assessment of sediment contamination and its associated impacts was not conducted to support alternatives that would allow source landfill waste to remain on the Refuge and adjacent non-Refuge portions of the Site without containment, which presents a limiting data gap for FS decision making. Contaminants are reported at concentrations in excess of promulgated New Jersey groundwater quality limits and New Jersey groundwater quality limits are potentially applicable requirements (KMPower 2019). Only one alternative in the Revised Draft FS (Alternative 5) has the potential to prevent further migration of contaminants from the landfill waste into the groundwater. The remaining alternatives allow source landfill waste to remain onsite without containment. The FS did not address current groundwater contamination, citing conclusions from the MNA study (Geosyntec 2017).

Several of the major conclusions, with respect to groundwater contamination from the Geosyntec (2017) MNA study, however, are not factual. The text states (p. 10, Section 3.2.1) that, "The data show that both dissolved and total metals concentrations in groundwater fluctuate, but have generally been stable over time since 2007. This indicates that natural processes upgradient, downgradient and within the Landfill are immobilizing and sequestering the metals in the soil matrix." Relatively stable concentrations of dissolved metals do not indicate that "….natural processes upgradient, downgradient and within the Landfill are immobilizing and sequestering the metals in the soil matrix." In fact, the dissolved metals concentrations indicate just the opposite, that the dissolved metals are readily available to migrate in the groundwater, as indicated by detections of dissolved metals in virtually every monitoring well. Dissolved metals will continue to migrate into the wetlands until, either their source(s) are depleted, or geochemical conditions change to those more favorable for sequestering the metals.

The Geosyntec (2017) MNA study text also states that (p. ix), "Metals are mostly not detected in filtered groundwater samples, indicating that metals concentrations are present in colloidal fractions, which are not readily transported with groundwater." As described above, dissolved metals have been detected at concentrations that exceed New Jersey's Groundwater Quality Standards in every monitoring well.

The decision to not include current groundwater contamination in the FS based on the assumptions that dissolved metals are mostly not detected in the groundwater, and that the metals are immobilized and sequestered in the soil matrix is not supported by the data.

1.2 Sources of Known or Suspected Hazardous Waste

Several known and potential sources of hazardous substances have been documented for the Site. As discussed in Section 10.1.1, the Landfill received municipal solid wastes and septic wastes from municipalities, private haulers, and homeowners for twenty years. Industrial wastes were also reportedly disposed of in the Landfill and the observations of drums containing such wastes appear to confirm those reports (Geosyntec 2018a). Pesticides, herbicides, and oil were used to control rodents, mosquitoes, and dust as part of the Landfill's operation. Though not confirmed by any of the previous investigations, other potential contaminant sources could be skeet shooting activities (i.e., PAHs from clay pigeon fragments and lead from shot) at the north end of the Site, lead from on-site hunting activities, petroleum hydrocarbons from the storage and maintenance of vehicles and landscaping equipment, and unauthorized dumping (Geosyntec 2018a). The unpermitted construction and demolition debris that was imported to build fire roads across the Site could also have introduced contaminants.

The 2018 RI Report also documented a number of potential upgradient sources of contaminants that could possibly contribute to surface water and sediment contamination within Loantaka Brook and Black Brook. The potential upgradient sources included greenhouses, sewage treatment plants, runoff from roadways and golf courses, and a shooting range (see Section 4.1, Geosyntec 2018a).

1.3 Known or Suspected Contaminants

The specific COPCs for human health are identified in the 2014 BHHRA (CDM 2014). The COPCs for the Site for soils by class include VOCs, SVOCs, pesticides, PCBs, dioxins/furans, and metals. The COPCs for the Site for surface water by class include SVOCs, PCBs, and metals. The COPCs for the Site for sediment by class include VOCs, SVOCs, pesticides, PCBs, dioxins/furans, and metals. The COPCs for the Site for groundwater by class include VOCs, SVOCs, and metals.

The specific contaminants of potential ecological concern (COPECs) for ecological receptors are identified in the 2016 BERA. The COPECs for the Site by class include SVOCs, pesticides, PCBs, dioxins/furans, and metals.

1.4 Release and Transport Mechanisms

Hazardous substances including VOCs, SVOCs, PCBs, pesticides, dioxins/furans, and metals are found in surface and subsurface soils across the site. Many of the same contaminants have been detected in surface water, sediment, and groundwater across the Site and adjacent to the Site in the Refuge. Much of the Landfill waste is exposed at the surface, or only covered by a thin layer of soil (Geosyntec 2018a). The precipitation that falls on the Landfill that does not evapotranspire back into the atmosphere either infiltrates through the Landfill material and into the shallow groundwater below, or runs off into the onsite ponds or to the adjacent wetlands, including the Refuge. The meteoric water infiltrating through the waste material could mobilize contaminants from the waste and into the groundwater below. Runoff can mobilize waste material and contaminated soil into the adjacent waterways and wetlands, contaminating both sediment and surface water.

Groundwater across the site is contaminated due to being in contact with waster material (Geosyntec 2018a). The groundwater redox conditions are highly reducing beneath the Site, which can further mobilize metal contaminants from the waste material that would otherwise not be soluble. A confining clay layer is present at depths of generally less than 20 feet (ft) below ground surface (bgs) across the Site, which is expected to limit the potential vertical migration of contaminated groundwater. As previously mentioned, groundwater is at or near the ground surface across the Site and in hydraulic communication with surrounding surface water bodies, including the Refuge's wetlands (Geosyntec 2018a). Therefore, contaminated groundwater could potentially contaminate surrounding surface water and the sediment at, and downstream from groundwater-surface water discharge locations. As the redox conditions change when groundwater leaves the Site, contaminants with solubilities that were redox-dependent (e.g., some dissolved metals) would be expected to precipitate out of solution, potentially leading to high contaminant concentrations at those redox inflection points, either within the subsurface soils or in sediments at the surface water discharge location.

With respect to the influence that redox reactions have on the speciation and mobility of heavy metals, the conceptualization is explained by Geosyntec (2017, p. 11) which states that, "*Groundwater at well MW-7, located in the middle of the Landfill, is highly reducing and methanogenic; it also has relatively high concentrations of total and dissolved organic carbon. The groundwater geochemistry at well MW-1 is similar to well MW-7, it is methanogenic with high concentrations of total and dissolved organic carbon. Due to the heterogeneous nature of landfills, these conditions may not be consistent across the entire site. The groundwater sample from downgradient well X-3* [Figure 3] *is oxidizing with a positive [oxidation reduction potential (ORP)], and there is no evidence of methane and total or dissolved organic carbon. There is no nitrate and the data suggest some manganese reduction, but overall, it is the most oxidizing of the four sample locations."* As shown in Figure 3, monitoring well MW-2 is located between MW-1 and X-3. At MW-2, dissolved arsenic, manganese, thallium and iron concentrations have been detected above New Jersey Ambient Groundwater Quality Standards indicative of reducing conditions (see RI Figure 4-2). Therefore, between MW-2 and X-3 there is a geochemical transition zone in which conditions become more oxidizing and metals precipitate out of solution. It is not known to what degree the metals precipitate within the aquifer matrix, pore-water, sediment, or surface water. If the metals precipitate out of the groundwater at greater depths, they should not result in adverse ecological impacts. However, if the metals remain in solution until entering shallower more oxidizing environments (e.g., pore-water, sediment, surface water), they could result in ecological impacts and potential human exposures. Furthermore, these dissolved metals could be bioconcentrated within the pore water and sediment due to 1) evapotranspiration removing the water but leaving the metals behind, and 2) bioaccumulation within the plants during the growth cycle and subsequent release and bioconcentration within the detritus following the plants death.

The geochemical transition zone between reducing and more oxidizing conditions likely forms a relatively narrow band, starting near the interface between the terrestrial system and the wetlands and ending several hundred feet within the wetlands.

For the purposes of this investigation, pore-water is defined as water within the zone being affected by evapotranspiration, and potentially discharging to surface water..

Dissolved metals have been detected in the 7 monitoring wells located along the geochemical transition zone on the Refuge property (i.e., MW-2, MW-4, MW-12, MW-14, MW 19, X-1 and X-2; Figure 3). Dissolved metals will continue to migrate into the wetlands until either their source(s) is depleted or geochemical conditions change.

1.5 Potential Receptors and Exposure Pathways

Relative to human health, receptors on the Refuge portion of the Site are expected to be limited to recreational users, which may occur through exposure to contaminated surface soils, sediments, surface water, and possibly shallow groundwater at groundwater-surface water discharge locations. The potential exposure routes for contaminated media at the Site include incidental ingestion, dermal contact, and inhalation.

Relative to ecological risk, receptors on the Refuge portion of the site are expected to be terrestrial birds and mammals, semi-aquatic birds and mammals, and aquatic vertebrates and invertebrates.

1.6 Land Use Considerations

As the Refuge portion of the Site and the adjacent wetlands are a designated Wilderness Area, land use would be limited to recreation.

The ballfield and shooting range located at the northern edge of the Site are occasionally used for recreational purposes.

1.7 Environmental Setting

This section describes the environmental setting for the Site and surrounding properties.

1.7.1 Climate

The climate of the Chatham Township, New Jersey area is classified as humid continental, consisting of cold winters and warm summers. The mean annual temperature is approximately 51°F, with the coldest average temperature of 29°F occurring in January and the warmest average temperature of 73°F occurring in July. The coldest mean daily temperatures below 40°F occur between December and March (Rutgers 2016a).

The mean monthly precipitation ranges from 3.06 to 4.65 inches, with an annual total mean precipitation of approximately 47 inches. Rainfall is spread throughout the year, with the wettest months being July and August (Rutgers 2016b).

The prevailing wind is from the southwest in the summer and from the northwest during the remainder of the year. Average wind speeds range from 9 to 17 miles per hour (USA.com 2016).

1.7.2 Topography

The topography is relatively flat and poorly drained, consisting mostly of low-lying areas including the Refuge wetlands (Gill and Vecchioli, 1965). The Site's topography is illustrated on Figure 4. The Site and the surrounding area lie at an elevation of approximately 240 feet above mean sea level (amsl; Geosyntec 2018a). Survey data from the RI Report (Geosyntec 2018a) soil boring locations advanced throughout the Site and in the adjacent lower areas indicate that the ground elevations ranged from 227 to 250 feet amsl (Geosyntec 2018a). The fire roads built across the site are elevated approximately four ft above the surrounding landscape.

1.7.3 Surface water Drainage

The Site is relatively flat and poorly drained with some saturated areas and wetlands existing on the Site itself; however, the Site is relatively elevated above the surrounding wetlands due to landfilling. Precipitation that does not evapotranspire or infiltrate through landfill wastes to groundwater is expected to runoff. Several on-Site ponds are expected to receive inputs from surface runoff as well as groundwater. Sheet flow from the Site is expected to also run off into the surrounding wetlands.

Black Brook flows from north to south near the eastern boundary of the site. Though portions of Black Brook are channelized, the majority of the surface water flow is un-channelized, low energy flow through dense wetlands.

1.7.4 Soils

Though the thin soil layer over the Landfill is discontinuous, most of the Landfill soils are classified as Udorthents, Refuse Substratum. The soil is characterized as silty loam that is spread over organic material, and is classified as well drained and does not frequently flood (USDA 1976). A second soil type called Carlisle Muck is reportedly present in the southern part of the Landfill (Geosyntec 2018a). That soil type is characterized as very poorly drained and frequently flooded. It is typically found in floodplains and is composed of herbaceous and/or woody organic material (USDA 1976).

1.7.5 Geology

The Site lies within a former glacial lake called Lake Passaic, which was formed during the Wisconsin Glaciation (Geosyntec 2018a). Sediments deposited within the lake include till and glaciolacustrine sand and gravel, silt, and clay. Regionally, thick deposits of the Wisconsin Glaciation terminal moraine lie to the northeast of the Landfill and the third basalt sheet, locally known as Long Hill, lies directly to the south (Gill and Vecchioli, 1965). See Geosyntec (2018a), map showing local surficial geology on and near the Landfill. Two overburden units are mapped within the Landfill and include stream terrace deposits and swamp and marsh deposits. In general, the Landfill is underlain by post-glacial swamp deposits interbedded with silt and sand. Coarser material was deposited directly from the ice and finer sediments were deposited at slower rates from remnant lakes following the retreat of glacial ice. Peat was deposited from shoreline vegetation of these remnant lakes and continues to be deposited throughout the heavily vegetated low-lying areas (Minard, 1967).

The most significant unconsolidated glacial sediments in the area of the Landfill are the glacial lake clay deposits. The glacial lake clay is characterized as medium to light gray and grayish-red to pale-red plastic clay containing intermixed silt. The clay forms a thick deposit that underlies the entire area and is reportedly more than 100 feet thick (Minard, 1967).

1.7.6 Hydrogeology

The hydrostratigraphic units at the Site generally consist of silt, peat and other organic materials, overlying stratified drift and sand channels (where present), beneath which lies a thick clay unit acting as an aquiclude (Geosyntec 2018a). The clay layer is located at depths of less than 20 ft bgs across the Site. A Site geologic cross section from Geosyntec (2018b) is included as Attachment 1. Groundwater is found at or within approximately five feet of the ground's surface across the Site.

1.7.7 Critical Habitats/Threatened or Endangered Species

The Site is surrounded by wetlands on its eastern, southern, and southwestern boarders (Figure 4). Wetlands also occur on the Landfill itself. Additionally, the Refuge-portion of the Site, along with the Refuge area adjacent to the Site are a designated Wilderness Area.

Threatened and Endangered species occurring at the Site include (Arcadis 2016):

- Bog Turtle (*Glyptemys muhlenbergii*), SE/FT
- Wood Turtle (*Glyptemys insculpta*), ST
- Blue-spotted Salamander (*Ambystoma laterale*), SE
- Barred Owl (*Strix varia*), ST
- Red-shouldered Hawk (*Buteo lineatus*), SE
- American Bittern (*Botaurus lentiginosus*), SE*
- Red-headed Woodpecker (*Melanerpes erythrocephalus*), ST
- Bobolink (*Dolichonyx oryzivorus*), SE*

Notes:
SE: State Endangered; ST: State Threatened; FT Federally Threatened
*Breeding population

1.7.8 Conceptual Site Model Figure

A graphical CSM illustrating the key Site features described in this section is included as Figure 5.

1.7.9 Data Gaps and Uncertainties

A review of the CSM reveals several data gaps relative to the Refuge-portion of the site and the potential migration of contaminants from the Site into the adjacent Refuge.

Subsurface soil and subsurface landfill waste has not been characterized for COPCs/COPECs throughout the Landfill, and specifically on the Refuge-portions of the Landfill. Twenty-one test pits were excavated on the Refuge to log landfill debris. Chemical testing was not conducted in the Landfill waste but focused on the Landfill-debris/natural soil interface. In addition, 14 of the 21 test pits were excavated at the edge of the Landfill to document horizontal extent of subsurface debris. Test pits within the Refuge study area are illustrated on Figure 3.

In addition, large areas of the Refuge portion of the Site were not sampled at all. The unsampled areas are also adjacent to some of the highest contaminant concentrations measured in soils (Geosyntec 2018a, 2018b). Examples of these unsampled areas are illustrated on Figures 6a and 6b. Note that the approximately 7 acre, unsampled area located in the northeast portion of the Site also lies adjacent to the area where the Revised Draft FS suggests that risks associated with high levels of contamination in that area indicate the need for a remedial action (Geosyntec 2018b). The northeast unsampled area also lies adjacent to wetlands in Refuge Wilderness Area.

A critical review of the RI/FS documents found that the sediment information collected in Black Brook during the RI was insufficient to determine the nature and extent of contamination, particularly with respect to potential upstream sources (KMPower 2019). Since Black Brook sediments have not been adequately characterized, the associated risk has not been fully assessed. Though 28 sediment samples were collected from within the Refuge, the majority of them were placed greater than 100 ft from the edge of the Landfill material, often 100s of feet from the nearest adjacent sample location (Figure 3). Considering that relief between the landfill and the surrounding wetlands is only a few feet, that the surface water flows throughout the wetlands are expected to be fairly low energy, and that the wetlands themselves are highly vegetated, any contaminated sediment transported off of the Site in overland flow events would not be expected to move far. Additionally, there are uncharacterized ponding areas near areas of high surface soil contamination on and off of the Site within the Refuge (Figure 6a). Notably, a pond that is clearly visible on many of the historical aerial photographs and satellite images lies at the northeast corner of the Site, near the contaminated area proposed for remedial action in the FS (Figure 6a; Geosyntec 2018b); however, the pond was not identified in the RI/FS documents and only one sediment sample was collected at its edge. Further, the surface flow patterns shown in RI Report figures (Figure 6a; Geosyntec 2018a) indicate that the surface runoff flows directly from those highly contaminated surface soils and into the pond area, but the sediment sample collected from the edge of the pond was not collected where the surface runoff would be deposited into the pond (Figure 6a).

The RI Report (Geosyntec 2018a) concluded that, "Black Brook likely receives hydrologic input from groundwater discharge," and groundwater flows from the Site to Refuge property (Figures 6a and 6b), which indicates that the contaminated groundwater plume from the Site can be expected to discharge into surface waters on the Refuge at some point (if it is not currently). This represents a likely complete exposure pathway from contaminated groundwater to human and ecological receptors within the Refuge. Furthermore, contaminated groundwater has the ability to contaminate surrounding surface water features, sediment pore water, and sediment at, and downstream from groundwater-surface water discharge locations. As the redox conditions change when groundwater leaves the Site, contaminants with solubilities that were redox-dependent (e.g., some dissolved metals) would be expected to precipitate out of solution, potentially leading to high contaminant concentrations at those redox inflection points, either within the subsurface soils or at the surface water discharge location [see discussion in Section 10.4).

A review of the previously collected Site data also indicates that 'emerging contaminants' often associated with landfill wastes and likely to occur at the Site were not included in previous analyte lists. According to USEPA (2014[c]), "An 'emerging contaminant' is a chemical or material that is characterized by a perceived, potential, or real threat to human health or the environment or by a lack of published health standards. A contaminant may also be "emerging" because a new source or a new pathway to humans has been discovered or a new detection method or treatment technology has been developed (DoD 2011)." These emerging contaminants — often detected in groundwater, surface water, sediment and soil — include Per- (and Poly-) Fluoro Alkyl substances (collectively, PFAS) such as Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfonate (PFOS). The PFAS compounds were historically used in several consumer products and industrial applications. Another emerging contaminant frequently detected at landfill sites includes 1,4-Dioxane, which was used in solvents, paint strippers, dyes, greases, varnishes and waxes and is typically detected at sites where solvents are present. 1,4-Dioxane is also highly mobile in groundwater.

The data gaps and potential release mechanisms noted above also indicate that the remedial alternatives proposed in the Revised Draft Final FS (Geosyntec 2018b) would not be protective of human health and the environment on the Refuge portion of the Site or on the off-site portions of the adjacent Refuge.

In the BERA, very sparse sampling coverage on the Refuge illustrates gaps in data for biota, surface soil, and sediment. Furthermore, no aquatic vegetation, forage fish or tadpole samples, and only a few incomplete invertebrate samples (two millipede samples and a partial earthworm sample) were collected from locations within the Refuge, which are data gaps.

No amphibians were observed in the segment of Black Brook that is at the Refuge boundary (though they were abundant at upstream locations) and no amphibians were sampled from locations that are on the Refuge, which is a data gap.

2. REFERENCES

Arcadis U.S., Inc. 2012. *Site Characterization Summary Report. Rolling Knolls Landfill Superfund Site, Chatham, New Jersey.* February.

CDM Federal Programs Corporation. 2014. *Baseline Human Health Risk Assessment, Rolling Knolls Landfill Superfund Site, Chatham, New Jersey*. June.

Department of Defense (DOD), 2011. Chemical & Material Risk Management Program. www.denix.osd.mil/cmrmd/ECMR/ ECProgramBasics.cfm

Department of Defense (DoD). 2013. DoD Quality Systems Manual for Environmental Laboratories, Version 5.0. July.

Foster Wheeler. 2000. Expanded Site Inspection Report: Rolling Knolls Landfill, Green Village, Chatham Township, Morris County, New Jersey.

Geosyntec Consultants (Geosyntec). 2017. Supplemental Groundwater and Baseline Monitored Natural Attenuation Investigation Report, Rolling Knolls Landfill Superfund Site. August.

Geosyntec. 2018a. *Remedial Investigation Report, Rolling Knolls Landfill Superfund Site*. January.

Geosyntec. 2018b. Revised Final Draft Feasibility Study Report, Rolling Knolls Landfill Superfund Site. July.

Integral Consulting. 2016. *Baseline Ecological Risk Assessment, Rolling Knolls Landfill Superfund Site, Chatham, New Jersey*. September.

Minard, J.P. 1967*. Summary Report on the Geology and Mineral resources of the Great Swamp National Wildlife Refuge New Jersey*. Geological Survey Bulletin, 1260-E.

NUS Corporation. 1986. *Report of Soil Sampling and Drilling Program at the Green Village Disposal Site.*

Rutgers University. 2016a. Monthly mean temperatures in Northern New Jersey (Division 1) from 1895-2016. Updated July 2016. Available from http://climate.rutgers.edu/stateclim_v1/data/north_njhisttemp.html.

Rutgers University. 2016b. Monthly precipitation in Northern New Jersey (Division 1) from 1895-2016. Updated July 2016. Available from http://climate.rutgers.edu/stateclim_v1/data/north_njhistprecip.html.

TRC. 2017a. *Reuse Assessment Report, Rolling Knolls Landfill Superfund Site, Chatham Township, New Jersey*. February.

TRC. 2017b. *Reuse Assessment Addendum Report, Rolling Knolls Landfill Superfund Site, Chatham Township, New Jersey*. April.

United States Department of Agriculture Soil Conservation Service. 1976. Soil Survey of Morris County.

USA.com. 2016. Summit, NJ weather. Available at http://www.usa.com/summit-nj- weather.htm.

United States Environmental Protection Agency (USEPA). 2002. EPA Guidance for Quality Assurance Project Plans, EPA QA/G-5, QAMS. December.

USEPA. 2005. Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP). EPA-505-B-04-900B. March.

USEPA. 2009. Guidance for Labelling Externally Validated Laboratory Analytical Data for Superfund Use. EPA 540-R-08-005, January.

USEPA. 2012. Optimized Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP) Worksheets. March.

USEPA. 2014a. Regional Screening Levels (Formerly PRGs), May 2020. Available at: http://www.epa.gov/region9/superfund/prg/

USEPA. 2014b. National Functional Guidelines for Superfund Organic Methods Data Review. EPA 540-R-014-002, August.

USEPA, 2014c. Emerging Contaminants – Perfuoroocatane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA). Emerging Contaminants Fact Sheet PFOS and PFOA. March

United States Fish & Wildlife Service. 1991. Contaminants in Fish and Sediments of the Great Swamp National Wildlife Refuge, Morris County, New Jersey. New Jersey Field Office, Pleasantville, NJ.

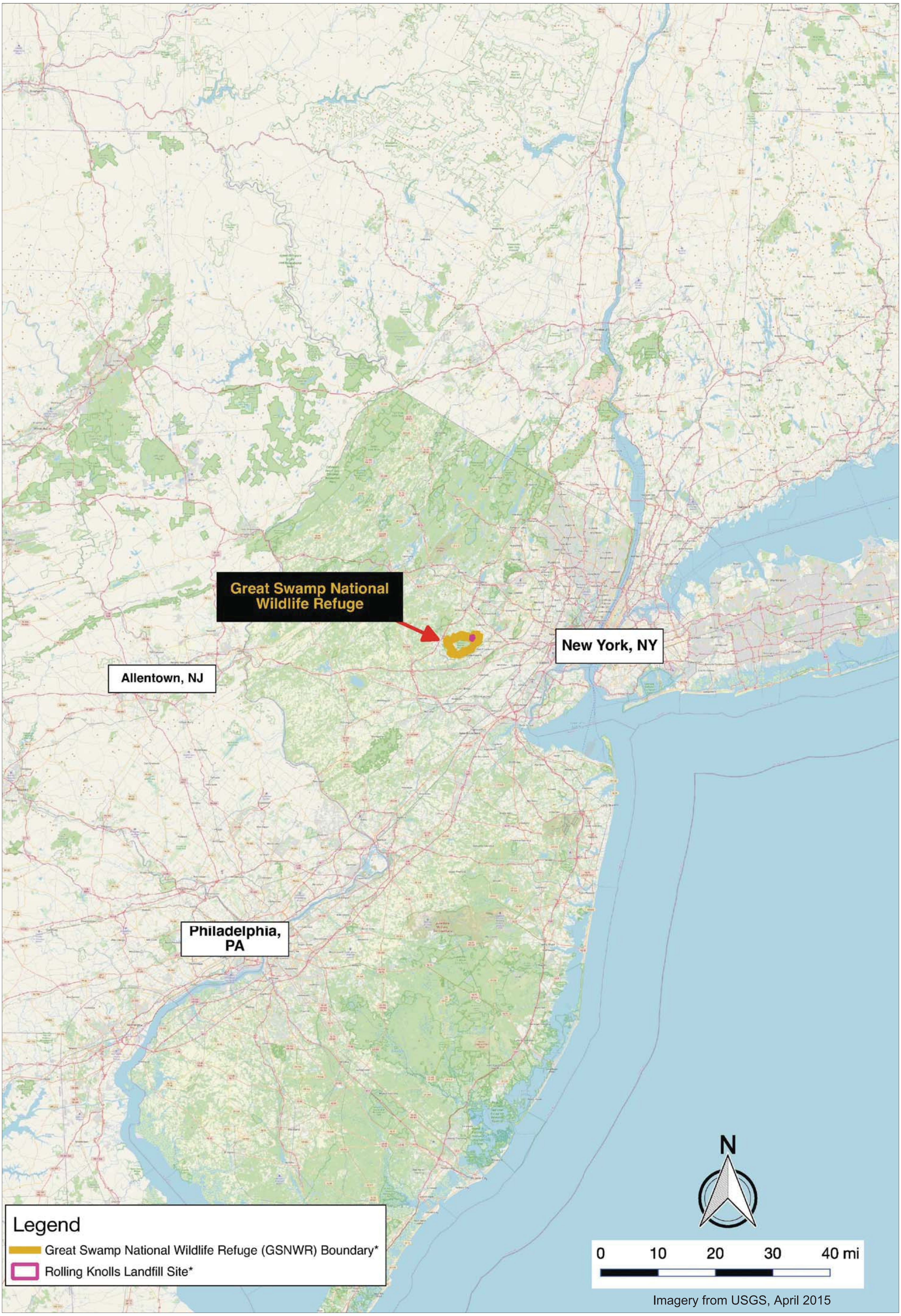
United States Fish & Wildlife Service. 2005. Contaminants in Fish and Sediments of the Great Swamp National Wildlife Refuge, Morris County, New Jersey: A 10-Year Follow-Up Investigation.

Weston Solutions Inc. 2003a. CLP Analytical Data of Soil and Sediment Samples; Rolling Knolls Landfill, Green Village, Chatham Township, Morris County, New Jersey.

Weston Solutions Inc. 2003b. PCB Field Screening Analytical Data of Soil and Sediment Samples; Rolling Knolls Landfill, Green Village, Chatham, Morris County, New Jersey.

Weston Solutions Inc. 2003c. Sampling Trip Report - Rolling Knolls Landfill.

Figures



PROJECT NAME:
ROLLING KNOLLS DATA GAP INVESTIGATION

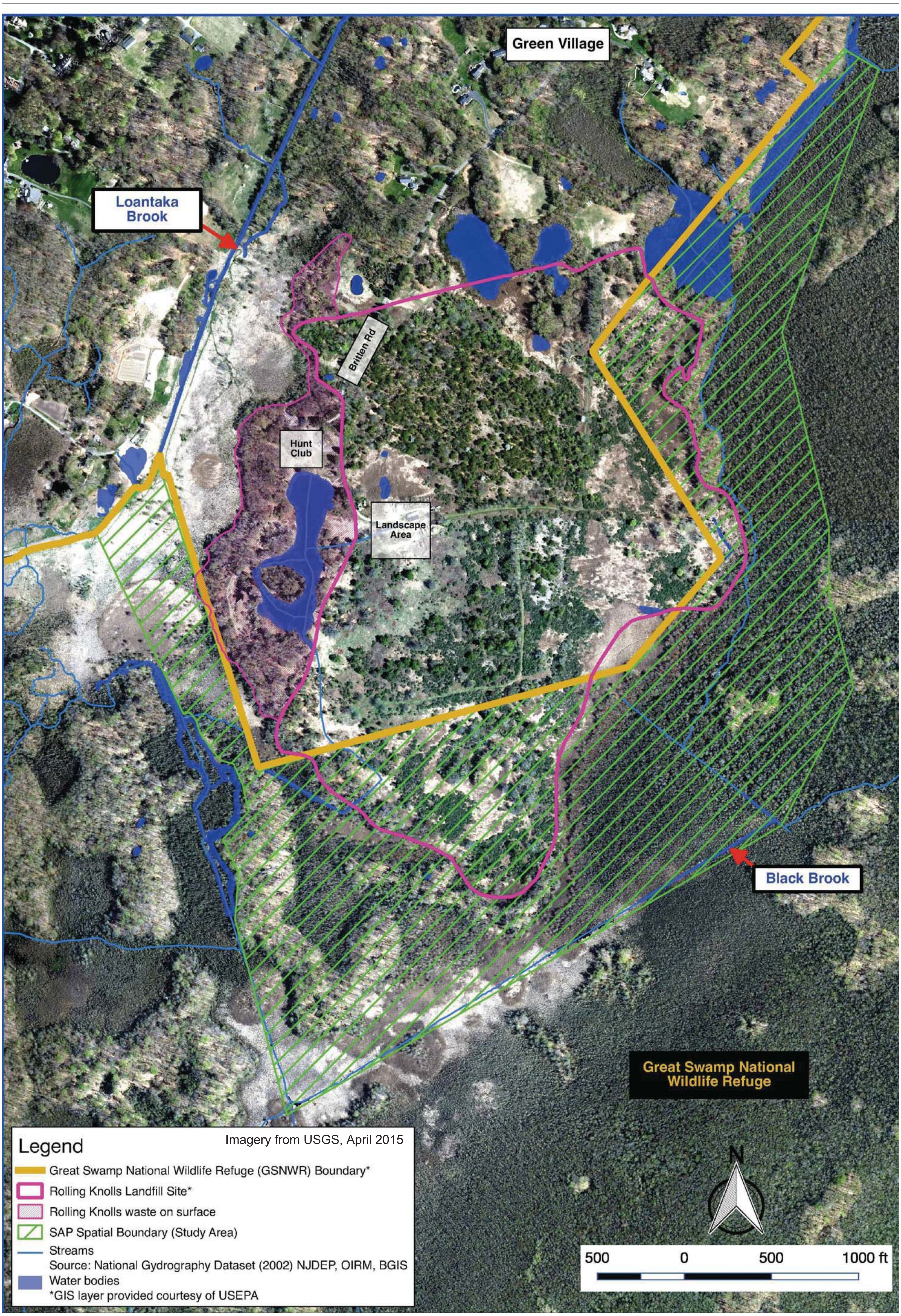
SECTION:
SITE LOCATION MAP

REVISION DATE:
9/1/2020

FINAL

DRAWING NO.
FIG 1

DRAWN BY:
PRESTON SOWELL



PROJECT NAME:
ROLLING KNOLLS DATA GAP INVESTIGATION

SECTION:
SITE MAP

REVISION DATE:
9/1/2020

FINAL

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FIG 2

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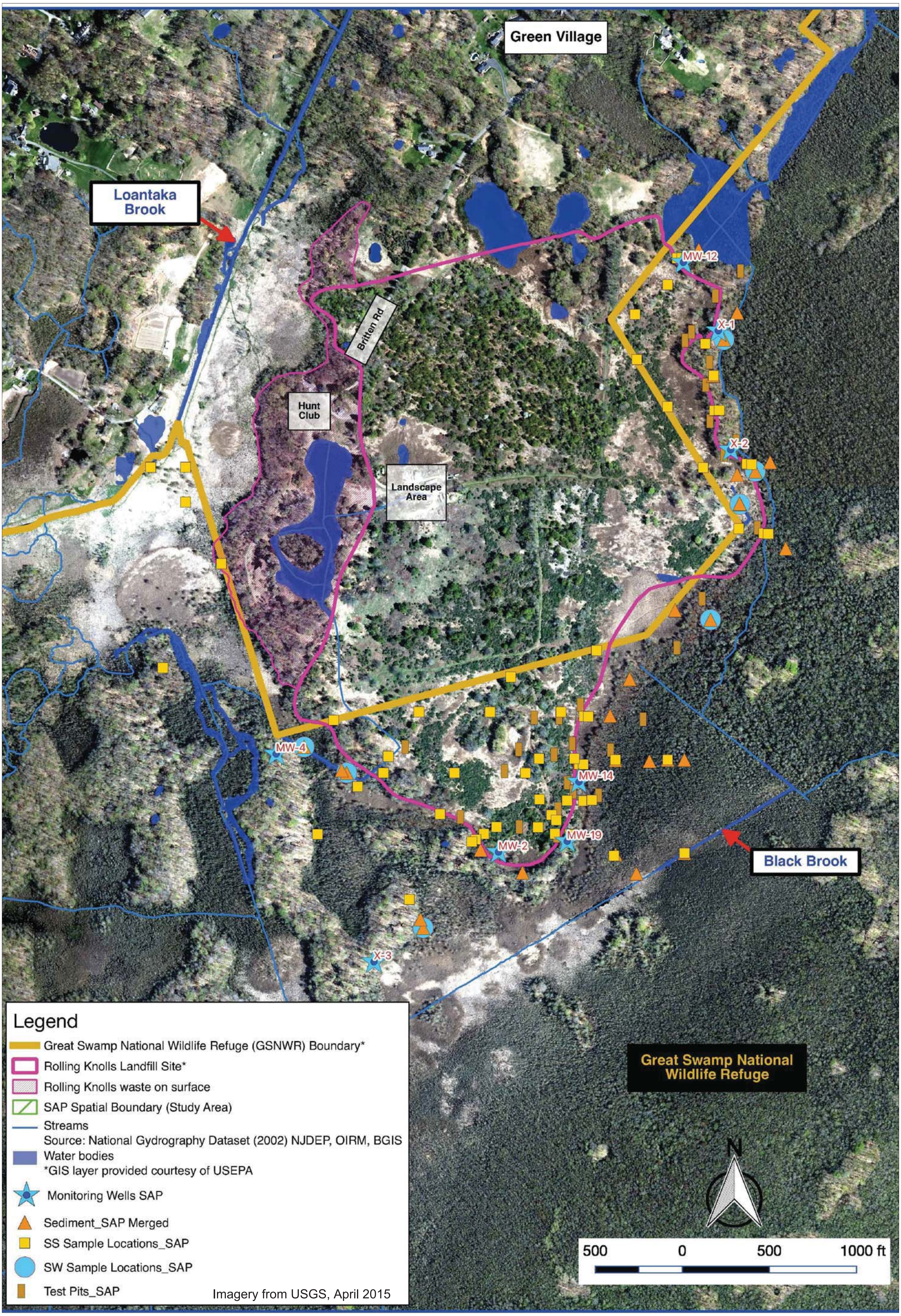
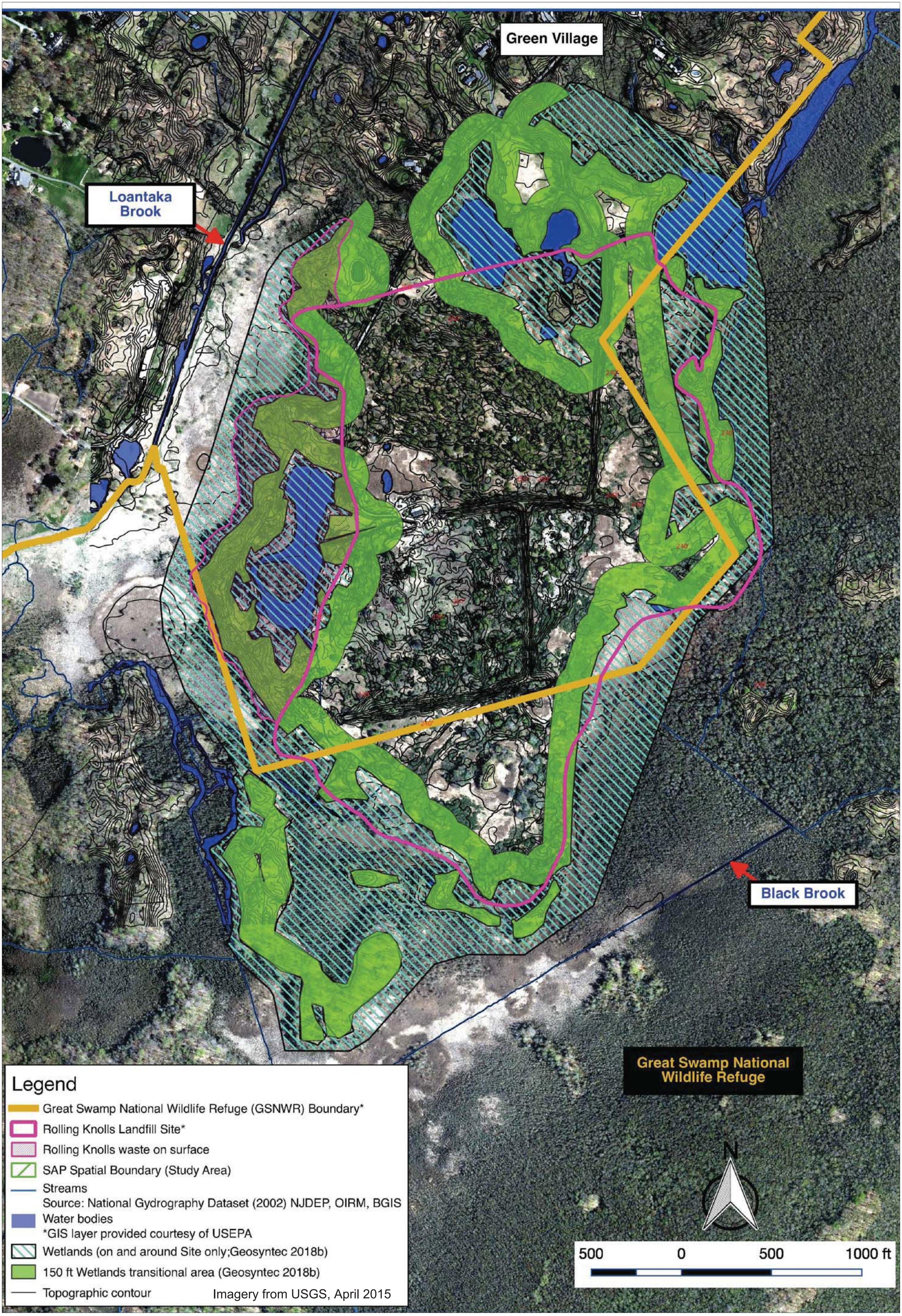
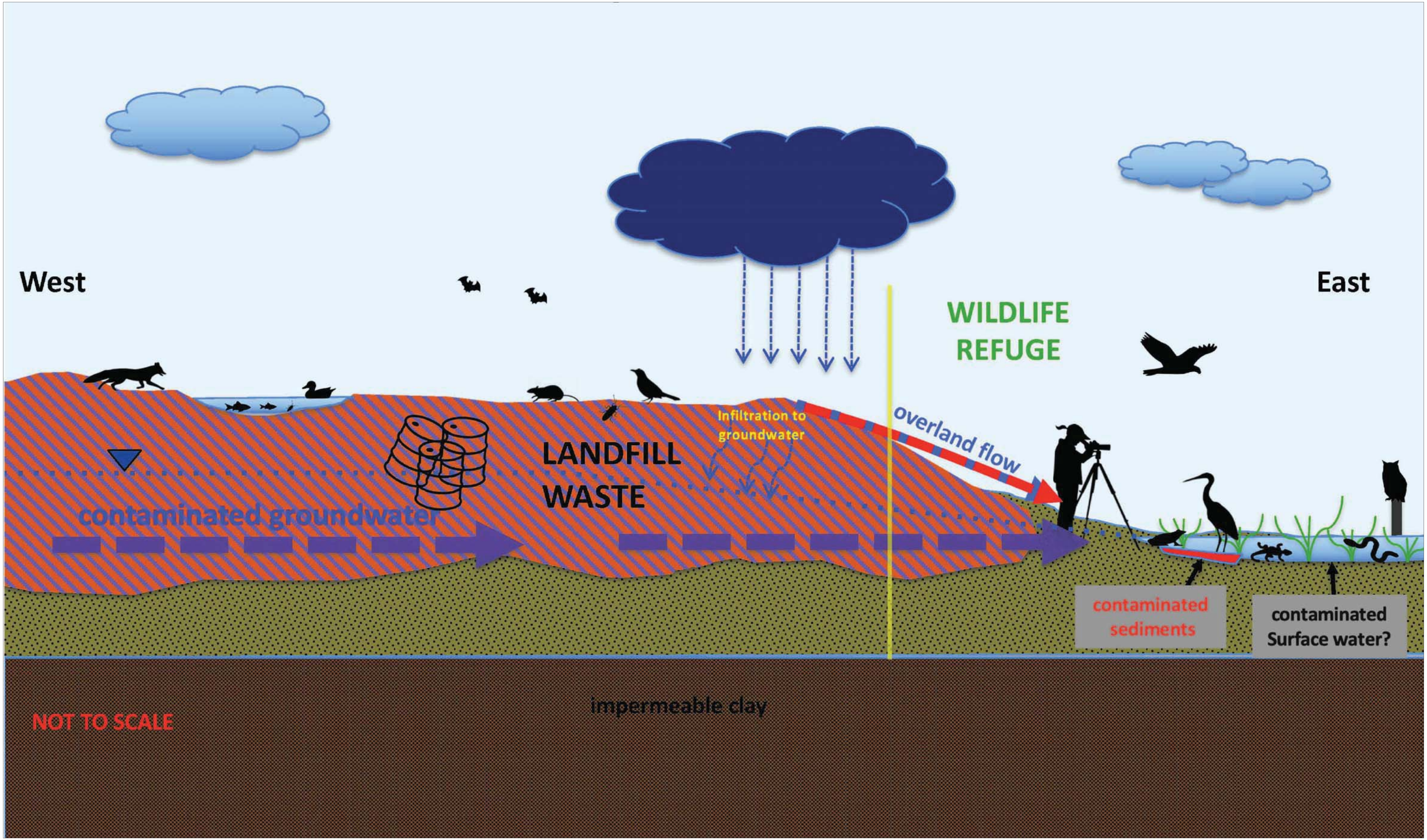


PROJECT NAME:	REVISION DATE:	DRAWING NO.
ROLLING KNOLLS DATA GAP INVESTIGATION	**9/1/2020**	**FIG 3**
SECTION:		DRAWN BY:
RI AND BERA SAMPLING LOCATIONS IN STUDY AREA	**FINAL**	PRESTON SOWELL



PROJECT NAME: **ROLLING KNOLLS DATA GAP INVESTIGATION**		REVISION DATE: **9/1/2020**	DRAWING NO. **FIG 4**
SECTION: **WETLANDS AND TOPOGRAPHY**		**FINAL**	DRAWN BY: PRESTON SOWELL



REVISIONS:			
No. 1		DATE	INITIALS
No. 2		DATE	INITIALS
No. 3		DATE	INITIALS

DESIGN:	P. SOWELL	9/1/2020 DATE
DRAWN:	P. SOWELL	9/1/2020 DATE
CHECKED:	-	- DATE

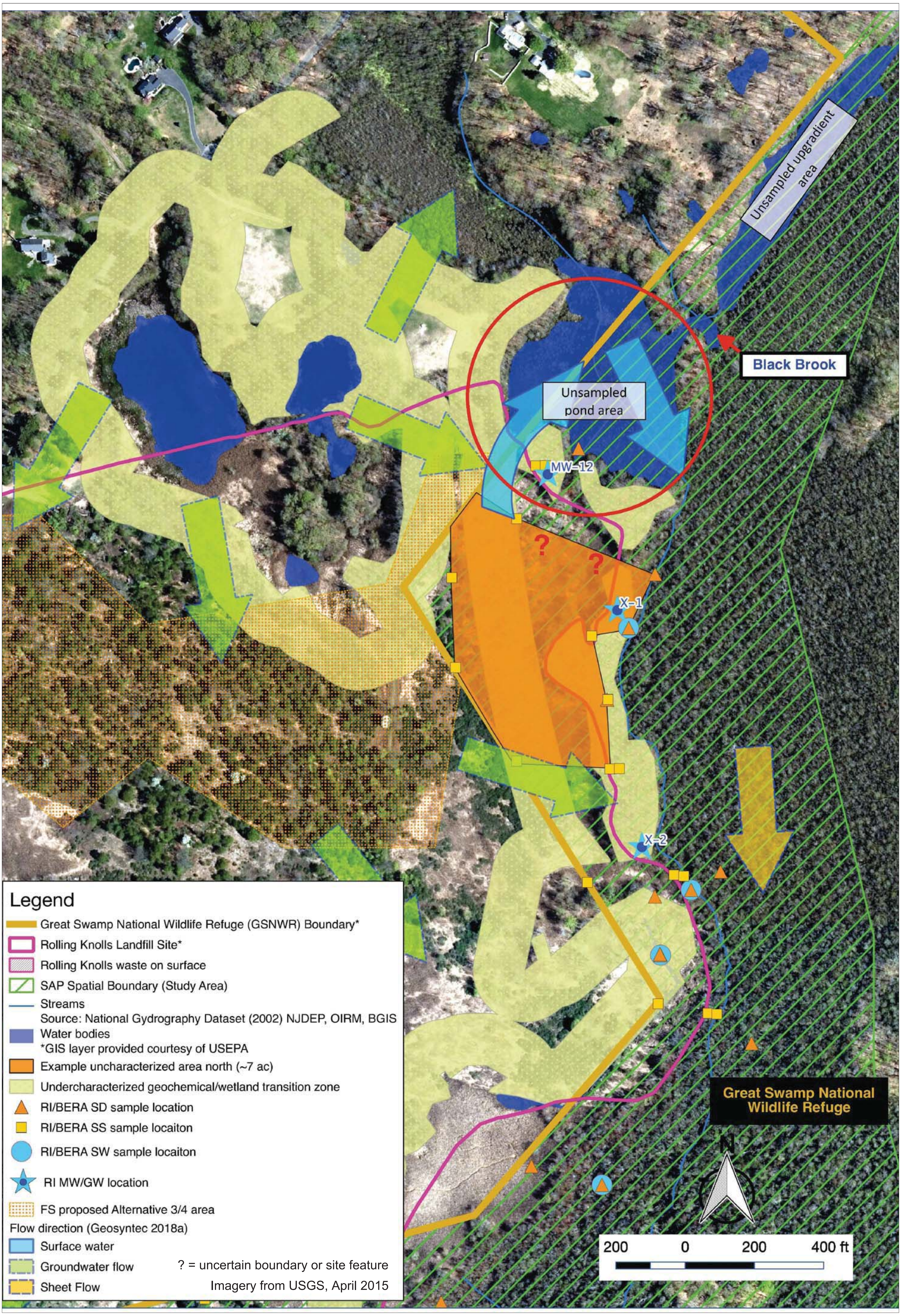
PROJECT NAME
ROLLING HILLS SUPP. RI/FS

SECTION
CONCEPTUAL SITE MODEL

REVISION DATE
9/1/2020
FINAL

DRAWING NO.
FIG 5

SHEET
1 OF 1



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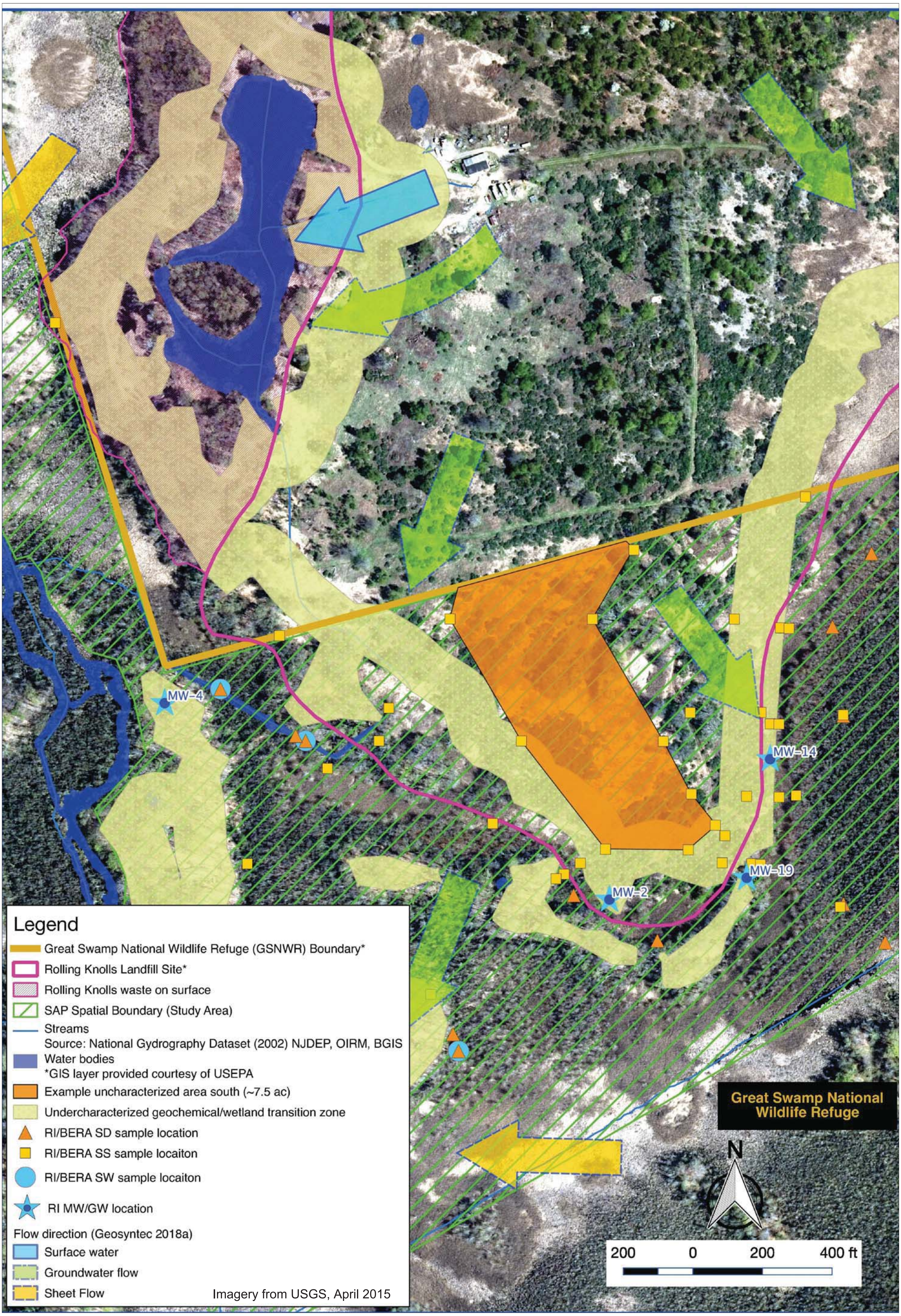
SECTION: **DATA GAP AREAS - NORTH**		**FINAL**	DRAWN BY: PRESTON SOWELL



PROJECT NAME:
ROLLING KNOLLS DATA GAP INVESTIGATION

SECTION:
DATA GAP AREAS - SOUTH

REVISION DATE:
9/28/2020

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FIG 6B

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