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Buffalo River Natural Resource Damage Assessment: Groundwater Injury Determination at Selected Sites Adjacent to the Buffalo River

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prepared for:

Buffalo River Natural Resource Trustees

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BUFFALO RIVER NATURAL RESOURCE DAMAGE ASSESSMENT: GROUNDWATER INJURY DETERMINATION AT SELECTED SITES ADJACENT TO THE BUFFALO RIVER

The Buffalo River (River) flows through the city of Buffalo, New York and ends at its confluence with Lake Erie and the head of the Niagara River. Throughout a history of development, industry, and shipping, the River and its shoreline have suffered from contamination by hazardous substances and oil.

The U.S. Department of the Interior (DOI) Fish and Wildlife Service, the State of New York Department of Environmental Conservation (NYSDEC), and the Tuscarora Nation (collectively the Trustees) are conducting a natural resource damage assessment (NRDA) of natural resources in and around the River. In conducting the NRDA, the Trustees are acting under their authority pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Section 107(f), 42 U.S.C. § 9607(f); Executive Order 12580; the National Contingency Plan (NCP), 40 C.F.R. Part 300 – Subpart G; the Oil Pollution Act of 1990 (OPA), 33 U.S.C. § 2701 et seq.; the Clean Water Act (CWA), 33 U.S.C. § 1251 et seq.; and the New York State Navigation Law (NYSNL), NYSNL Article 12. The purpose of this action is to evaluate natural resource injuries and losses in natural resource services within the assessment area due to discharges or releases of hazardous substances and oil; to plan and implement restoration actions to return any injured resources to their baseline condition; and to restore any associated interim service losses on behalf of the public.

The Trustees formally initiated NRDA efforts in 2008 with the issuance of a Preassessment Screen for the River (Trustees 2008). Shortly thereafter, the Trustees began working in cooperation with a potentially responsible party (PRP), Honeywell International, to perform NRDA activities. Since then, the Trustees have conducted a number of meetings with Honeywell, and have begun releasing a series of injury determination reports to document the occurrence of resource injury in the River and to keep the public apprised of ongoing assessment activities. The first injury report, released in December of 2011 by the Trustees, documents injury to fish in association with the existence of the fish consumption advisory for the River. This injury determination report documents injury to groundwater resources at selected sites adjacent to the Buffalo River.

As described in the DOI regulations at 43 C.F.R. Part 11, the purpose of an injury determination is "to ensure that only assessments involving well documented injuries resulting from the discharge of oil or release of a hazardous substance proceed through the type B assessment" (43 C.F.R. §11.61 (b)). This injury determination report provides a brief description of the assessment area and documents injury to groundwater, based on

documentation of hazardous substances in groundwater at concentrations in excess of promulgated thresholds.

This document does not quantify the magnitude of injury or potential service losses, including but not limited to cultural service losses; nor does it describe in detail all potential injuries to groundwater resources resulting from exposure to hazardous substances or oil. As NRDA activities progress, the Trustees anticipate issuing additional injury determination reports, and other documents described in the DOI regulations.

ASSESSMENT AREA

To date the assessment area for the NRDA has included:

- Riverine habitat from the confluence of Cazenovia Creek to the mouth of the River at Lake Erie - approximately the lower 6.2 miles of the main stem of the River;
- Aquatic habitat of the City Ship Canal that runs 1.4 miles south from the mouth of the River parallel to Lake Erie;
- Aquatic and terrestrial habitat of the Times Beach Confined Disposal Facility (TBCDF), where contaminated dredge materials from the River have been deposited.

As noted above, this report evaluates possible injuries to groundwater resources at selected sites adjacent to the Buffalo River (Exhibit 1). Although a number of industrial sites in the Buffalo River watershed have discharged hazardous substances and/or oil, for purposes of this document the Trustees are focusing on the groundwater resources at the Buffalo River Improvement Corporation (BRIC) sites: Mobil Oil (Exxon Mobil), Allied Chemical - Industrial Chemicals Division (PVS Chemicals), Allied Chemical - Specialty Chemicals Division (Buffalo Color Corporation), Republic Steel, and Donner Hanna Coke[1] (Exhibit 1). Honeywell International, Inc. has access rights for environmental remediation and investigation at the Buffalo Color and PVS Chemical sites. The five BRIC industries are accountable for the majority of the historical industrial discharges to the River (EPA 1975). In addition to releasing hazardous contaminants and oil to the River, operations at these sites have resulted in the contamination of groundwater resources.

The Trustees may choose to investigate and issue injury determination reports for additional sites or resources within the Buffalo River watershed in the future. More information on the Buffalo River NRDA can be found at: http://www.fws.gov/northeast/nyfo/ec/buffalo.htm.

[1] Republic Steel and Donner Hanna Coke sites are often collectively referred to as "Steelfields".

GROUNDWATER IN THE VICINITY OF THE RIVER

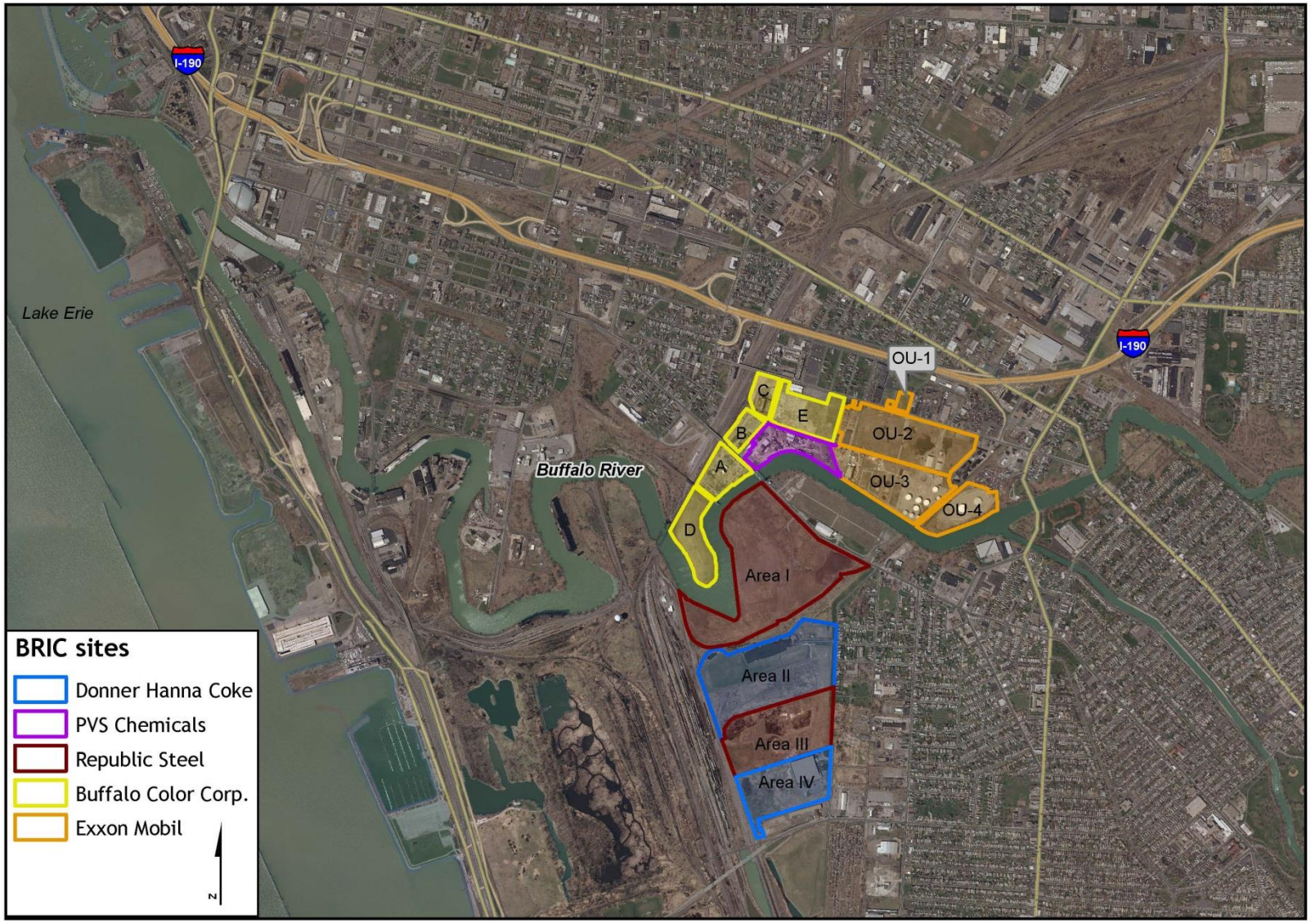
DOI regulations define groundwater resources as:

> *Water in a saturated zone or stratum beneath the surface of land or water and the rocks or sediments through which ground water moves. It includes ground water resources that meet the definition of drinking water supplies (43 C.F.R. § 11.14 (t)).*

Although the City of Buffalo water utility, Buffalo Water, currently draws water from Lake Erie, the groundwater in the Buffalo River watershed is classified as Class GA (fresh groundwaters), with its best use "as a source of potable water supply" under New York State law (6 NYCRR § Part 701.15). In addition, investigative reports indicate there is an exchange of water between the shallow groundwater at the BRIC sites and the Buffalo River (Mactec 2010; Malcolm Pirnie, Inc. 1989; Turnkey 1998).

The Buffalo area groundwater system features a fractured bedrock aquifer underneath an aquifer of unconsolidated deposits (EPA 1985b). The shallower unconsolidated aquifer includes both sand and gravel deposits and a thicker glaciolacustrine clay layer. The relatively impermeable clay layer causes a seasonal water table to form on top of it during wet periods, and as water collects upwards it eventually discharges to proximate surface water bodies (EPA 1985b). The flow of groundwater in the unconsolidated aquifer at the BRIC sites is generally towards the Buffalo River (EPA 1985b). At the Buffalo Color Corporation site, that ground-water movement within the unconsolidated aquifer ranges from 0.02 to 0.06 feet per year (EPA 1985b).

EXHIBIT 1 BUFFALO RIVER IMPROVEMENT CORPORATION (BRIC) SITES



0 0.25 0.5 0.75 1 Miles

Sources
Orthoimagery: NYS Orthos Online, 2011; Roads: The National Map;
BRIC Sites: Digitized from: NYSDEC, City of Buffalo Parcel Viewer,
or TurnKey Environmental Restoration LLC. 2005

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Trustees have documented a wide range of contaminants in groundwater at the BRIC sites at concentrations in exceedance of New York State Law (6 NYCRR § Part 703) groundwater quality standards, or New York State guidance values for Class GA waters. These include a wide range of organic (e.g., pesticides, petroleum derivatives, synthetic carbon-based chemicals) and inorganic (e.g., metals) contaminants. This section highlights a sub-set of contaminants of concern, and provides additional details on their occurances in groundwater at the BRIC sites, as well as some information about their toxicity and adverse effects on the environment.[2] Specifically, for purposes of this report, below we highlight:

- Polycyclic aromatic hydrocarbons (PAHs);
- Metals (arsenic, cadmium, chromium (both hexavalent and trivalent), copper, lead, mercury, and zinc);
- Aniline;
- Benzene, Toluene, Ethylbenzene, and Xylene (BTEX);
- Phenols; and
- Chlorinated Benzenes.

POLYCYCLIC AROMATIC HYDROCARBONS (PAHS)

Polycyclic Aromatic Hydrocarbons (PAHs) describe a group of over 100 organic compounds found in petroleum and coal derivatives, such as coke. Of the breakdown products of oil that persist in the environment, PAHs are some of the most toxic. PAHs are also concentrated in the refining process, resulting in higher concentrations of PAHs in refined petroleum products as compared to crude oil (Connell and Miller 1981). Comprised of clusters of benzene rings in multiple combinations, examples include anthracene, benz(a)anthracene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorine, naphthalene, phenanthrene, and pyrene. PAHs can also be from pyrogenic origins; meaning that besides occurring in petroleum products they can also be produced from the incomplete burning of organic matter (Kuzia and Black 1985). Operations at ExxonMobil, a former petroleum refining and storage site, resulted in multiple oil spills that released PAHs into the environment (Roux 2000). Although PAHs of pyrogenic origin can be mobilized atmospherically, PAHs typically are not very

[2] This report does not evaluate the potential for human exposure to contaminants, or site-specific risks to human health. The NYSDEC actively oversees monitoring and clean-up efforts at each of the BRIC sites and at other locations in and around the River, and is responsible for the implementation of institutional controls to address human exposure to groundwater contamination. Although descriptions of ongoing environmental clean-up efforts, which have the potential to ameliorate the extent of groundwater and other resource injury, are included in this report, readers are referred to the NYSDEC for additional information on site-specific human health risks associated with contaminated sites in and around the River. The NRDA effort that the Trustees are undertaking on behalf of the public is separate and distinct from these remediation efforts.

mobile in the environment and are often adsorbed to particles in soil and sediment (Eisler 2000).

Once PAHs are released into the environment (usually through road runoff or when petroleum is spilled), PAHs are stable and persistent. Biological organisms can uptake PAHs, which accumulate in fatty tissues. Depending on a specific organism's ability to metabolize and excrete PAHs, this class of contaminant can bioaccumulate in individual organisms as well as biomagnify through food webs (Eisler 2000; EPA 2000).

Several PAHs including benz(a)anthracene, benzo(a)pyrene, chrysene, and dibenzo(a,h)anthracene are some of the most potent carcinogens known to exist (Eisler 2000; ATSDR 1995). Although the occurrence of cancer in aquatic organisms has not been definitively linked to PAHs, they have been implicated in causing a variety of developmental anomalies and tumors in fish and aquatic mammals. PAHs have also been shown to cause a variety of other toxicological responses in aquatic organisms, birds, and mammals, including inhibited survival, growth, and reproduction (Eisler 2000).

Laboratory research shows that PAHs can affect the skin, liver, immune system, as well as the reproductive system in mice, but researchers have not observed these negative effects in humans (ATSDR 1996). However, the International Agency for Research on Cancer (IARC) has determined that benzo(a)pyrene is a Group 1 carcinogen to humans: occupational exposure during jobs such as coal gasification, coke production, or paving and roofing with coal tar pitch can cause cancer in humans. The IARC has also classified other PAHs such as benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, and chrysene as possibly carcinogenic to humans (IARC 2010).

METALS

Metals occur naturally in the Earth's crust. At low doses many metals are nutrients, and some are necessary for the proper functioning of metabolic processes. However, at elevated concentrations metals uniformly cause toxic effects to biota. Metals typically become an environmental concern when they are released into the environment from anthropogenic activities such as smelting. The resulting expansion in the distribution of metals and natural weathering and microbial processes affect the bioavailability of metals in the environment (EPA 2007a). For example, because water hardness has been shown to decrease metal bioavailability, and therefore toxicity, water concentrations of many metals are regulated based on water hardness (EPA 2007b). In water, metals typically bind to particles in soil or accumulate in sediments. But because metals are elements, they cannot be degraded, and are therefore persistent in the environment. This report focuses on arsenic, cadmium, chromium, copper, mercury, lead, and zinc; each of which is discussed in greater detail below.

Arsenic (As)

Historically arsenic was most commonly used in pesticides. Today arsenic is widely used to pressure-treat wood, as an additive to animal feed, and in batteries, dye-manufacturing, alloys, and glass. The U.S. is the largest worldwide consumer of arsenic (although most arsenic is now imported; ATSDR 2007a). Arsenic typically enters the environment through smelting of metal ore, leachate (e.g., treated wood in landfills), or from the

burning of treated wood (ATSDR 2007a; USGS 2000). In the case of the Buffalo Color site, the dye manufacturing process and improper waste-disposal resulted in the release of arsenic to groundwater (GGF 2009).

Arsenic can form both organic and inorganic compounds; with the latter generally more toxic than the former. Although arsenic is a nutrient for some species of animals, and does not generally bioaccumulate in tissues (EPA 1984), adverse health effects in biota can include dehydration, kidney and bladder failure, respiratory effects, and cardiovascular effects (ATSDR 2007a).

Human exposure to inorganic arsenic can cause a variety of negative health effects including irritated lungs, nausea and vomiting, paraesthesia (or "pins and needles" sensation) in the hands and feet, warts, and redness and swelling of the skin. Organic arsenic such as methyl and dimethyl compounds can cause damage to the kidneys when ingested. The Department of Health and Human Services (DHHS), the EPA, and the IARC all recognize inorganic arsenic as a known carcinogen in humans. Ingestion of inorganic arsenic potentially increases the risk of cancer in the bladder, liver, lungs, and skin (ATSDR 2007a).

Cadmium (Cd)

Human activities (principally, the production of zinc, copper, and lead) are primarily responsible for the release of cadmium to the environment. Major uses of cadmium include electroplating, pigment production, and in the manufacture of plastic stabilizers and batteries (Eisler 2000). Historically the PVS Chemical Solutions site housed operations for dyes and other chemicals (GGF 2009), operations likely to be responsible for the high concentrations of cadmium found in the groundwater at the PVS chemicals site. Like other elemental metals, cadmium does not degrade in the environment. In aquatic environments cadmium typically exists in its divalent oxidation state, and therefore its bioavailability is influenced by water hardness (increased water hardness decreases bioavailability). Cadmium can bioaccumulate in individual organisms and can biomagnify through food webs.

Cadmium does not serve any biological function, and is universally toxic to biota in sufficient concentrations. Excess cadmium can cause toxic effects such as decreased growth, inhibition of reproduction, immobility, and death to organisms at all trophic levels (Eisler 2000). In humans, cadmium exposure can cause both short- and long-term effects. Ingestion of high levels of cadmium causes vomiting and diarrhea; and breathing cadmium can cause severe damage to the lungs. Chronic exposure to low levels of cadmium via water, food, or air can cause kidney disease, lung damage, and fragile bones. Additionally the DHHS and IARC classify cadmium as a human carcinogen (ATSDR 2012a).

Chromium (Cr)

Chromium is best known for its use in the production of stainless steel in chrome plating. It is usually released into the environment through discharge of industrial effluents. High concentrations of chromium were found at the former industrial waste disposal site, Area D of the Buffalo Color Corporation. Chromium typically exists either in a trivalent (III)

or hexavalent (VI) oxidation state in water. Although the trivalent form is considered a nutrient, and the hexavalent form is considered a toxicant, both forms can be toxic to biota at elevated concentrations (Eisler 2000). Toxic effects of chromium to aquatic organisms include adverse impacts on growth, enzymatic function, histopathology, and survival. Higher trophic level organisms such as birds and mammals can experience more severe effects including mutagenic, teratogenic, and carcinogenic effects (Eisler 2000).

Chromium (III) and chromium (VI) have different health effects on humans; chromium (VI) is far more toxic than chromium (III). Acute exposure to high levels of chromium (VI) via inhalation leads to irritation of the nose which may result in nose ulcers and other breathing problems such as wheezing, cough, and asthma. Both chromium (VI) and chromium (III) can cause skin irritations including redness and swelling of the skin. In laboratory research on animals researchers have observed that ingestion of chromium (VI) causes stomach and small intestine ulcers as well as anemia. Exposure to chromium (VI) can also cause damage to the male reproductive system in animals. The DHHS, IARC, and EPA have all determined that chromium (VI) is a known human carcinogen. Breathing in chromium (VI) causes lung cancer in both humans and animals, and ingesting water contaminated with chromium (VI) may increase the chance of stomach tumors (ATSDR 2012b).

Copper (Cu)

Copper is considered an essential nutrient, but can be toxic at elevated concentrations. Municipal effluents, leaching of copper-based anti-fouling paints, and atmospheric deposition of aerosolized copper from mining and industrial operations are the largest sources of copper to aquatic environments (Eisler 2000). Buffalo Color Area D produced a variety of copper based dyes and acids and thousands of pounds of copper waste by-products (Malcolm Pirnie, Inc. 1989). In water, copper typically exists in a divalent oxidation state, which is particle-reactive, and results in the adherence of copper to soils and sediments. Aquatic organisms are generally more sensitive to the toxic effects of copper than are higher trophic level organisms; as a result copper is considered one of the most toxic metals to aquatic organisms. Adverse effects include decreased growth, reproduction, and survival (Eisler 2000).

Humans are generally less sensitive to the toxic effects of copper than are aquatic biota. However, exposure to high amounts of copper can be harmful to human health. Inhalation of copper can cause throat and nose irritation, and consuming a high amount of copper induces vomiting or diarrhea. In very high doses copper can damage the liver and kidneys, and can even result in death (ATSDR 2004a).

Mercury (Hg)

Mercury does not serve any biological function, and is universally toxic in sufficient concentrations. Originally used in gold extraction and the production of mirrors, then in the chlor-alkali industry and in the production of electrical instruments, mercury is currently used in pharmaceuticals, agricultural fungicides, and in the production of plastics (Clarkson and Marsh 1982 in Eisler 2000). Between 1926 and 1970 Buffalo

Color Area D produced dihydroxyanthraquinone which created mercury-contaminated waste, which was subsequently disposed of onsite (Malcolm Pirnie, Inc. 1989)

Mercury is unique among metals because elemental mercury is a liquid at room temperature and readily volatilizes. In water, however, mercury typically exists in a divalent oxidation state (either in its ionic form or as mercurous ion (Hg_2^{2+})), which readily binds to particles. Forms of mercury with relatively low toxicity can be transformed into forms with high toxicity through biological and other processes. For example, when exposed to inorganic mercury bacteria can produce methylmercury, the most toxic and bioavailable form of mercury. Mercury can also biomagnify through food webs, affecting higher trophic level organisms. A mutagen, teratogen, and carcinogen, at low concentrations mercury can cause adverse impacts to animal reproduction, growth, development, behavior, blood chemistry, vision, and metabolism; and at high concentrations it is lethal (Eisler 2000).

Human health effects of mercury are dependent on the form of mercury and the route of exposure. Exposure to high levels of all types of mercury can negatively impact the nervous system and cause permanent brain damage. Acute exposure to high levels of metallic mercury vapors can cause immediate effects such as nausea, vomiting, diarrhea, skin rashes, and eye irritation. Exposure to high levels of methylmercury or metallic mercury can also damage a developing fetus in pregnant women (ATSDR 1999).

Lead (Pb)

Lead is ubiquitously considered a hazardous pollutant. Lead is found in high concentrations at the Steelfields sites, a by-product of the steel, iron, and metallurgical coke operations of the Donner Hanna Coke and Republic Steel companies (GGF 2009). It can form inorganic and organic compounds and can be integrated into larger molecules. Anthropogenic activities can alter the bioavailability of lead, and have been implicated in significantly altering the biogeochemical cycling of lead in the environment. In water, dissolved cationic forms of lead and organic lead compounds are the most toxic forms. In fresh surface water, hardness plays a key role in the bioavailability of lead (Eisler 2000).

Organisms readily absorb lead, though there are no known metabolic functions that require lead. In vertebrates, lead is deposited in bone and soft tissues, which can serve as a continual source of exposure. Enzymes involved in blood formation are affected by lead, and delta aminolevulinic acid dehydratase (ALAD) inhibition is a commonly measured response to lead exposure in organisms. Although many organisms can bioaccumulate lead, it has not been shown to biomagnify through food webs (Eisler 2000).

Elevated concentrations of lead in humans have been shown to cause a variety of adverse health effects including neurological and reproductive effects (ATSDR 2007b; Eisler 2000). Exposure to lead can cause an increase in blood pressure or anemia in adults. High lead levels can damage the brain and kidneys and can lead to death. High levels of lead exposure also affect the reproductive system in humans: in pregnant females lead can cause miscarriage, and in males lead can damage sperm production. Elevated lead concentrations can cause weakness in the fingers, wrists, or ankles (ATSDR 2007b).

Elevated blood lead levels in children have also been associated with lower cognitive abilities and delinquent behavior (ATSDR 2007c).

Zinc (Zn)

Zinc is one of the most abundant metals on the planet. Production of galvanized metals contributes to dispersion of zinc throughout the environment. Zinc is found in elevated levels in groundwater at the Steelfields site; with production of alloy, corrosion-resistant bars at the Republic Steel Corporation (GGF 2009) and other processes related to steel production likely contributing to contamination. In water, like other metals, zinc adheres to particles and consequently is usually deposited in soils and sediments (Eisler 2000).

Zinc is considered to be an essential nutrient, and is required for the proper functioning of some metabolic processes. However, excess exposure to zinc can cause cancer, adverse reproductive effects, and even mortality in organisms at varying concentrations, depending upon the sensitivities of the organism (ATSDR 2005a; Eisler 2000). In general, aquatic organisms and birds are more sensitive than mammals to the toxicological effects of zinc. Although many organisms can bioaccumulate zinc, it does not appear to biomagnify through the food web.

Oral exposure to high levels of zinc can cause nausea and vomiting in humans. Chronic exposure to high levels of zinc via ingestion can cause anemia. Research also indicates that human skin exposure to zinc acetate and zinc chloride will cause skin irritation (ATSDR 2005a).

ANILINE

Aniline, an aromatic amine, is most well-known for its use in dye manufacturing (e.g. aniline-based dyes), but is also a common industrial intermediary chemical used in the production of products ranging from polyurethane foam to explosives (ATSDR 2002). Aniline is typically released into the environment via coal tar and shale oil processing, industrial waste streams, and accidental releases (Canada 1994). The Buffalo Color site formerly housed synthetic aniline based dye production. The use of aniline was so prevalent in the dye manufacturing process at that site that the previous company name was National Aniline & Chemical Company (GGF 2009).

In the environment aniline is readily broken down in surface water through photolysis, but still accumulates in aquatic sediments (ATSDR 2002). Although aniline does not appear to bioaccumulate through food webs it can cause adverse toxicological effects to exposed aquatic organisms including immobilization, growth and reproductive effects, and mortality (Canada 1994).

Human exposure to aniline damages hemoglobin, a molecule in red blood cells that transports oxygen to tissues in the body, which prevents the hemoglobin from effectively transporting oxygen. Aniline poisoning resulting from acute, high exposure to the toxicant can cause cyanosis (or a blue skin color), dizziness, headaches, convulsions, irregular heartbeat, coma and in some cases death. Chronic exposure to aniline at lower levels may also cause poisoning. The EPA has classified aniline as a probable human

carcinogen; however the IARC has determined that there is inadequate information to appropriately classify aniline's carcinogenic properties (ATSDR 2002).

PHENOLS

Phenols are a class of organic compounds defined by the presence of a hydroxyl group on a benzene ring or other aromatic hydrocarbon. In the U.S. pentachlorophenol (PCP), the most toxic of the phenols, is used primarily as a wood preservant. Phenols are often considered a nuisance contaminant because of their propensity to taint (e.g., via taste or smell) drinking water and fish. The major source of phenol is coal tar, and coal tar is a by-product of coke production, which occurred at the Donner Hanna Coke site (GGF 2009).

Phenols are an environmental concern in aquatic ecosystems because they can cause both direct and indirect effects on biota. Their chemical structure often causes phenols to act like acids, changing the pH of water and adversely affecting the reproduction, physiology, and survival of aquatic organisms (EPA 1976). Phenols can also increase biological oxygen demand in water, thereby reducing oxygen and indirectly harming aquatic organisms in surface water. PCP is rapidly bioconcentrated; organisms absorb PCP directly from the surrounding water rather than through their diet. PCP has been shown to cause adverse effects to all trophic levels of aquatic organisms (Eisler 2000).

Exposure to phenols can adversely affect humans if inhaled, ingested, or if there is contact with the skin. If inhaled, phenols can cause respiratory irritation and headaches. Ingestion can result in internal burns which may lead to death. Skin contact with high amounts of phenols has been shown to cause burns, liver damage, irregular heart beat, and death. Additionally, researchers have observed muscle tremors and coordination loss in animals that were exposed to very high concentrations of phenols in their water (ATSDR 2008).

BENZENE, TOLUENE, ETHYLBENZENE AND XYLENE (BTEX)

Benzene, toluene, ethylbenzene and xylene (BTEX) are a suite of volatile organic compounds that are common constituents of refined petroleum products (e.g., gasoline). As a former oil refining site, the ExxonMobil site is contaminated with BTEX compounds from the refining process (Roux Associates 2000). BTEX compounds are typically used as solvents in industrial processes or in the synthesis of other organic chemicals, including plastics.

Data available on the effects of BTEX indicate they are toxic to aquatic organisms. Of the four compounds, benzene has the potential to cause the most severe adverse effects, such as impacts to the central nervous system (ATSDR 2000) Although the EPA has not promulgated ambient water quality criteria for these chemicals, thresholds have been set for human consumption and these compounds are also covered under narrative regulations pertaining to oil and grease (EPA 1976).

Exposure to the each of the individual BTEX compounds can cause neurological impairment and can negatively affect human health (ATSDR 2004b). Inhalation of high levels of benzene causes dizziness, confusion, headaches, tremors, unconsciousness, and

at very high levels may even result in death. Ingesting benzene can cause irritation of the stomach, dizziness, rapid heart rate, or death (ATSDR 2007d). Toluene exposure through inhalation can result in many of the same symptoms of benzene exposure but can also cause hearing and color vision loss (ATSDR 2001). Ethylebenzene is less toxic than benzene or toluene; although high levels of ethylbenzene exposure still causes eye and throat irritation, and dizziness (ATSDR 2007e). Exposure to xylenes at high levels can also cause many of the same symptoms as toluene or benzene (ATSDR 2005b). Studies investigating the toxicity of BTEX compounds as a mixture are few, but research models indicate that exposure to high levels of BTEX via inhalation (20 ppm of each compound) likely increases neurotoxic effects in humans (ATSDR 2004b).

CHLORINATED BENZENES

Chlorinated benzenes are a class of twelve similar compounds: monochlorobenzene; 1,2-,1,3-,1,4-dichlorobenzene; 1,2,3-, 1,2,4-, 1,3,5-trichlorobenzene; 1,2,3,4-, 1,2,3,5-, 1,2,4,5-tetrachlorobenzene; pentachlorobenzene; and hexachlorobenzene. Chlorinated benzenes have been used as solvents, electrical insulators, pesticides, herbicides, fungicides, and dye carriers. Chlorinated benzenes are found at elevated concentrations at the PVS Chemical site. The former dye manufacturing and other chemical production processes at that site (GGF 2009) likely used chlorinated benzenes. Additionally, manufacturers have used chlorinated benzenes in the production of pesticides such as DDT. Manufacturing processes can release chlorinated benzenes into the air through emissions, or to the water during waste disposal (EPA 1985a).

Chlorinated benzenes tend to have low water solubility and high soil adsorption, and will bioaccumulate in the fatty tissues of biological organisms. Chlorinated benzenes negatively affect fish and invertebrate reproduction, and can be toxic to plants. Insects exposed to chlorinated benzenes suffer from developmental effects, and shortened lifespans. Although the impacts of chlorinated benzenes on birds and mammals are not fully understood, researchers have documented the presence of chlorinated benzenes in the fat of wild animal populations and bird eggs (EPA 1985a).

Humans can be exposed to chlorinated benzenes from the air, water, or food. Exposure to 1,2,4-trichlorobenzene at levels of 3 to 5 ppm in air can irritate the respiratory system and eyes. Other health impacts of trichlorobenzenes are largely unknown but research on mammals indicates acute exposure to trichlorobenzenes can cause damage to the liver and kidney (ATSDR 2010; EPA 1985a). Research of acute and sub-chronic exposure via inhalation, or ingestion of dichlorobenzene in animals resulted in adverse effects on the heart, kidney, liver, spleen, thymus, and the central nervous system. Humans exposed to 1,2-dichlorobenzene and 1,4-dichlorobenzene at high concentrations were found to experience irritation of the eyes and nose, difficulty breathing and an upset stomach (ATSDR 2006).

INJURY DETERMINATION

According to the DOI NRDA regulations:

> *An injury to the ground water resource has resulted from the discharge of oil or release of a hazardous substance if one or more of the following changes in the physical or chemical quality of the resource is measured:*
>
> *(i) Concentrations of substances in excess of drinking water standards, established by sections 1411–1416 of the SDWA [Safe Drinking Water Act], or by other Federal or State laws or regulations that establish such standards for drinking water, in ground water that was potable before the discharge or release;*
>
> *(ii) Concentrations of substances in excess of water quality criteria, established by section 1401(1)(d) of the SDWA, or by other Federal or State laws or regulations that establish such criteria for public water supplies, in ground water that before the discharge or release met the criteria and is a committed use, as the phrase is used in this part, as a public water supply;*
>
> *(iii) Concentrations of substances in excess of applicable water quality criteria, established by section 304(a)(1) of the CWA, or by other Federal or State laws or regulations that establish such criteria for domestic water supplies, in ground water that before the discharge or release met the criteria and is a committed use as that phrase is used in this part, as a domestic water supply; or*
>
> *(iv) Concentrations of substances sufficient to have caused injury as defined in paragraphs (b), (d), (e), or (f) of this section to surface water, air, geologic, or biological resources, when exposed to ground water. (43 C.F.R. § 11.62(c)(1)).*

Determination that injury to groundwater has occurred at the BRIC sites consists of the documentation below, which demonstrates that there is (1) a pathway for the hazardous substance from a release point to the groundwater, and (2) groundwater has been injured pursuant to paragraph (i) of the injury definition above. Pursuant to paragraph (i) above, groundwater in the River's watershed is classified as Class GA fresh groundwater with its best use "as a source of potable water supply" under New York State law (6 NYCRR § Part 701.15). The applicable state regulations are the NYSDEC groundwater and surface water standards (6 NYCRR § Part 703) in effect at the time of sampling.

DETERMINATION OF INJURY

As noted above, the purpose of this report is to document that injury to groundwater resources in the vicinity of the Buffalo River has occurred. Information presented below demonstrates that the elements contained in the DOI NRDA regulations have been met, fulfilling the requirements for groundwater injury determination (43 C.F.R. § 11.61 through 11.63). Specifically, across the five BRIC sites this report presents information to establish:

- Sources and pathways for the release of the hazardous substances and oil to groundwater resources.

- Groundwater contamination in exceedance of applicable groundwater standards (Class GA; 6 NYCRR Part 701), drinking water Maximum Contaminant Levels (MCLs) (10 NYCRR, Subpart 5-1), or guidance values for the following:
    - Water characteristics: pH;
    - Inorganic contaminants: arsenic, barium, beryllium, cadmium, chromium (hexavalent), chromium (trivalent), copper, cyanide, iron, lead, magnesium, manganese, mercury, nickel, nitrate, nitrite, selenium, sodium, sulfate, sulfide, and zinc.
    - Organic contaminants: 1,1-dichloroethene, 1,2-dichlorobenzene, 1,2-dichloroethene, 1,2,4-trichlorobenzene, 1,2,4-trimethylbenzene, 1,3 -dichlorobenzene, 1,3,5-trimethylbenzene, 1,4-dichlorobenzene, 2-butanone, 2,4-dimethylphenol, 4-isopropyltoluene, 4-chloroaniline, acenaphthene, acetone, aniline, anthracene, benzene, benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chloride, chlorobenzene, chloroform, chrysene, ethylbenzene, fluoranthene, fluorene, ideno(1,2,3,-cd)pyrene, methylene chloride, naphthalene, n-butylbenzene, n-propylbenzene, phenanthrene, phenol, pyrene, sec-butylbenzene, toluene, vinyl chloride, and xylenes.

PATHWAY

An important component of injury determination in the context of NRDA is the documentation of an injury pathway. A pathway is defined as:

> *The route or medium through which…a hazardous substance is or was transported from the source of the discharge or release to the injured resource (43 C.F.R. § 11.14(dd)).*

The BRIC industries have had a series of operational malfunctions throughout their operational history resulting in spills of hazardous substances and oil. Releases of hazardous substances and oil in excess of permitted levels, and inadequate disposal of waste materials (e.g. on-site waste ponds) have also served as release points for hazardous chemicals. Once hazardous substances or oil were released into the environment the pathway to groundwater in the shallow aquifer was through unconsolidated soils underneath the BRIC sites. Contaminants in groundwater are subsequently remobilized and re-released as they flow through the contaminated aquifer. Below, we provide brief descriptions of each site, and then provide examples of the releases of hazardous substances and/or oil that led to the pathways of groundwater contamination and a summary of remedial actions that have been conducted to date. Remedial actions may serve to reduce the severity or degree of natural resource injuries, which are being evaluated as part of the NRDA effort. For more information on remedial activities at each of the BRIC sites, readers are referred to the NYSDEC website at: http://www.dec.ny.gov/chemical/37554.html.

PVS Chemical Solutions/Allied Chemical Corporation-Industrial Chemical Division Site

The PVS Chemical Solutions site is the former Allied Chemical Corporation -Industrial Chemical Division site. The site is located at 55 Lee Street and borders the former Buffalo Color Corporation site on the north and 1,500 linear feet of the River to the south (Exhibit 1). Groundwater at the site occurs at a depth of around eight to fifteen feet and flows south toward the River (NYSDEC 2011). The Allied Chemical Corporation - Industrial Chemical Division historically produced sulfurous chemicals including sulfur dioxide, sulfuric acid, and other chemicals such as anhydrous ammonia and diethanolamine (GGF 2009). In 1981, PVS Chemicals purchased the sulfuric acid and sulfur manufacturing facilities from Allied Chemical (PVS Chemicals 2011) but Honeywell International, Inc. (the corporate successor of Allied) retained access rights for environmental remediation at the PVS site. PVS Chemicals, through its subsidiary, PVS Chemical Solutions, continues to operate the facility today, producing many of the same chemicals it has produced historically.

- **Pathway:** As part of their former disposal practices, between 1930 and 1977 Allied Chemical released liquid wastes into an unlined seepage pit on site (NYSDEC 2011). The seepage pit held nitric and sulfuric acid, sulfur drainings, and nitric rinses containing cadmium (NYSDEC 2011). The unlined seepage pit allowed hazardous substances to migrate into the soil and groundwater below the site. From 1982 to 1989 groundwater was monitored in the vicinity of the seepage pit and Phase I & II RCRA site investigation reports were completed, showing groundwater violations for pH, iron, lead, and other metals and demonstrating a pathway through which hazardous substances entered groundwater from the pit. NYSDEC listed contaminants of concern for the site include arsenic, cadmium, chlorobenzene, and sulfuric acid (NYSDEC 2011).

  Broken pipes also allowed for the contamination of groundwater. A 1996 NYSDEC lawsuit against PVS Chemicals declared that "acid had entered discharge water due to leaking pipes, broken valves, equipment failures and inadequate containment measures" (Buffalo News 1996). Subsequently, NYSDEC cited PVS Chemicals in a 1996 lawsuit for 20 CWA violations, which also covered illegal releases of contaminants to the groundwater and the air due to the faulty pipe system, demonstrating yet another pathway for groundwater contamination at the site (Buffalo News 2002).

- **Remedial Efforts:** Some remediation efforts have occurred at the PVS Chemicals site. For example, the unlined liquid waste seepage pit was excavated in 1977. In response to the broken pipe system, PVS Chemicals installed above ground pipes and replaced "valves, fittings, pumps, mechanical equipment, and containment structures" (Buffalo News 1997). Additionally, as a result of a 2002 Stipulation and Order of Settlement between NYSDEC and PVS Chemical, in 2003 PVS conducted a second soil and groundwater investigation (NYSDEC 2011). PVS installed a groundwater monitoring network on site (FTA 2002; FTA 2003), and agreed to construct a water treatment facility, install liners around pipes and valves, remove old pipes, and conduct quarterly groundwater monitoring (Buffalo News 2002; NYSDEC 2011).

Steelfields/Donner Hanna Coke and Republic Steel Site

The 215-acre Steelfields site encompasses the former Donner Hanna Coke and Republic Steel sites and is now primarily owned by the Buffalo Urban Development Corporation. It is divided into four areas: Area I is the former Republic Steel plant parcel, Area II is the former Donner Hanna Coke plant parcel, Area III is the former Republic Steel warehouse parcel, and Area IV is the former Donner Hanna Coke yard parcel (Exhibit 1; Turnkey 1998). Republic Steel primarily produced iron and steel products and Donner Hanna Coke primarily produced coke for Republic Steel (Turnkey 1998). Historically, Republic Steel and Donner Hanna Coke maintained operations from the early 1900s through 1982 (Turnkey 1998).

- **Pathway:** Contaminants found at the Republic Steel and Donner Hanna Coke sites are common by-products of the site's previous uses for coal handling, coke processing, and steel manufacturing, such as metals and PAHs (Turnkey 1998). Remediation in Area I from 2003 to 2008 included the removal of soils contaminated with benzene, semi-volatile organic compounds, and metals; and the establishment of a groundwater collection and treatment system to remove oil contaminants. A 2009 report of the long-term groundwater monitoring for Areas I- III found concentrations of benzene, n-butylbenzene, sec-butylbenzene, isopropylbenzene, n-propylbenzene, arsenic, and cyanide in exceedance of their respective groundwater quality standards, or guidance values for at least one monitoring well on the property (Turnkey 2009). The pathway for most groundwater contamination likely existed as a result of normal operations, and improper handling and disposal of materials and their residuals at the ground surface (Turnkey 1998). Specific incidences of potential groundwater contamination do exist: prior to 1953 the Donner Hanna facility discharged ammonia still waste containing phenol directly into a well approximately 145 feet below ground (Millock et al. 1979). Later, in 1968, Republic Steel was also responsible for a spill of heating and lubrication oil (Buffalo Courier Express 1968).

- **Remedial Efforts:** In 1984, LTV Steel purchased the majority of the Republic Steel and Donner Hanna Coke sites, sold physical assets, and began remediation to allow for future development (GGF 2009). In 1998, a voluntary clean-up plan and site assessment report was issued (Turnkey 1998). Partial environmental remediation occurred at the site under LTV ownership, but accelerated in scope beginning in 2002 when Steelfields purchased the site (GGF 2009). As alluded to above, from 2003 to 2008 extensive remediation occurred (GGF 2009). In addition to the removal of soils and groundwater collection and treatment in Area I, Area II remediation also encompassed a groundwater pump and treatment system as well as a containment cell. Remediation efforts for Area III have included the removal of contaminated soils. However, despite remediation efforts, groundwater contamination persists in Areas I-III.

  The Donner Hanna Coke site Area IV was remediated under the Brownfields Clean-up Program (BCP). Remediation included the removal of contaminated

soils and solid waste, and the construction of a passive groundwater remediation system. Institutional controls on the site prohibit groundwater use and restrict the site to industrial uses only. In 2007 the NYSDEC declared the remediation complete (NYSDEC 2013a).

Buffalo Color Corporation Site

The Buffalo Color Corporation (Buffalo Color) site is the former Allied Chemicals - Specialty Chemicals Division site. The site is divided into five areas (A through E). Area D was a hazardous waste disposal site and areas A, B, C, and E housed facility operations (Exhibit 1). Allied Chemicals' corporate predecessors commenced operations at the site in 1879 and manufactured a variety of organic chemicals and dyes typically using aniline and aniline derivatives until they sold the site to Buffalo Color in 1977 (Mactec 2008). Buffalo Color continued operations until 2003 and primarily produced indigo dye, alkylanilines, and dye intermediates (Mactec 2008). In 2005 Buffalo Color declared bankruptcy, and although Buffalo Color owns the majority of the site, Honeywell International (Allied Chemicals' corporate successor) acquired access rights for environmental remediation and investigation (Mactec 2008).

- **Pathway:** Pathways for groundwater contamination include spills, and improper disposal practices of products and by-products of operations. Buffalo Color disposed of wastewater from their dye manufacturing process in three ponds in Area E starting in the 1970's. Although the ponds were closed and Buffalo Color removed the sludge and liner materials by 1988, the NYSDEC found contaminants down-gradient of the ponds in the groundwater, demonstrating a link between the ponds and contamination of the groundwater (Mactec 2008). Between 1957 and 1960 Buffalo Color installed a deep ammonium sulfate wastewater disposal well 180 feet below ground in Area E, representing another conduit for contaminants to enter groundwater. In 1960, Buffalo Color extended the well depth to 744 feet, and in 1989 the well was plugged in accordance with a NYSDEC approved closure plan (Mactec 2008).

  Buffalo Color Area D was a hazardous waste disposal site which included iron oxide sludge lagoons, open pit burning of solid and liquid wastes, a storage area for other metal oxide sludges, and incineration of chemical wastes (Gouck 1984, Malcolm Pirnie, Inc. 1989). Incinerated materials at Buffalo Color Area D included naphthalene-based wastes (a PAH) and 1,2-Dichlorobenzene, a chlorinated benzene (Malcolm Pirnie, Inc. 1989). Additionally, in 1997 a broken sewer pipe six feet underground in Area D caused the release of elemental mercury to site soils (Mactec 2008). Contamination of groundwater occurred as a consequence of the chemical constituents from the waste storage areas becoming soluble and migrating downwards (Malcolm Pirnie, Inc. 1989).

  Remedial Efforts: The Area D remedial investigation report was released in 1989 and the Areas "ABCE" remedial investigation report was released in 2008. The 1989 Remedial Investigation report for Area D eventually led to a 1991 agreement between the NYSDEC, and Allied-Signal and Buffalo Color to clean-

up the site. The clean-up included containment mechanisms for the contaminated sediment, wells for the treatment of polluted groundwater and a cap of the area with clean fill and grasses (GGF 2009).

In 2005 Honeywell conducted an Interim Corrective Measure (ICM) clean-up to address problems at areas A, B, C, and E. Some of the work they completed addressed the contaminated groundwater at the sites. The ICM installed a groundwater extraction system in Area A to manage the movement of groundwater to the Buffalo River; for Areas B, C, and E, the ICM controlled the discharge location of the groundwater through the existing sewer system (NYSDEC 2009).

Other clean-up work through the State's BCP on Areas A, B, C, and E began in June of 2009 and more thoroughly addressed groundwater contamination. In addition to the 2005 ICM groundwater extraction system in Area A, remedial work under the BCP included a hydraulic barrier between the Buffalo River and Area A groundwater, and an extraction system to increase the effectiveness of the system. Other efforts included measures to monitor, control, and treat groundwater in Areas B, C, and E (NYSDEC 2009). Remediation efforts undertaken through the BCP have made progress: in January 2011 the NYSDEC certified the completion of the remedial activities at Area C (NYSDEC 2011).

ExxonMobil Site

The ExxonMobil site covers approximately 90 acres on the north side of the River near its origin at the confluence of Buffalo and Cazenovia Creeks (Roux 2000; Roux 2007). The site is split into multiple Operational Units (OU) including four terrestrial units OU-1 through OU-4 (Exhibit 1). ExxonMobil's corporate predecessor, the Standard Oil Company, purchased the majority of the site in 1892 (Roux 2000). A portion of the site was owned by the City of Buffalo between 1915 and 1951, and used for a municipal dump between 1921 and 1951 (Roux 2000). Through 1981, the site was used primarily for petroleum refining operations and subsequently for petroleum distribution and storage operations (Roux 2000). In 2005 ExxonMobil sold a 35.8 acre portion of the site with distribution and storage facilities to Buckeye Terminals LLC, owned by Buckeye Partners, LP, a former subsidiary of the Standard Oil Company (Roux 2007; 2010).

- **Pathway:** Groundwater contamination at the ExxonMobil site is the result of a series of spills, operational malfunctions, and disposal practices (NYSDEC 2005). As noted above, since PAHs are the primary long-lived toxic constituent of petroleum products such as gasoline and oil, groundwater contamination with PAHs, such as benz(a)anthracene and naphthalene, is understood to be a direct result of these releases of crude oil and spills of gasoline at the Exxon Mobil site. Roux Associates (2000) documented approximately 70 incidents of unpermitted petroleum product discharges between 1976 and 2000 ranging from multiple small discharges causing oily sheens on the Buffalo River to larger spills of gasoline. A 1993 spill released 42,600 gallons of super unleaded gasoline on the ground. Although ExxonMobil recovered some of the product, over 20,000

gallons of gasoline could not be recovered and remains in the groundwater and subsurface. Former Exxon Mobil employees also reported pump malfunctions that released frequent discharges of crude oil to the ground surface. For example, a 1976 steel tank rupture released an unknown amount of cracking stock into the environment, yet the spill was widespread and significant enough to cause abandonment of several nearby residences (Roux 2000).

- **Remedial Efforts:** In 2006, the ExxonMobil site entered the BCP (Roux 2007). Exxon Mobil has completed work on some sections of the property including soil excavation and off-site disposal. Cleanup activities related to groundwater began in April, 2013 and include the construction of a vertical low permeable wall in order to inhibit movement of contaminated groundwater. Other cleanup efforts through the BCP are currently under NYSDEC investigation and alternatives analysis review (NYSDEC 2013b).

SELECTED GROUNDWATER VIOLATIONS INDICATIVE OR SUGGESTIVE OF INJURY TO GROUNDWATER RESOURCES

The five BRIC industrial sites share a similar history of environmental contamination through releases of hazardous substances and/or oil. As a result, each BRIC site exhibits the presence and persistence of groundwater contamination. Below we present information that demonstrates hazardous substances or oil were, or are in the groundwater at BRIC sites in exceedance of groundwater quality standards, or groundwater quality guidance values. Data sources for this injury determination are site-wide environmental investigations, such as Remedial Investigations or Feasibility Studies. For some sites, subsequent studies or monitoring reports are used because groundwater contamination is more adequately characterized in these reports. The selected violations represented below document examples of contamination of groundwater with hazardous substances or oil above respective injury thresholds. Each of these exceedances constitutes injury to groundwater resources or is suggestive of injury to groundwater resources under the DOI Regulations at CFR Part 11. The selected exceedances are not meant to be exhaustive of all documented or potential injury that has occurred or continues to occur at these sites.

PVS Chemical Solutions/Allied Chemical Corporation-Industrial Chemical Division Site

At the PVS Chemical Solutions site violations of groundwater standards and guidance values occurred for pH and a number of inorganic and organic contaminants including arsenic, zinc, PAHs (such as naphthalene), and chlorinated benzenes (such as 1,2-, 1,3-, 1,4-dichlorobenzene, and 1,2,4- trichlorobenzene) (FTA 2003). Exhibit 2 presents maximum observed groundwater contamination levels (Class GA; 6 NYCRR Part 703) documented in the PVS Chemicals 2002 and 2003 quarterly monitoring reports. A map of the PVS Chemical site showing the locations of groundwater quality monitoring sites on the property is presented in Exhibit 3.

Steelfields/Donner Hanna Coke and Republic Steel Site

Contaminants at the Steelfields site include benzene, toluene, ethylbenzene and xylene (BTEX), PAHs, and metals such as lead, phenols, and cyanide (Turnkey 1998). Exhibit 4 presents well monitoring results from 1997 through 1998 that document contamination in

excess of groundwater standards at the Steelfields sites Areas I-IV for a variety of organic and inorganic substances (Turnkey 1998). Exhibit 5 presents the locations of the well monitoring locations at Steelfields Areas I-IV.

Buffalo Color Corporation Site

Violations of water quality standards in groundwater of the Buffalo Color Areas “A” through “E” have been documented for a number of inorganic and organic contaminants (Mactec 2008). Investigative documents reveal significant groundwater contamination with metals such as arsenic, chromium, lead, and mercury; and organic contaminants such as chlorinated benzenes and PAHs. Groundwater contaminants such as aniline are common products and by-products of historical activities at the Buffalo Color site (Mactec 2008). Exhibit 6 displays results from the 1989 Remedial Investigation for Area D that demonstrate numerous groundwater standard violations for inorganic and organic contaminants including chlorinated benzenes (e.g. 1,2-, 1,3-, 1,4-dichlorobenzene, 1,2,4 trichlorobenzene) and PAHs (e.g. benz(a)anthracene, fluoranthene,naphthalene, phenanthrene; Malcolm Pirnie, Inc. 1989); and Exhibit 7 depicts the locations of the groundwater monitoring well sites. The 1989 Remedial Investigation also found an oily sheen in soils, and a six-foot layer of light non-aqueous phase liquid in the groundwater (Malcolm Pirnie, Inc. 1989). Exhibits 8 and 9 present results from the 2008 Remedial Investigation for Areas "ABCE". Exhibit 9 depicts the amounts and types of groundwater contaminants found on site.

ExxonMobil Site

Discharges at the ExxonMobil site have resulted in underground plumes of liquid petroleum, first reported in 1989 (NYSDEC 2005) and still present in 2013 as petroleum product floating on the surface of the groundwater (NYSDEC 2013b). This report presents data from monitoring reports from the third quarter of 2007. Exhibit 10 presents groundwater contamination for a variety of organic contaminants including BTEX and other petroleum products or by-products, and Exhibit 11 depicts the locations of the separate-phase product contamination (Roux 2007). Additionally, at OU-4, separate-phase product was observed during the installation of monitoring wells in 2000, and collected from multiple wells (Roux 2010). The total estimated volume of recoverable and trapped (in the subsurface) separate-phase liquid is approximately 1,900 gallons (Roux 2010).

EXHIBIT 2 **GROUNDWATER VIOLATIONS AT THE PVS CHEMICAL SOLUTIONS SITE FROM 2002-2003 INDICATED IN QUARTERLY MONITORING REPORTS**

CONTAMINANTS	ENFORCEABLE STANDARD, OR GUIDANCE VALUE (µG/L)	MAXIMUM OBSERVED VIOLATION (µG/L)
pH	6.5 – 8.5[1]	2.4[1]
Arsenic	25	10,500
Cadmium	5	6,380
Chromium	50	794
Copper	200	1,590
Iron	300	5,600
Lead	25	230
Manganese	300	56,000
Nickel	100	15,900
Nitrate / Nitrite	10,000	199,000
Selenium	10	13.9
Sulfate	250,000	45,100,000
Zinc	5,000	48,600
Acetone	50[2]	510
Benzene	1	68
2 Butanone	50[2]	78
Chloride	250,000	643,000
Chlorobenzene	5	4,800
1,2 Dichlorobenzene	3	1,800
1,3 Dichlorobenzene	3	450
1,4 Dichlorobenzene	3	1000
Chloroform	7	260
Ethylbenzene	5	18
Naphthalene	10[2]	2000
Phenol	1	200
Toluene	5	42
1,2,4 Trichlorobenzene	5	120
Xylenes	5	90

Source: (FTA 2003). Note: Only contaminants with two or more violations are presented. The maximum contaminant violations presented are from the cited report and may not be universal maxima over time and space for the site.

Note: The enforceable state regulations are the 1998 NYSDEC groundwater and surface water standards (6 NYCRR § Part 703) in effect at the time of sampling.

1. pH is defined as the negative base 10 log of the hydrogen ion concentration in moles per liter of solution.

2. New York State Guidance Values for Class GA Waters 1998.

EXHIBIT 3 WELL MONITORING LOCATIONS AT PVS CHEMICAL SOLUTIONS SITE (FTA, 2002)

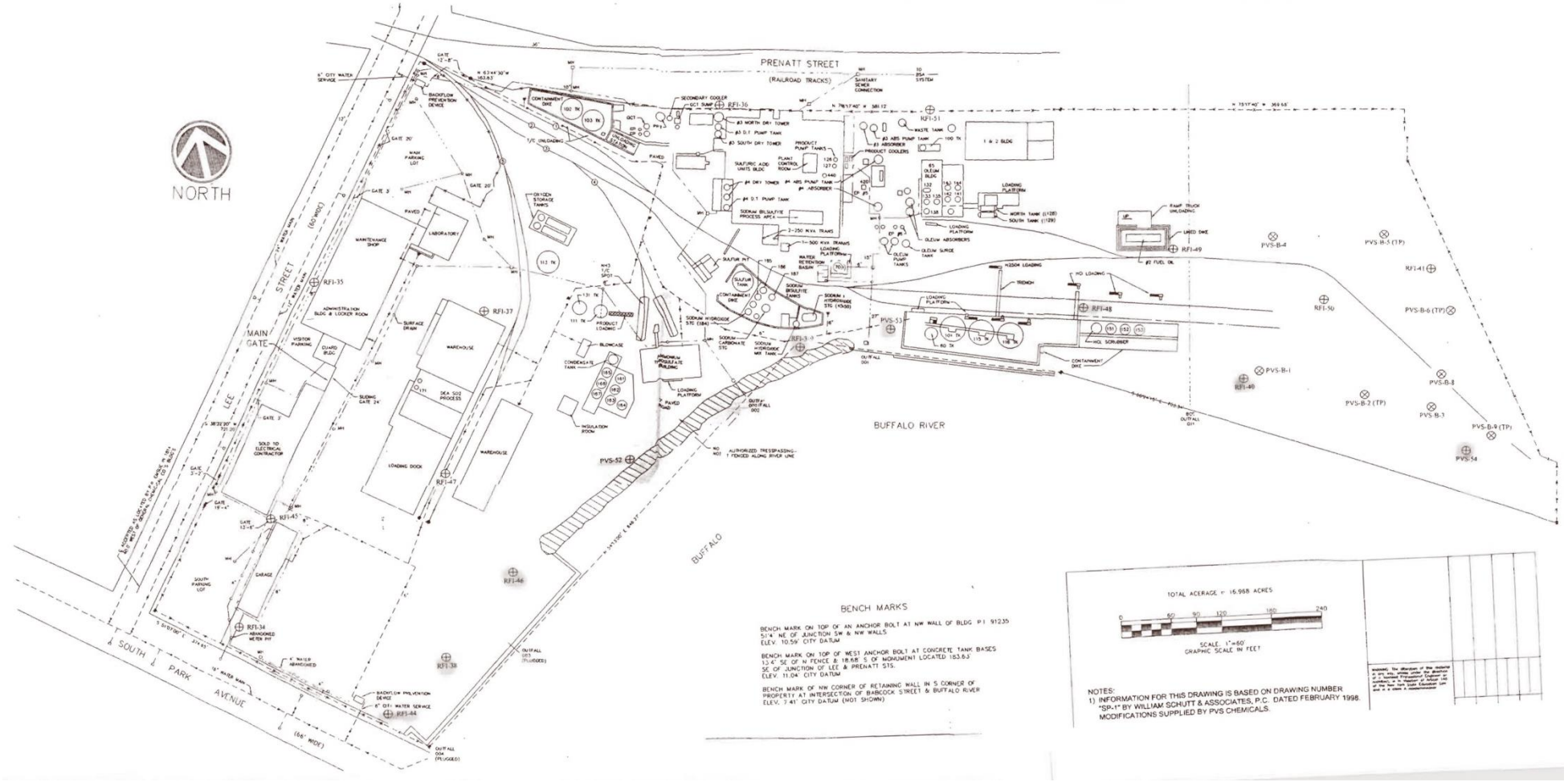


EXHIBIT 4 **GROUNDWATER VIOLATIONS FOR THE STEELFIELDS SITE FROM 1998 VOLUNTARY CLEAN-UP INVESTIGATION**

CONTAMINANTS	ENFORCEABLE STANDARD, OR GUIDANCE VALUE (µG/L)	MAXIMUM OBSERVED VIOLATION (µG/L)
Arsenic	25	110
Beryllium	3	154
Cadmium	10	108
Chromium	50	312
Copper	200	4,580
Cyanide	100	17,000
Iron	300	11,400,000
Lead	25	78,400
Magnesium	35,000	2,420,000
Manganese	300	248,000
Selenium	10	21
Sodium	20,000	728,000
Zinc	300	26,100
Acenaphthene	20[1]	400
Acetone	50[1]	900
Anthracene	50[1]	270
Benzene	0.7	12,000
Benz(a)anthracene	0.002[1]	240
Benzo(b)fluoranthene	0.002[1]	320
Benzo(k)fluoranthene	0.002[1]	160
Chrysene	0.002[1]	260
Ethylbenzene	5	250
Fluoranthene	50[1]	660
Fluorene	50[1]	340
Indeno(1,2,3-cd)pyrene	0.002[1]	140
Naphthalene	10	3,900
Phenanthrene	50	680
Phenol	1	150
Pyrene	50[1]	460
Toluene	5	400
Xylenes (total)	5	880

Source: Turnkey 1998. Note: Only contaminants with two or more violations are presented. The maximum contaminant violations presented are from the cited report and may not be universal maxima over time and space for the site.

Note: The enforceable state regulations are the 1998 NYSDEC groundwater and surface water standards (6 NYCRR § Part 703) in effect at the time of sampling.

1. New York State Guidance Values for Class GA Waters 1998.

EXHIBIT 5 WELL MONITORING LOCATIONS AT STEELFIELDS AREAS I-IV (TURNKEY, 2005)

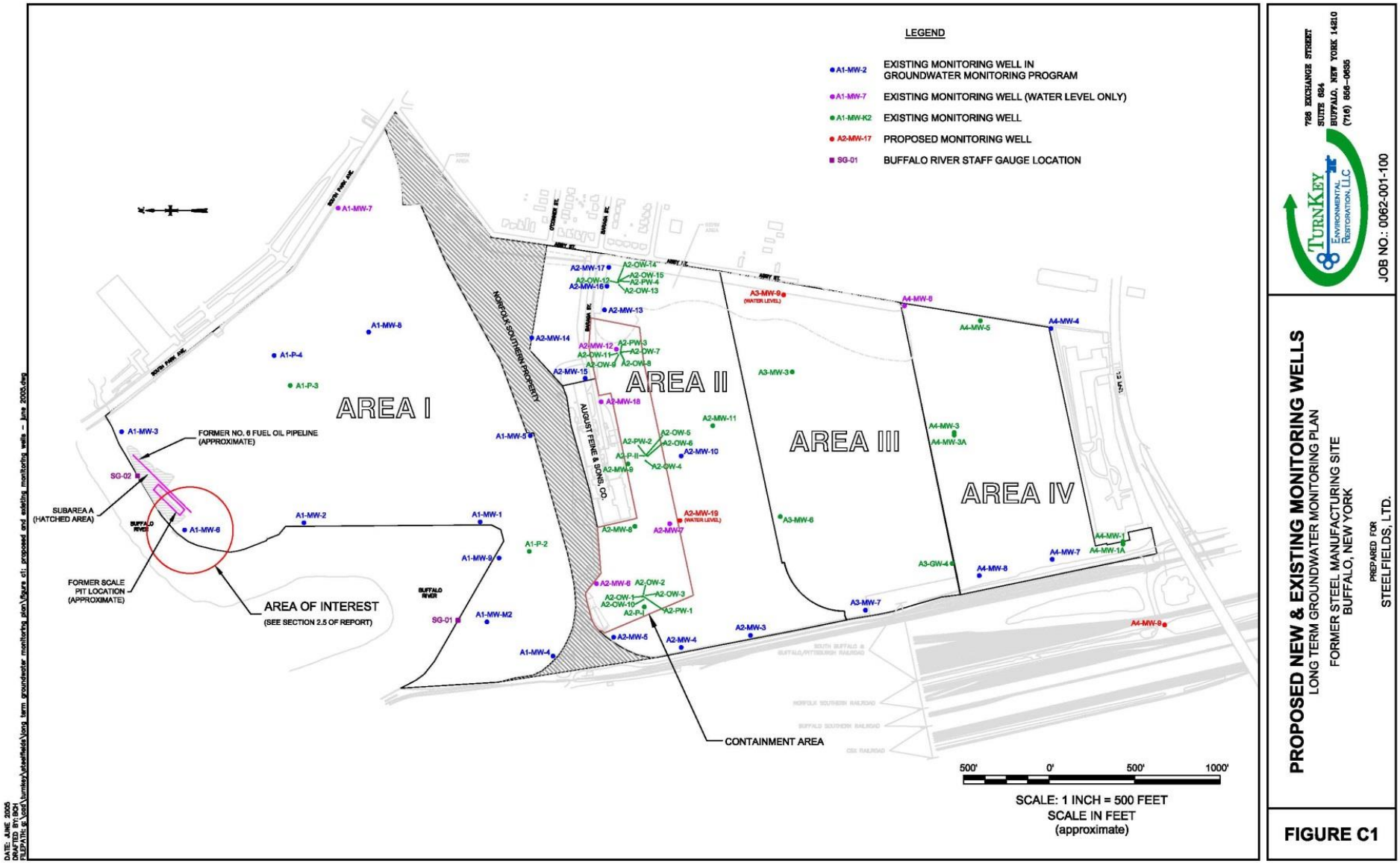


EXHIBIT 6 BUFFALO COLOR AREA D SITE GROUNDWATER VIOLATIONS

CONTAMINANTS	ENFORCEABLE STANDARD, OR MAXIMUM CONTAMINANT LEVEL (µG/L)	MAXIMUM OBSERVED VIOLATION (µG/L)
Arsenic	25	1,820
Barium	1,000	1,020
Cadmium	10	127
Chromium	50[1]	2,140
Chromium (hexavalent)	50	130
Copper	1,000	78,700
Lead	25	3,030
Mercury	2	50
Zinc	5000	9,950
Benzene	Not detectable	28,000
Benzo(a)pyrene	Not detectable	7
Chlorobenzene	5 [1]	48,000
1-2 Dichlorobenzene	5 [1]	21,000
1-3 Dichlorobenzene	5 [1]	49
1-4 Dichlorobenzene	5 [1]	4,900
1,1 Dichloroethene	5 [1]	8
1,2 Dichloroethene	5 [1]	19
Ethylbenzene	5 [1]	43,000
1,2,4 Trichlorobenzene	5 [1]	1,200
Toluene	5 [1]	4,700
Vinyl Chloride	2 [1]	6
Xylenes (total)	5 [1]	1,700

Source: Malcolm Pirnie, Inc. 1989. Note: Only contaminants with two or more violations are presented. The maximum contaminant violations presented are from the cited report and may not be universal maxima over time and space for the site.

Note: The enforceable state regulations are the 1978 NYSDEC groundwater and surface water standards (6 NYCRR § Part 703) in effect at the time of sampling.

1. Maximum Contaminant Levels (MCLs) for drinking water by the New York State Department of Health (10 NYCRR, Subpart 5-1, Public Water Supplies).

EXHIBIT 7 WELL MONITORING LOCATIONS AND AREAS OF CONCERN AT BUFFALO COLOR SITE D (PARSONS, 2001)

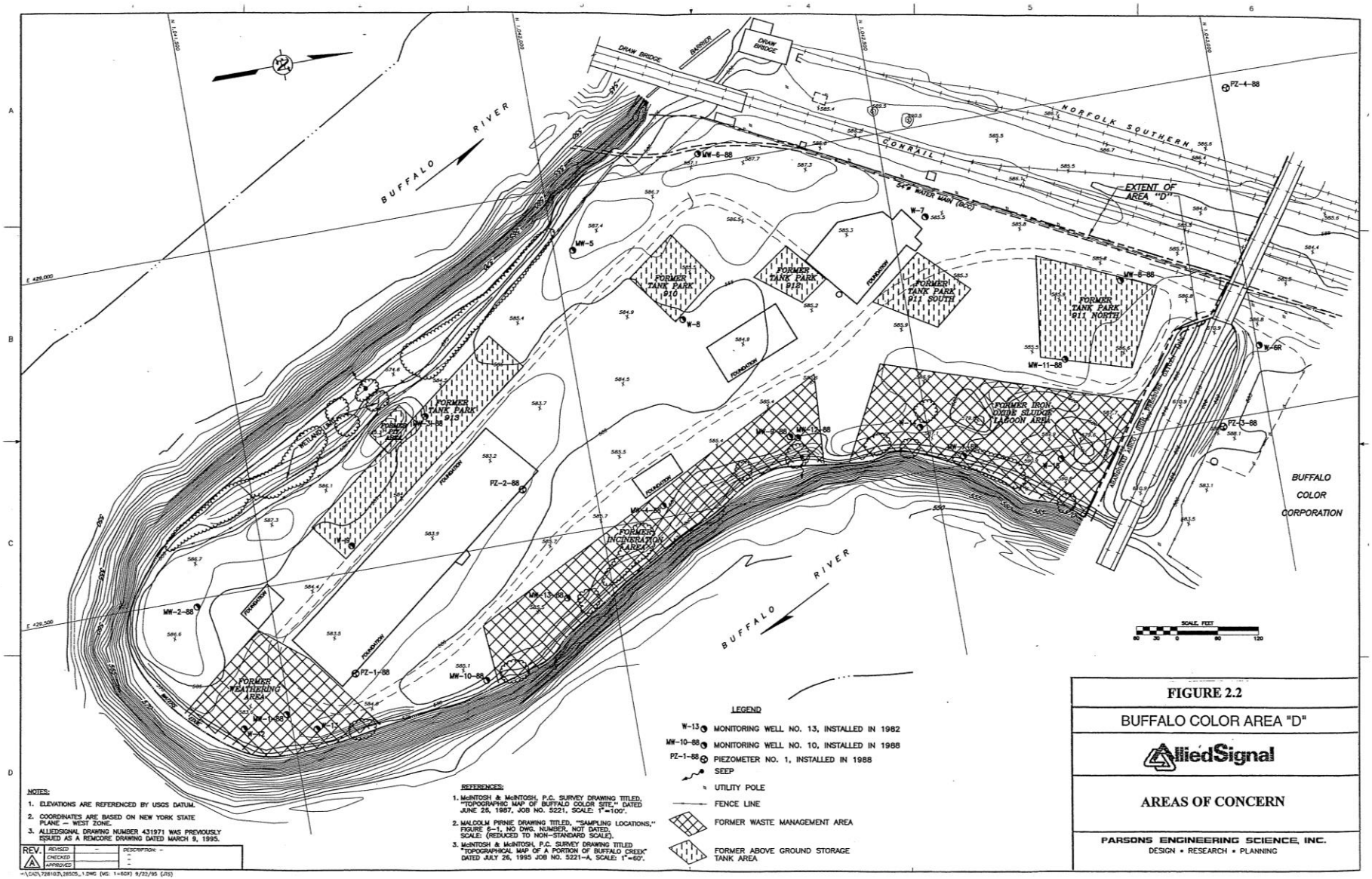


EXHIBIT 8 BUFFALO COLOR AREA "ABCE" GROUNDWATER VIOLATIONS, 2008

CONTAMINANT	ENFORCEABLE STANDARD, OR GUIDANCE VALUE (µG/L)	MAXIMUM VIOLATION (µG/L)
Arsenic	25	1,700
Chloride	250,000	5,870,000
Cyanide	200	870
Chromium (trivalent)	50	2,060
Iron	300	1,110,000
Lead	25	70
Magnesium	35,000[1]	512,000
Manganese	300	31,500
Mercury	0.7	3
Sodium	20,000	2,020,000
Sulfate	250,000	4,240,000
Sulfide	50[1]	14,400
Acenaphthene	20[1]	1,400
Aniline	5	16,000
Benzene	1	6,700
Benz(a)anthracene	0.002[1]	80
Benzo(b)fluoranthene	0.002[1]	95
4-Chloroaniline	5	21
Chlorobenzene	5	33,000
1-2 Dichlorobenzene	3	4,400
1-3 Dichlorobenzene	3	140
1-4 Dichlorobenzene	3	2,300
Chrysene	0.002[1]	70
Ethylbenzene	5	1,300
Methylene Chloride	5	350
2-4 Dimethylphenol	1	71
Naphthalene	10[1]	50,000
Toluene	5	120
Xylenes (total)	5	9,100

Source: Mactec 2008. Note: Only contaminants with two or more violations are presented. The maximum contaminant violations presented are from the cited report and may not be universal maxima over time and space for the site.

Note: The enforceable state regulations are the 2008 NYSDEC groundwater and surface water standards (6 NYCRR § Part 703) in effect at the time of sampling.

1. New York State Guidance Values for Class GA Waters 1998.

EXHIBIT 9 WELL MONITORING LOCATIONS AND GROUNDWATER CONTAMINANTS AT BUFFALO COLOR SITES A,B,C,E (MACTEC, 2008)

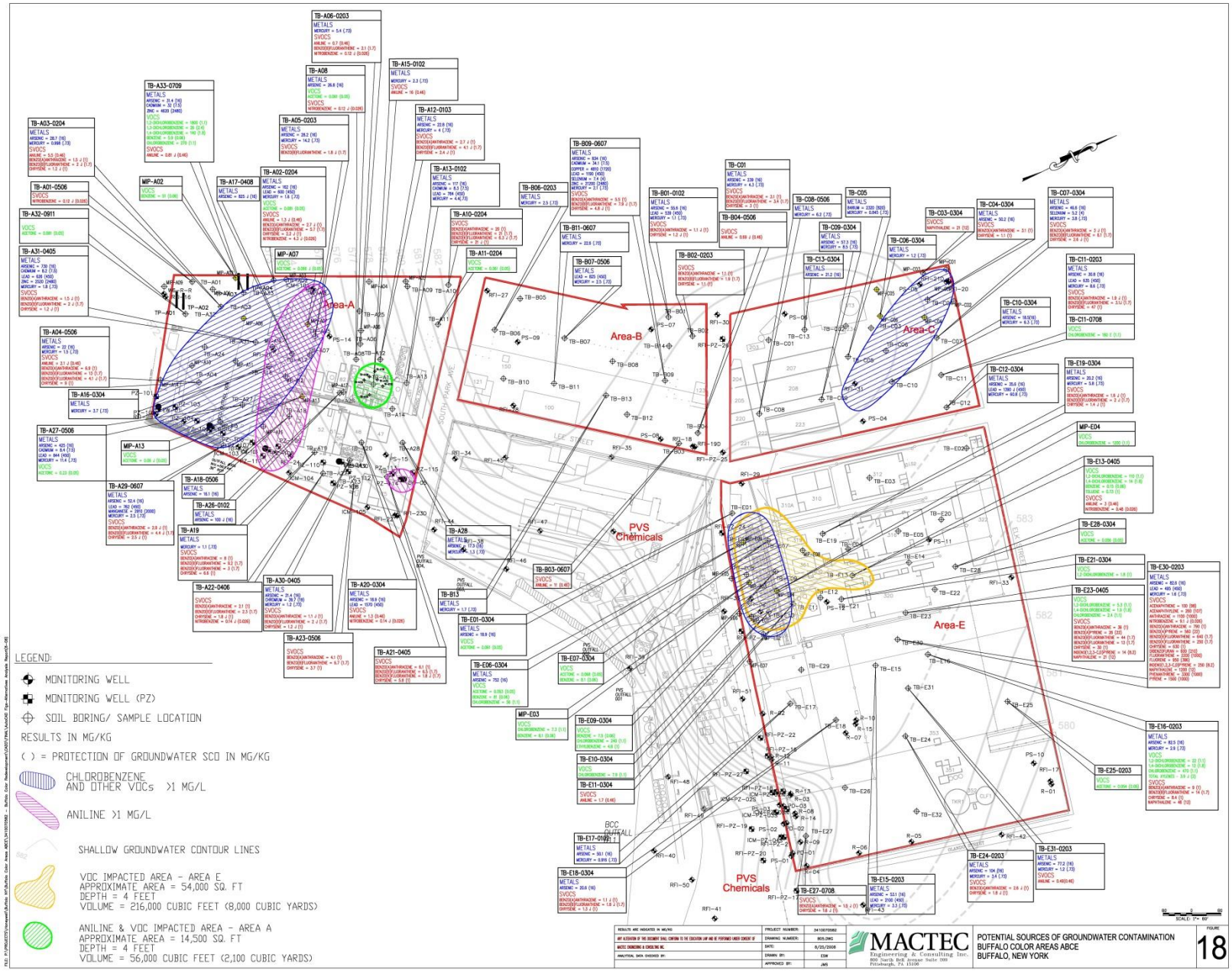


EXHIBIT 10 GROUNDWATER VIOLATIONS FOR EXXONMOBIL SITE FROM THE 2007 THIRD QUARTER MONITORING REPORT

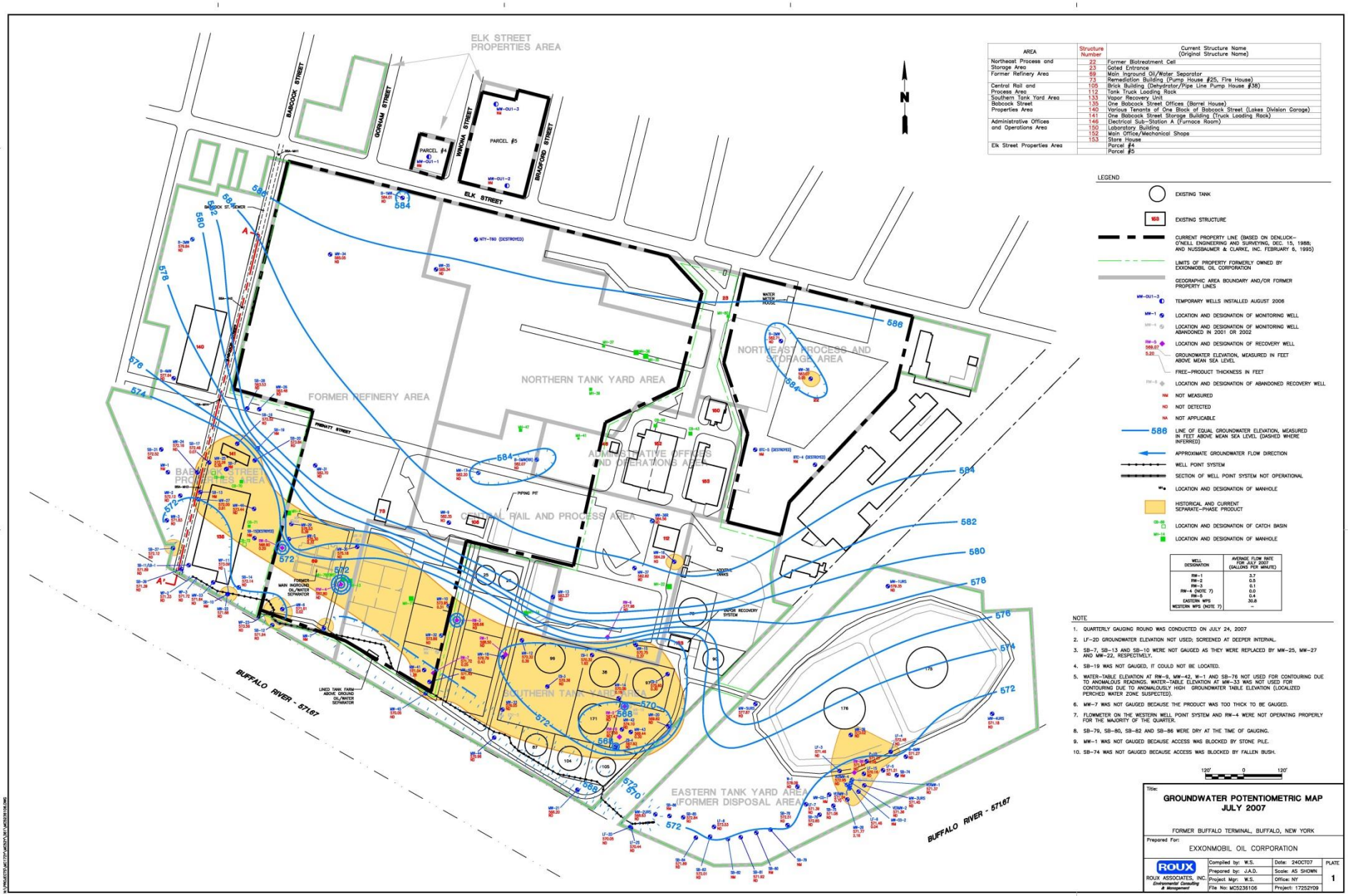
CONTAMINANT	ENFORCEABLE STANDARD, OR GUIDANCE VALUE (µG/L)	MAXIMUM VIOLATION (µG/L)
Acenaphthene	20[1]	185
Anthracene	50[1]	81.9
Benz(a)anthracene	0.002[1]	4.12
Benzene	1	2,310
1,2,4 Trimethylbenzene	5	1,270
1,3,5 Trimethylbenzene	5	50.7
n-Butylbenzene	5	26.5
n-Propylbenzene	5	101
sec-Butylbenzene	5	8.06
Ethylbenzene	5	389
Flourene	50[1]	248
Naphthalene	10	117
Phenanthrene	50[1]	593
Pyrene	50[1]	94
4 Isopropyltoluene	5	8.24
Toluene	5	43.7
Xylenes (total)	5	185

Source: Roux 2007. Notes: Only contaminants with two or more violations are presented. The maximum contaminant violations presented are from the cited report and may not be universal maxima over time and space for the site.

Note: The enforceable state regulations are the 1998 NYSDEC groundwater and surface water standards (6 NYCRR § Part 703) in effect at the time of sampling.

1. New York State Guidance Values for Class GA Waters 1998.

EXHIBIT 11 WELL MONITORING LOCATIONS AND CONTAMINANT (SEPARATE-PHASE PRODUCT) LOCATIONS AT EXXON MOBIL SITE (ROUX, 2007)



AREA	Structure Number	Current Structure Name (Original Structure Name)
Northeast Process and Storage Area	22	Former Biotreatment Cell
	23	Gated Entrance
Former Refinery Area	89	Main Inground Oil/Water Separator
	73	Remediation Building (Pump House #25, Fire House)
Central Rail and Process Area	105	Brick Building (Dehydrator/Pipe Line Pump House #38)
	112	Tank Truck Loading Rack
Southern Tank Yard Area	133	Vapor Recovery Unit
Babcock Street Properties Area	135	One Babcock Street Offices (Barrel House)
	140	Various Tenants of One Block of Babcock Street (Lakes Division Garage)
	141	One Babcock Street Storage Building (Truck Loading Rack)
Administrative Offices and Operations Area	146	Electrical Sub-Station A (Furnace Room)
	150	Laboratory Building
	152	Main Office/Mechanical Shops
	153	Store House
Elk Street Properties Area		Parcel #4
		Parcel #5

WELL DESIGNATION	AVERAGE FLOW RATE FOR JULY 2007 (GALLONS PER MINUTE)
RW-1	3.7
RW-2	0.5
RW-3	0.1
RW-4 (NOTE 7)	0.0
RW-5	0.4
EASTERN WPS	30.8
WESTERN WPS (NOTE 7)	--

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