SECTION 3

INDIAN CREEK GROUNDWATER FLOW SYSTEM

3.0 INDIAN CREEK GROUNDWATER FLOW SYSTEM

3.1 Description of Area

The Indian Creek Groundwater Flow System, (ICGFS) includes that area of the Bannister Federal Complex where groundwater flowing onto and across the site, if not influenced by the effects of building footing tile drains and groundwater pumping wells would ultimately discharge to Indian Creek. Specific SWMUs in this flow system are shown in Figure 3.1. Detailed descriptions of these areas have been provided in previous reports and/or work plans and will not be reproduced here.

Final remedial alternatives for all SWMU's in the flow system are institutional and engineering controls for soil, and for groundwater, the continued operation of the groundwater pump and treat system. Sampling, maintenance and reporting activities are also required.

3.2. Alluvial Stratigraphy

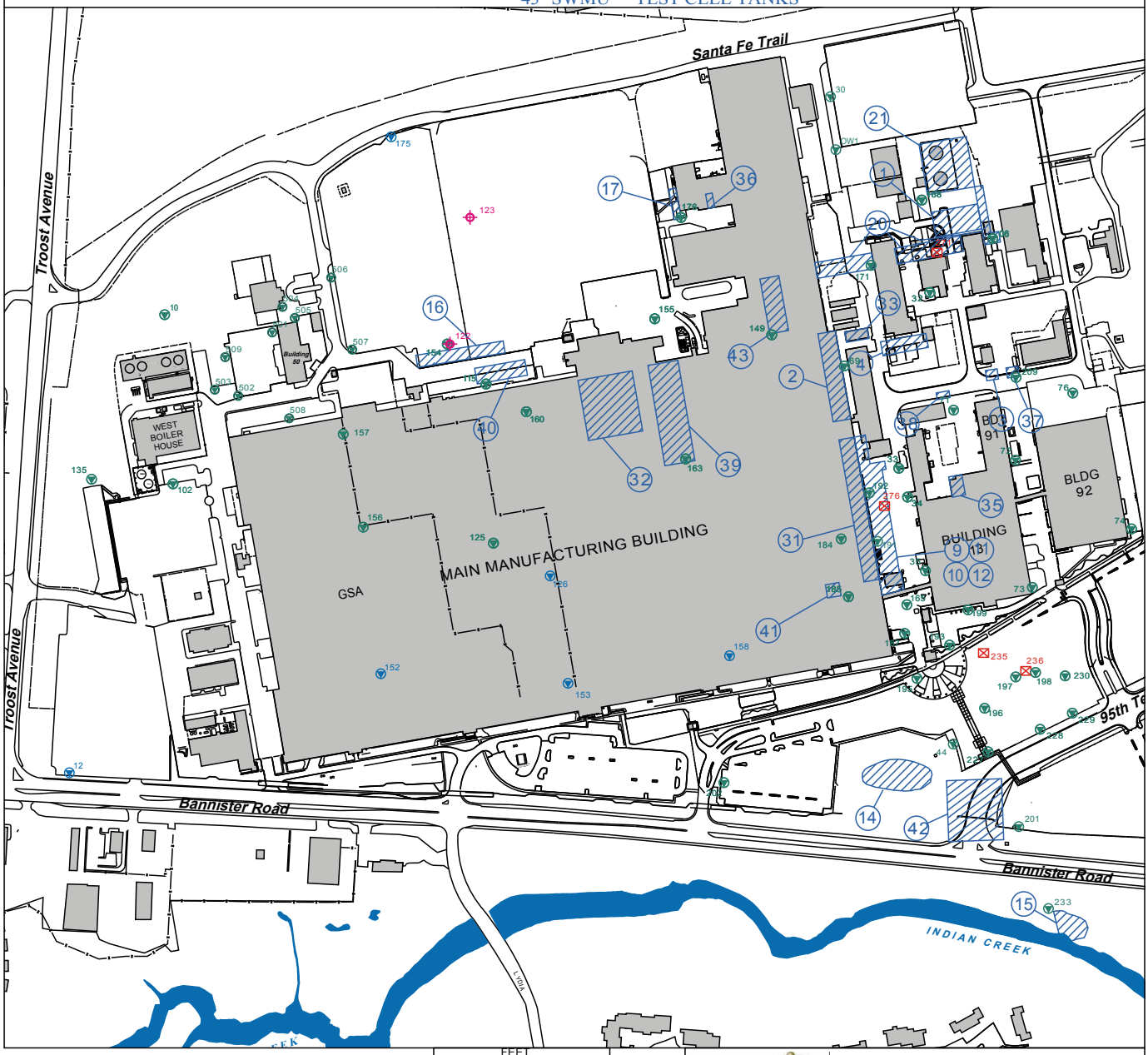
A description of the alluvial stratigraphy of the site is provided in Section 1.3.1. The alluvial stratigraphy in the ICGFS is best expressed by the fence diagram for the TCE Still Area (Figure 3.2). The basal gravel discussed in Section 1.3.1, comprised of angular limestone and sandstone gravel within a sand-silt-clay matrix, is continuous throughout the flow system and ranges in thickness from approximately 2 to 6 feet. Fill material is also present throughout and consists primarily of clayey silt.

3.3 Monitoring Wells

Sixty one groundwater monitoring wells consisting of one hundred thirteen individual completions exist in this flow system to monitor water quality (Figure 3.1). The majority of the wells are dual completion wells. The lower completions are screened in the more permeable basal-gravel unit to detect dense, chlorinated solvents migrating along the base of the alluvial aquifer. The upper completions are screened across the water table to detect possible sources of floating contaminants like petroleum. A few triple completion wells (e.g., 31, 33, and 34) have these same screened intervals with the addition of a middle screen generally completed at approximately 20 ft. below land surface. The middle completions target a zone initially suspected of being more permeable relative to the upper zone. Subsequent hydraulic testing demonstrated that this zone has hydraulic properties similar to the upper zone (DOE 1990a). Consequently, only dual or single completion wells are now installed.

Evaluation of upper and lower completion wells over time allows analysis of degradation noted through changes in overall ratios of TCE, 1, 2 –DCE and vinyl chloride. This evaluation also allows one to note the migration of contamination to lower depths over time (e.g., wells 39 and 37).

1	SWMU	UNDERGROUND TANK FARM
2	SWMU	TCE STILL LOCATION
3	SWMU	WASTE TRANSFER SPILL AREA
4	SWMU	CLASSIFIED WASTE TRENCHES
9	SWMU	BLDG. 57 ACID & ALKALINE TANKS
10	SWMU	WASTE OIL TANK UNDER PLATING BLDG.
11	SWMU	SUBSTATION 18 N. OR PLATING BLDG.
12	SWMU	DEPARTMENT 26 OUTSIDE
14	SWMU	OLD 002 OUTFALL
15	SWMU	NEW 002 OUTFALL
16	SWMU	SALES BUILDING
17	SWMU	BUILDING 54
20	SWMU	ABANDONED FUEL LINES
21	SWMU	FUEL OIL TANK UNLOADING AREA
31	SWMU	DEPARTMENT 26 - INSIDE
32	SWMU	DEPARTMENT 27 - INSIDE
33	SWMU	OIL HOUSE
35	SWMU	EAST BOILERHOUSE
36	SWMU	MAINT. VEHICLE REPAIR SHOP SUMP
37	SWMU	ABANDONED SUMP
39	SWMU	DEPARTMENT 95
40	SWMU	FORMER CHIP HANDLING BUILDING
41	SWMU	DEPT. 20 DEGREASER PIT
42	SWMU	95TH TERRACE
43	SWMU	TEST CELL TANKS



In-service monitoring well location
In-service water level only well location
In-service bedrock well location
In-service interceptor well location

FEET
0 125 250 500
0 25 50 100 150
METERS

Kansas City Plant
National Security Asset

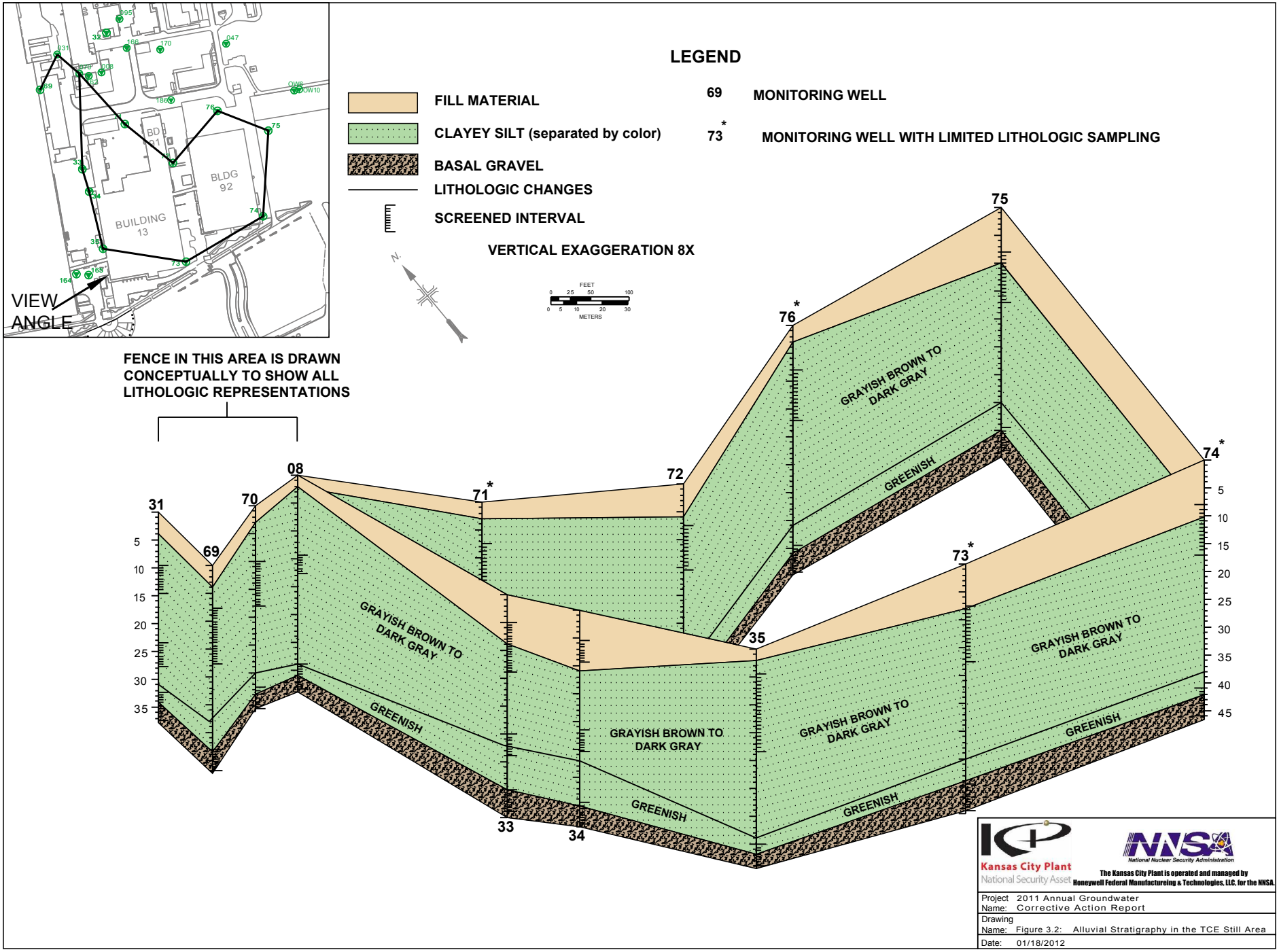
National Nuclear Security Administration

The Kansas City Plant is operated and managed by Honeywell Federal Manufactureing & Technologies, LLC, for the NNSA.

Project Name: 2011 Annual Groundwater Corrective Action Report

Drawing Name: Figure 3.1: Indian Creek Groundwater Flow System

Date: 01/19/2012


LEGEND
FILL MATERIAL
CLAYEY SILT (separated by color)
BASAL GRAVEL
LITHOLOGIC CHANGES
SCREENED INTERVAL
69 MONITORING WELL
73* MONITORING WELL WITH LIMITED LITHOLOGIC SAMPLING
VERTICAL EXAGGERATION 8X
N
FEET
METERS
VIEW ANGLE
BUILDING 13
BLDG 92
FENCE IN THIS AREA IS DRAWN CONCEPTUALLY TO SHOW ALL LITHOLOGIC REPRESENTATIONS
GRAYISH BROWN TO DARK GRAY
GREENISH
Kansas City Plant
National Security Asset
National Nuclear Security Administration
The Kansas City Plant is operated and managed by Honeywell Federal Manufactureing & Technologies, LLC, for the NNSA.
Project Name: 2011 Annual Groundwater Corrective Action Report
Drawing Name: Figure 3.2: Alluvial Stratigraphy in the TCE Still Area
Date: 01/18/2012

3.4 Work Performed in 2011

The KCP completed active corrective action of DOE owned areas of the BFC in 2006. The site is currently operating under what DOE terms "Long Term Stewardship" whereby the site implements final remedies required by the corrective action program.

As discussed previously, DOE submitted a RCRA Class 3 Permit modification request in 2011 to expand the description of Facility in the permit to include the entire BFC and to add the GSA as a Permittee. The Class 3 modification also proposed a modification to the groundwater monitoring and pumping systems.

This report includes groundwater data collected from wells owned by GSA located in the Building 50 area. DOE already maintains the stormwater permit for the BFC that includes drainage from GSA owned areas and has previously reported data from the four regulated storm sewers. A Groundwater Flow and Transport Model was developed for the KCP to simulate historical groundwater flow and transport within the alluvial aquifer up to present day and to prognosticate flow and contaminant transport under a hypothetical future scenario of no groundwater pumping (Laase 2010a). Using data from this study, a design exercise was completed to evaluate a variety of "new" pumping systems to effectively contain the ICGFS and BRGFS plumes to meet current site cleanup standards at revised facility compliance point wells. Results of this study served as the basis for the revised system outlined in the Class 3 modification.

3.5 Groundwater Flow Directions

Potentiometric surface maps based on 2011 water level data collected as a part of the second semi-annual sampling event are provided as Figures 3.3 and 3.4 with actual water levels provided in Table 3.1 at the end of this section**.** As was the case for the BRGFS, water levels in the ICGFS in the second semi-annual event are collected as a separate task so as to be collected over the shortest time period possible. The second semi-annual sampling event often takes 4 weeks to complete, whereas, water levels can be collected in only a few days. Static water levels collected over a large area over a short time interval reduce water level variability that may occur over a month's time (e.g., rain events). DOE also voluntarily sampled wells designated as water level only wells in the second semi-annual sampling event. Results from these wells are discussed in this report.

3.5.1 ICGFS Upper Completion Water Levels

Flow in upper completion wells is influenced by the action of building footing tile drains, groundwater pumping wells, and possibly, leaking underground utilities.

Groundwater elevations in the area of the West Boilerhouse (WBH) in the far northwestern edge of the Bannister Federal Complex continue to be depressed due to the removal of groundwater by building footing tile drains that exist around the perimeter of the building (Fig. 3.3). This lowering of the water table is also manifested by depressed water levels in monitoring wells 102 and 135 adjacent to the boilerhouse and even a slight perturbation noted in surrounding monitor well 10. Footing tile drain flows in the West Boilerhouse are typically

5 to10 gpm. This is the most of any captured footing tile drain system in the Bannister Federal Complex. Groundwater in the northwest corner of the MMB and from much of the Building 50 area also flows toward the WBH footing tile drains.

Groundwater elevations in the central portions of the MMB (e.g., wells 125, 126, 160, and 163) continue to be lower than elevations at either the northern or southern edges of the building. Groundwater flowing on to the MMB is captured by the action of building footing tile drains while groundwater in the northwestern edge of the building is captured by the West Boilerhouse footing tile drains. This has been a consistent feature of groundwater flow in the MMB for years.

Mounding of groundwater was again present in the southeast portion of the MMB from wells 153, 158 and 185 during the second semi-annual sampling event, possibly derived from leaking utilities. A mound has been present in this general area for a number of years. Groundwater in the southeast portion of the MMB flows either to building footing tile drains located within the building itself, flows off of the southeast corner of the building toward and ultimately into groundwater pumping wells in the southeast parking lot or flows to the south toward Indian Creek. Groundwater in the southwest portion of the MMB ultimately flows toward and into Indian Creek.

A significant groundwater depression was noted in the area of pumping wells 235 and 236. The depression covers the entire southeast parking lot. Wells 197 and 198 were again dry upon sampling. When this occurs, site convention is to use the corresponding lower completion elevation for the wells. In addition, wells 196, 228 and 229 were not utilized in the preparation of upper completion potentiometric surface maps due to insufficient water. The lower completion water levels for these wells were also used in preparation of the potentiometric surface map.

Historically, anomalously high water levels were recorded in monitoring well 43U located in the far southeast portion of the flow system. This well completion was not considered representative of groundwater flow in the area and historically was not used in preparation of upper completion maps. However, subsurface integrity video inspections of this well completion have shown no anomalies. Water levels for this well were, therefore, used in the preparation of 2011 upper completion maps. The cause for the elevated water level in the upper completion of this well is unknown. No buried utilities are known to exist in this area.

A groundwater mound in the area of the former North and South Lagoons discussed in Section 2 extends westward into the ICGFS and impacts water levels in wells 76 and 209 shown in the east central edge of Figure 3.3. This mound alters flow in this area whereby groundwater on the west side of the divide flows westward into the ICGFS and is captured by either the Building 91 sump or pumping well 271.

Also of note is a small area of elevated groundwater defined by monitoring well 73 at the southeast corner of Building 13. This is likely related to grass watering that occurs in this area.

Several perturbations in groundwater flow are also noted from wells in the eastern end of the ICGFS. Well 72 is located adjacent to the Building 91 (BD 91) groundwater collection sump. A groundwater depression is again manifested from the use of the water level in the upper

completion of monitoring well 72 located immediately east of BD 91. This depression is consistent with that noted in previous years and serves to inhibit flow to the south.

Footing tile drain elevations in the MMB were not used in preparation of ICGFS upper completion potentiometric surface maps while drain elevations for the West Boilerhouse and Building 91 sump were. The use of the latter two elevations is corroborated by water levels in adjacent wells. As discussed in previous years, the drain elevation is utilized if surrounding wells exhibit depressed elevations caused by dewatering. This is almost always the case. Potentiometric surface maps from the 2011 second semi-annual sampling event that omit the West Boilerhouse and BD91 drain elevations are provided at as an attachment to the end of this section.

3.5.2 ICGFS Lower Completion Water Levels

Much of the groundwater entering the ICGFS from the north flowing under the MMB is ultimately captured by building footing tile drains. Only groundwater flowing from a small part of the southwestern portion of the ICGFS flows uninhibited to Indian Creek. The 2011 lower completion potentiometric surface map denotes a groundwater depression at the West Boilerhouse and capture of groundwater in the central portion of the MMB through the action of building footing tile drains (Figure 3.4). The elevation of the West Boilerhouse sump was used in making the lower completion potentiometric surface map. Water level elevations in wells 102, 135, 157, 502, 503 and 508 serve to show groundwater capture in this area.

Wells 501-509 monitor groundwater in the area of Building 50 just east of the West Boilerhouse. Water levels from these wells indicate that lower completion groundwater flow from the Building 50 area primarily flows southwestward toward the West Boilerhouse footing tile drain system with a smaller component flowing into the MMB footing tile drain system.

A groundwater depression is again noted inside the MMB as manifested by water levels in wells 125, 126, 160, 163, and 156.

Groundwater capture in the area of the former plating building degreaser is evident from water levels in monitoring well 192 adjacent to pumping well 276 on the east edge of the MMB. As shown later in this section, the area around well 192 defines a small area of concentrated solvent contamination.

A distinct groundwater mound is again noted in the southeast portion of the MMB created from elevated water levels in wells 153, 158, 185, 187, 35 and 165. This mound may be due to the presence of leaking underground utilities in this area of the MMB combined with the effect of footing tile drains.

FEET
0 125 250 500
0 25 50 100 150
METERS

Kansas City Plant
National Security Asset

NNSA
National Nuclear Security Administration

The Kansas City Plant is operated and managed by Honeywell Federal Manufactureing & Technologies, LLC, for the NNSA.

In-service monitoring well location

In-service water level only

In-service interceptor well location

Contour Interval: 2ft.

Project Name:	2011 Annual Groundwater Corrective Action Report
Drawing Name:	Figure 3.3: Indian Creek Flow System Upper Completion Potentiometric Surface Map, Fall 2011
Date:	02/01/2012

FEET
0 125 250 500
0 25 50 100 150
METERS

In-service monitoring well location

In-service water level only

In-service interceptor well location

Contour Interval: 2ft.

Kansas City Plant
National Security Asset

NNSA
National Nuclear Security Administration

The Kansas City Plant is operated and managed by Honeywell Federal Manufactureing & Technologies, LLC, for the NNSA.

Project Name:	2011 Annual Groundwater Corrective Action Report
Drawing Name:	Figure 3.4: Indian Creek Flow System Lower Completion Potentiometric Surface Map, Fall 2011
Date:	02/03/2012

The sump in the basement of Building 91 also serves as a groundwater extraction point. Monitoring well 72L is located near this drain. The elevation of the sump was used in making the lower completion potentiometric surface map. The water elevation in well 72 creates the cone of depression manifested by operation of the drain (Fig. 3.4).

Complete capture of groundwater is noted in the area of pumping wells 235 and 236 in the southeast parking lot. These wells serve to capture any potential contamination that may migrate southward in the direction of Indian Creek.

In summary, groundwater flow in the ICGF is influenced by multiple anthropogenic features including basement building footing tile drains, leaking underground utilities and groundwater pumping wells. As was the case for upper completion wells, much of the groundwater within the ICGFS is captured by building footing tile drains in the MMB, WBH, and the Building 91 sump. Southward flow of groundwater on the eastern side of the MMB is inhibited by a groundwater mound located in the southeast quadrant of the MMB with any potential offsite migration to the south prevented by pumping from wells 235 and 236. Only groundwater in the far southwest corner of the MMB is not impacted by footing tile drains or pumping wells. Groundwater flow south of the MMB, Building 13 and Building 92 not captured by building footing tile drains or pumping wells 235 and 236 travels southward toward and into Indian Creek.

Vertical Gradients

Evaluation of vertical gradients within monitoring wells of the ICGFS is problematic in that the area is highly industrialized and riddled with utilities (water lines, sewer lines, steam lines, etc.), some of which may be leaking. Drains also serve to mask natural flow, especially flow adjacent to and under buildings. Pumping wells also serve to mask natural flow. All of these extraneous influences result in some areas of the flow system exhibiting an upward gradient (e.g., well 165) with a downward vertical gradient noted from wells just a short distance away (e.g., well 185).

Overall, however, downward gradients exist in ICGFS wells, especially those in and near buildings and pumping wells. This feature is believed to be directly related to differences in specific yield of the upper unconsolidated aquifer compared to the basal gravel. In areas not effected by drains and pumping (e.g., wells 202, 155, 193 a downward gradient is noted. Historical water levels from a number of ICGFS wells are provided at the end of this section.

3.5.3 Groundwater Flow Rates

Horizontal hydraulic gradients within this flow system are extremely variable as groundwater travels through an industrialized environment. Steep horizontal hydraulic gradients are present in the vicinity of man-made influences such as building footing tile drain systems and pumping wells. Conversely, extremely low horizontal hydraulic gradients are present in the vicinity of groundwater divides, such as the flow divide located in the central portion of the MMB.

Groundwater flow rates were calculated for the northern and southern portions of the flow system from the 2011 second semi-annual sampling event. Man-made influences from pumping

wells and building footing tile drains located in the central, western and eastern portions of the flow system distort groundwater flow in these areas so as to render flow velocities of little practical use. Therefore, flow rates calculated below are based on wells that show minimal effect from man- made influences.

The estimated groundwater velocity in the northern portion of the ICGFS running from well 175 to wells 507 and 155 on the north and northeast sides of the MMB was approximately 246 ft./yr. This flow rate was determined using a horizontal hydraulic gradient of 0.0048 ft/ft, a hydraulic conductivity of 14.0 ft/d as calculated for the basal gravel from the green clay aquifer test conducted in the KCP's north parking lot (DOE, 1994), and an effective porosity of 10%. Flow direction was southerly.

Velocities in the southern portion of the flow system running from the southeast parking lot (SEPL) to Indian Creek using wells 201, 43, and 233 produced a calculated flow rate of approximately 5975 ft/yr. This is based on a horizontal hydraulic gradient of 0.03274 ft/ft and a hydraulic conductivity of 50 ft/day (indicative of the southern portion of the SEPL) and an effective porosity of 10%. Flow direction was south-southeastwardly.

3.5.4 Contaminant Transport Rates

Groundwater flow directions and rates within the Indian Creek flow system vary both spatially and temporally. Consequently, considerable variation in the contaminant transport rate within the system is also expected. Prior to operation of the groundwater pumping system and before any site characterization began, groundwater contamination discharged to the building-footing tile drains (DOE, 1994).

Because groundwater contamination discharged to the building footing tile drains and the possible effect and duration of a hydraulic mound at the south end of the MMB running into the southeast parking lot that existed before the installation of SEPL pumping wells 235 and 236 (DOE, 1999), it is not possible to use the distance of plume travel and the estimated time since the release occurred to calculate a contaminant transport rate.

Dissolved organic contaminants at the KCP are subject to both physical (adsorption/absorption) and biological attenuation processes. The extent to which these mechanisms have occurred and are occurring is dependent on the size and age of the spills and the biogeochemical conditions in the aquifer. Over the approximately sixty years since the initial solvent release, a balance has been established between the rate of migration from the source areas and attenuation/removal processes.

Groundwater modeling conducted in 2010 to evaluate groundwater flow and contaminant transport under a variety of future use scenarios noted that contaminant migration was significantly increased in the absence of building footing tile drains (Laase, 2010a). Groundwater flow rates in the southern portion of the flow systems are significant.