# CONFIRMATORY SURVEY
# OF THE
# GROUP E EFFLUENT DISCHARGE PATHWAY AREAS
# FORT ST. VRAIN NUCLEAR STATION
# PLATTEVILLE COLORADO

## INTRODUCTION

The Public Service Company of Colorado (PSC) operated a 330 MWe High Temperature Gas Cooled Reactor (HTGR) from July 1979 until August 1989. The plant, designated as the Fort St. Vrain Nuclear Station (FSV), was authorized for construction on September 17, 1969 when the U.S. Nuclear Regulatory Commission (NRC) issued a provisional construction permit. Construction was completed in December 1973 and a facility operating license, License No. DPR-34, Docket No. 50-267, was granted on December 21, 1973. Initial fuel loading commenced on December 26, 1973 and initial criticality was achieved January 31, 1974. After a prolonged period of startup testing, low-power operation and plant modifications, the plant was committed for commercial operation on July 1, 1979. Full power was achieved November 6, 1981 (PSC 1995a).

In the nuclear steam supply system for FSV, heat was produced by fission in the HTGR utilizing a uranium-thorium fuel cycle. Graphite was used for the moderator, core structure, and reflector. High temperature helium was used as the primary coolant to produce superheated and reheated steam at a temperature of 1,000° F to match conventional thermal station conditions. The entire nuclear steam supply system, including the reactor core, graphite moderator and reflector, steam generators and helium circulators, was contained within a Prestressed Concrete Reactor Vessel (PCRV).

During the operational period, FSV operated for approximately 890 effective full-power days; FSV was shut down on August 18, 1989. The PSC Board of Directors reviewed and confirmed the Executive Management decision that FSV would not be restarted, and that PSC would pursue decommissioning of FSV. The decision to permanently shut down and decommission FSV was based on related technical and financial considerations. Problems were identified with the control rod drive assemblies and the steam generator steam ring headers that presented significant technical

obstacles which could be overcome, but at a significant financial cost and time commitment. In addition, due to the uniqueness of the HTGR fuel cycle, the cost to purchase new fuel was prohibitive. This, in conjunction with low plant availability and correspondingly high operating costs, made continued operation of FSV impractical.

In May 1991, the NRC granted PSC a 10 CFR 50 Possession Only License. On November 23, 1992, the NRC issued the Order to Authorize Decommissioning of Fort St. Vrain and Amendment No. 85 to Possession Only License No. DPR-34 (PSC 1995b). PSC's objective was the dismantlement and decommissioning of FSV to release all site areas for unrestricted use. To accomplish this, a portion of the PCRV structure and the radioactive balance-of-plant equipment that exceeded the limits for unrestricted use were decontaminated or removed as described in the Fort St. Vrain decommissioning plan.

The radiological status of the FSV environs was evaluated in the FSV Initial Radiological Site Characterization Report in order to provide information pertinent to the decommissioning and final survey of FSV (PSC 1992). There were no spills or accidents during operation of FSV which had the potential of contaminating the site. The Radiological Environmental Monitoring Program (REMP) was continued throughout the decommissioning to ensure that any contamination of the site environs which could have occurred as a result of decommissioning activities was detected.

The FSV facility was largely left intact following decommissioning; dismantlement of structures was confined to the PCRV, and portions of the Reactor Building, Turbine Building, and Liquid Waste System. Following defueling, the PCRV contained the majority of the remaining radioactive inventory. The radioactive source term at FSV was primarily a result of neutron activation of both metallic and concrete components, and impurities contained in graphite components of the PCRV. These activation products included beta-gamma emitters such as Co-60, Eu-152, and Eu-154, and low-energy beta and x-ray emitters such as H-3, C-14, and Fe-55, with H-3 and Fe-55 the largest contributors to the total radionuclide inventory (PSC 1995a).

FSV's final survey included all pertinent structures, surfaces, and systems and components, concentrating on those previously identified as contaminated or potentially contaminated during the dismantlement/decommissioning phases. At the request of the NRC's Division of Waste Management, the Environmental Survey and Site Assessment Program (ESSAP) performed an independent confirmatory survey of the repower area in March 1995 at the Fort St. Vrain site (ORISE 1995a). Subsequent independent survey activities at FSV included licensee survey package reviews, confirmatory surface scans, and comparison surface activity measurements (e.g., side-by-side measurements) performed from September 25 through 27, 1995 (ORISE 1996a). During the period January 22 through 25, 1996, ESSAP performed instrument comparison activities—including side-by-side surface activity measurements and surface scans—and reviews of the licensee's embedded piping program and use of *in situ* gamma spectrometry for determining the licensed material contribution to exposure rate (ORISE 1996b). Most recently, ESSAP performed independent confirmatory surveys during the period September 30 through October 3, 1996. Specifically, ESSAP performed surface scans, surface activity measurements, and exposure rate measurements; and reviews of the licensee's hard-to-detect-nuclide (HTDN) assessment program. A draft report describing these activities was prepared and submitted to the NRC for comment on January 30, 1997 (ORISE 1997a).

In October 1996, PSC completed final survey activities for the Group E Effluent Discharge Pathway areas at FSV and issued Volume 6 of the Final Survey Report (PSC 1996). The effluent discharge pathway consists of open land areas, storage and evaporation ponds and basins, concrete-lined ditches, unlined ditches, and the 10.1 hectare (25 acre) Farm Pond. Water from both ditches was routinely used for irrigation of the surrounding fields and pastures. It is also known that water would leak from the Goose Quill Ditch providing a means of transport of radioactive materials to the surrounding soil. Additionally, the ditches were periodically dredged to maintain flow rates and avoid overflow. The removed vegetation and sediment were routinely deposited on the banks adjacent to the ditches (PSC 1996).

The NRC's Division of Waste Management requested that ESSAP perform independent confirmation survey activities of the Effluent Discharge Pathway areas at Fort St. Vrain.

## SITE DESCRIPTION

The FSV facility is located approximately 56 kilometers [km(35 miles)] north of Denver and 5.6 km northwest of the town of Platteville, in Weld County, Colorado (Figure 1). The site is located in an agricultural area of gently rolling hills. Grade elevation at the plant is 1,460 meters (4,790 feet) above sea level. The site consists of 6995 hectares (ha) owned by PSC, identified as the Owner-Controlled Area, of which approximately 260 ha were designated as the exclusion area during plant operation. Farming has been continued on Owner-Controlled Areas of the site, but there are no farming operations or permanent residences located within the Restricted Area which is surrounded by a security fence.

The station is located on the east side of Weld County Road 19½ approximately 3.2 km south of the confluence of the South Platte River and the St. Vrain River. Neither of the rivers is considered navigable. Cooling for the plant was provided by mechanical draft cooling towers. Make-up to the cooling towers was provided from the rivers, and supplemented by shallow well water. Nineteen shallow wells are located on the site. The licensee also owns rights to surface water in four irrigation ditches that traverse portions of the site.

Effluent from the plant was discharged to a point west of the plant and Weld County Road 19½, where it entered the concrete-lined Goose Quill Ditch. The Goose Quill Ditch runs north and east approximately 2,135 meters (m) before terminating at the Jay Thomas Ditch. The Jay Thomas Ditch flows north approximately 700 m from the confluence with the Goose Quill Ditch where it empties into the Farm Pond. Outfall from the pond eventually terminated at the South Platte River (Figure 2).

PSC divided the Effluent Discharge Pathway areas into fourteen survey units, designated E001 through E014, and classified the units into two categories based on the potential for residual contamination. The two categories, referred to as affected or unaffected are defined as follows: Affected areas are those areas that have potential radioactive contamination or known radioactive contamination; unaffected areas are all areas not classified as affected and are not expected to contain residual radioactivity. Area classification was determined by plant operating history and the results

of previous radiological surveys. PSC designated eleven of the survey units as affected. These survey units included the Goose Quill Ditch and its banks (E001 and 002), the Farm Pond and its outfall (E003), the Jay Thomas Ditch and its banks (E004 and 006), Irrigation Ditches 1 through 6 and the North and South Marshes (E008 and 010), permanent pasture and farmland both east and west of Weld County Road 19 ½ (E011 through 013), and a sediment storage area (E014). All of these affected survey units are outside the FSV restricted area. Three survey units within the restricted area were classified unaffected and included the East and West Settling Basins and Storage Basins (E005), Sewage Lagoons 1 and 2 and East and West Evaporation Ponds (E007), and the South Evaporation Pond (E009).

## OBJECTIVES

The objectives of the confirmatory survey were to provide independent contractor field data reviews and radiological data for use by the NRC in evaluating the adequacy and accuracy of the licensee's procedures and final status survey results.

## DOCUMENT REVIEW

ESSAP reviewed the licensee's final status survey documentation for survey units contained within Volume 6 (PSC 1996). Documents were reviewed for adequacy, accuracy, completeness, and consistency. Data were also reviewed for appropriateness of calculations and interpretations relative to the guidelines.

## SURVEY PROCEDURES

On March 31 and April 1, 1997, ESSAP, with support from the NRC, performed a confirmatory survey of the Effluent Discharge Pathway at the Fort St. Vrain Nuclear Station. The survey consisted of visual inspections, gamma surface scans and surface soil sampling of selected portions of the discharge pathway, that included Sections A, C, and D of the Goose Quill Ditch banks, Irrigation Ditches 3 and 5, the adjacent pasture land north of the Goose Quill Ditch and east and west of Irrigation Ditch 3, the South Marsh, and the sediment storage pile. The survey was conducted in

accordance with a survey plan dated March 26, 1997 (ORISE 1997b) which was submitted to and approved by the NRC's Division of Waste Management. Survey procedures were performed in accordance with the ORISE/ESSAP Survey Procedures and Quality Assurance Manuals (ORISE 1995b and c). This report summarizes the procedures and results of the survey.

## Reference System

Sampling locations for the Goose Quill Ditch banks were referenced to a grid system established by PSC. Sampling locations for Irrigation Ditch 5 and the sediment storage pile were referenced to the nearest PSC final survey sampling location. All locations were recorded on PSC generated maps provided to ESSAP.

## Surface Scans

Surface scans for gamma activity were performed over 100 % of the South Marsh and Sections A, C, and D of the Goose Quill Ditch banks out to three meters. Gamma scans were performed over 75 to 100% of the unlined bottoms of Irrigation Ditches 3 and 5 and along the adjacent land out to one meter. The pasture land both east and west of Irrigation Ditch 3 was randomly scanned over approximately 25% of the area. Scans were performed using NaI scintillation detectors coupled to ratemeters with audible indicators. Locations of elevated direct radiation were marked for further investigation. Figure 3 shows areas covered by surface scans.

## Soil Sampling

A total of 19 surface soil samples (0-15 cm) was collected from the Goose Quill Ditch banks and Irrigation Ditch 5 at locations of slightly elevated gamma activity identified by surface scans or at locations selected based on the licensee's documentation (Figure 4). Nine of these samples were collected in a 10 meter by 10 meter grid block established by the licensee as a result of investigation sampling, in order to perform analytical comparison with the licensee's results (Figure 5). Additionally, 4 surface samples were collected from random locations in the sediment storage area for comparison purposes (Figure 6).

## SAMPLE ANALYSIS AND DATA INTERPRETATION

Samples and data were returned to ORISE's ESSAP laboratory in Oak Ridge, Tennessee for analysis and interpretation. Soil samples were analyzed by gamma spectrometry. The radionuclides of interest were Co-60 and Cs-137; however, spectra were also reviewed for other identifiable photopeaks. Sample analysis was performed in accordance with the ORISE/ESSAP Laboratory Procedures Manual (ORISE 1995d). Gamma spectrometry data were reported in units of picocuries per gram (pCi/g). Results were compared with the licensee's documentation and NRC site-specific guidelines established for release for unrestricted use.

## FINDINGS AND RESULTS

### DOCUMENT REVIEW

ESSAP reviewed the licensee's final survey plan and report, including the final status survey data for the areas included within Volume 6 and comments were provided in a January 2, 1997 correspondence (ORISE 1997c).

### SURVEY RESULTS

#### Surface Scans

Surface scans identified eight locations of slightly elevated gamma activity on the banks of the Goose Quill Ditch and three locations in Irrigation Ditch 5.

**Radionuclide Concentrations in Soil**

Radionuclide concentrations and the sum of the ratios in ESSAP biased soil samples are presented in Table 1. Soil samples were analyzed by gamma spectrometry and the spectra were evaluated for the primary radionuclides of interest—Co-60 and Cs-137, as well as any other identifiable photopeaks. The results of the 9 samples collected from the 10 meter by 10 meter grid in Section A of the Goose Quill Ditch and the 4 samples collected from the sediment storage area were directly compared to the licensee's results and are presented in Table 2.

Radionuclide concentrations for ESSAP biased soil samples ranged from less than 0.1 to 8.8 pCi/g for Co-60 and from less than 0.1 to 6.3 pCi/g for Cs-137. The highest concentrations of both Co-60 and Cs-137 were from the soil sample collected near Flag 157 in Section D of the Goose Quill Ditch banks. The sum of the ratios for these samples ranged from less than 0.1 to 1.9.

Radionuclide concentrations in comparison soil samples ranged from less than 0.1 to 3.2 pCi/g for Co-60 and from 0.1 to 1.6 pCi/g for Cs-137. PSC samples collected from the same locations ranged from 0 to 5.72 pCi/g for Co-60 and from 0 to 3.27 pCi/g for Cs-137. Both ESSAP's and PSC's highest concentrations were from the same sampling location.

## COMPARISON OF RESULTS WITH GUIDELINES

The primary contaminants of concern for this site are beta-gamma emitters resulting from the operation of the FSV facility and include Co-60, Cs-134 and -137, and Eu-152, -154, and -155. Gamma spectrometry were reviewed for all radionuclides of concern, however, only Co-60 and Cs-137 photopeaks showed concentrations significantly above the minimum detectable concentrations of the procedure and are the only data reported. The applicable soil concentration guidelines for Co-60 and Cs-137 are 5.59 pCi/g and 18.7 pCi/g, respectively (PSC 1996), and together must meet the sum of the ratios criteria (i.e., less than unity).

One sample, collected from the Goose Quill Ditch banks at Flag 157 in Section D, exceeded the Co-60 guideline at 8.8 pCi/g and the sum of the ratios criteria at 1.9. All other radionuclide concentrations were below the respective site guidelines and their sum of ratios were less than unity.

## SUMMARY

On March 31 and April 1, 1997, at the request of the NRC's Division of Waste Management, ESSAP performed a confirmatory survey of the Effluent Discharge Pathway at the Fort St. Vrain Nuclear Station. Survey activities included document reviews, surface scans, and soil sampling.

Surface scans identified eight locations of slightly elevated surface gamma activity along the banks of the Goose Quill Ditch and three locations in Irrigation Ditch 5. Surface soil samples were collected from nine of these locations and from two additional locations selected after reviewing PSC documentation. Analytical results from these samples show that one sample collected in Section D at Flag 157, exceeded the sum of ratios criteria at 1.9. The concentration of Co-60 in the sample from Flag 157 also exceeded the Co-60 guideline at 8.8 pCi/g.

Radionuclide concentrations in surface soil samples collected for comparison with PSC results were all within guideline limits and for most samples were comparable to the PSC results.

# FIGURES

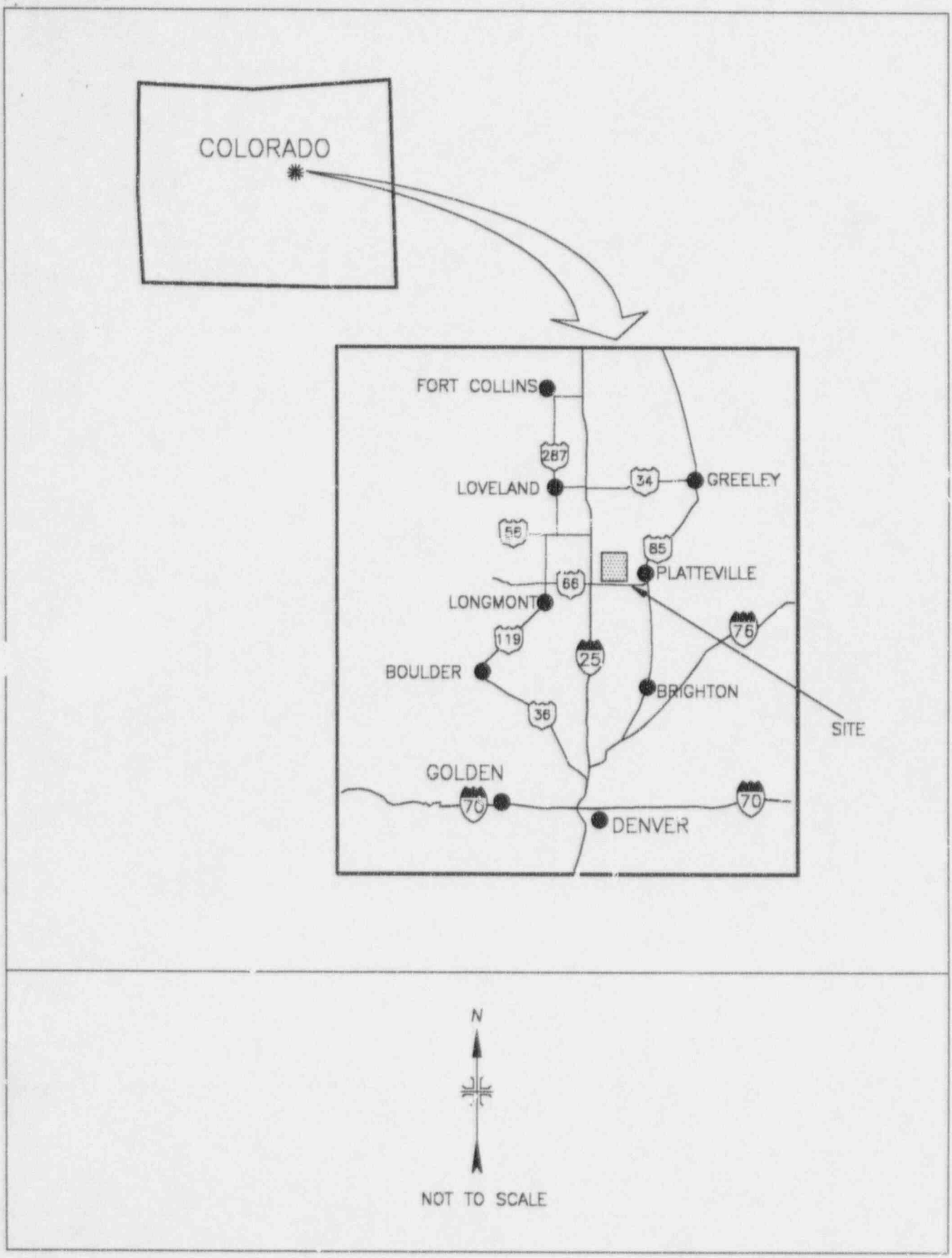
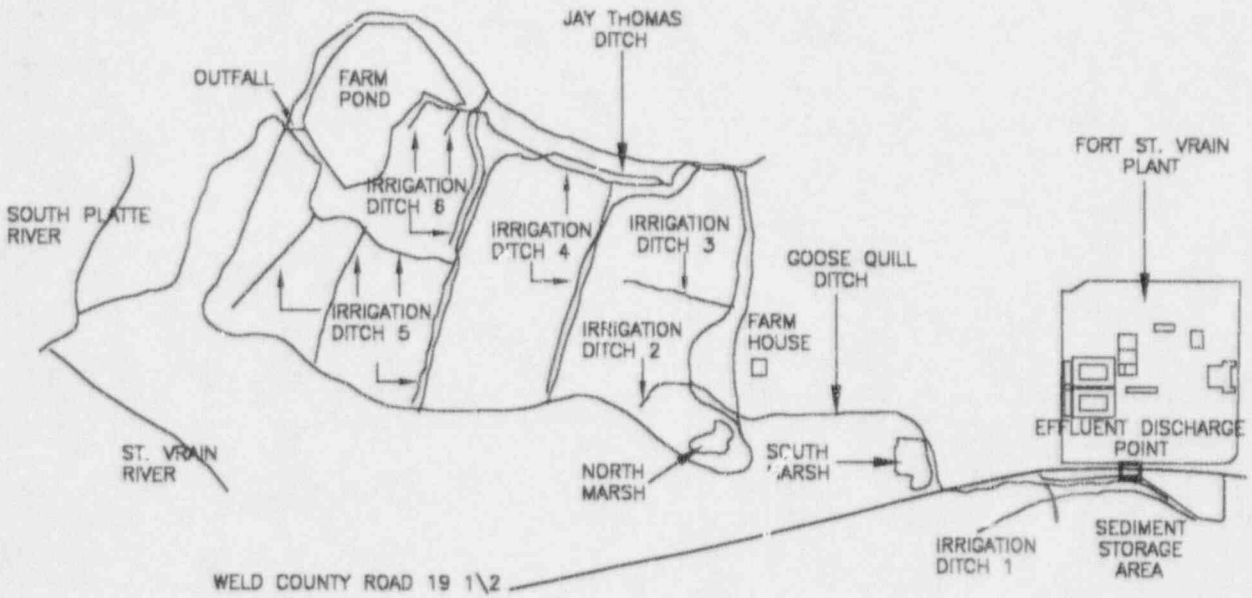



FIGURE 1: Location of the Fort St. Vrain Site – Platteville, Colorado



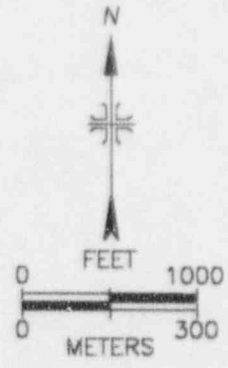
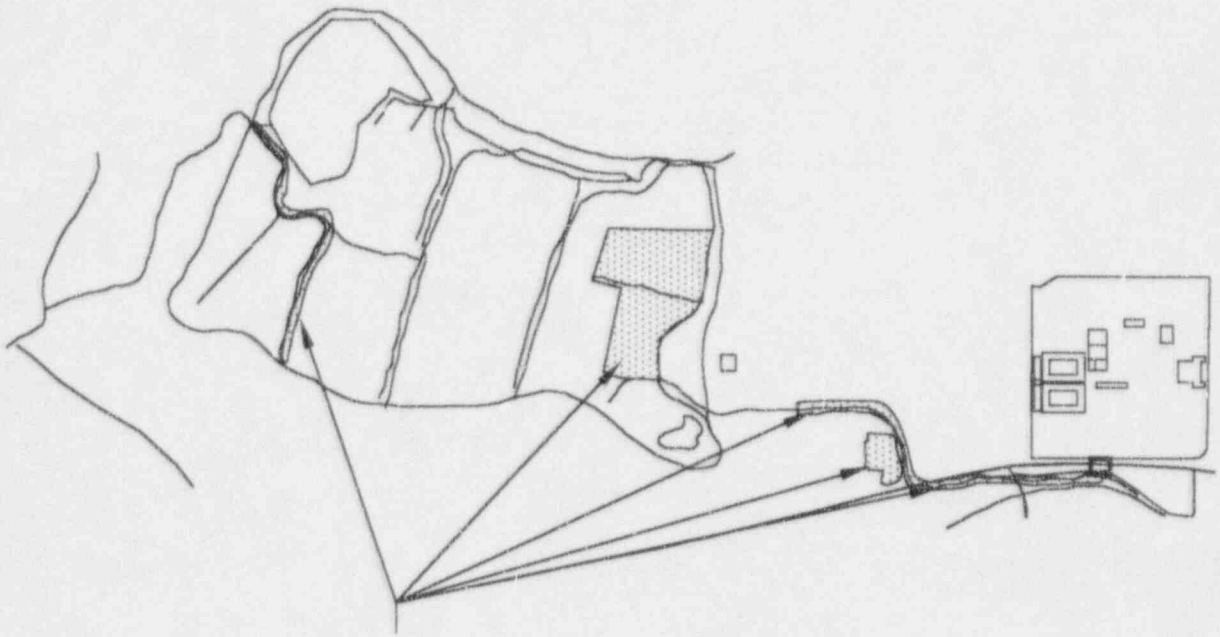




FIGURE 2: Fort St. Vrain Effluent Discharge Pathway



AREAS SCANNED

SURVEYED AREA

N

FEET 0 1000

METERS 0 300

FIGURE 3: Fort St. Vrain Effluent Discharge Pathway Scan Coverage

687-004 (1)

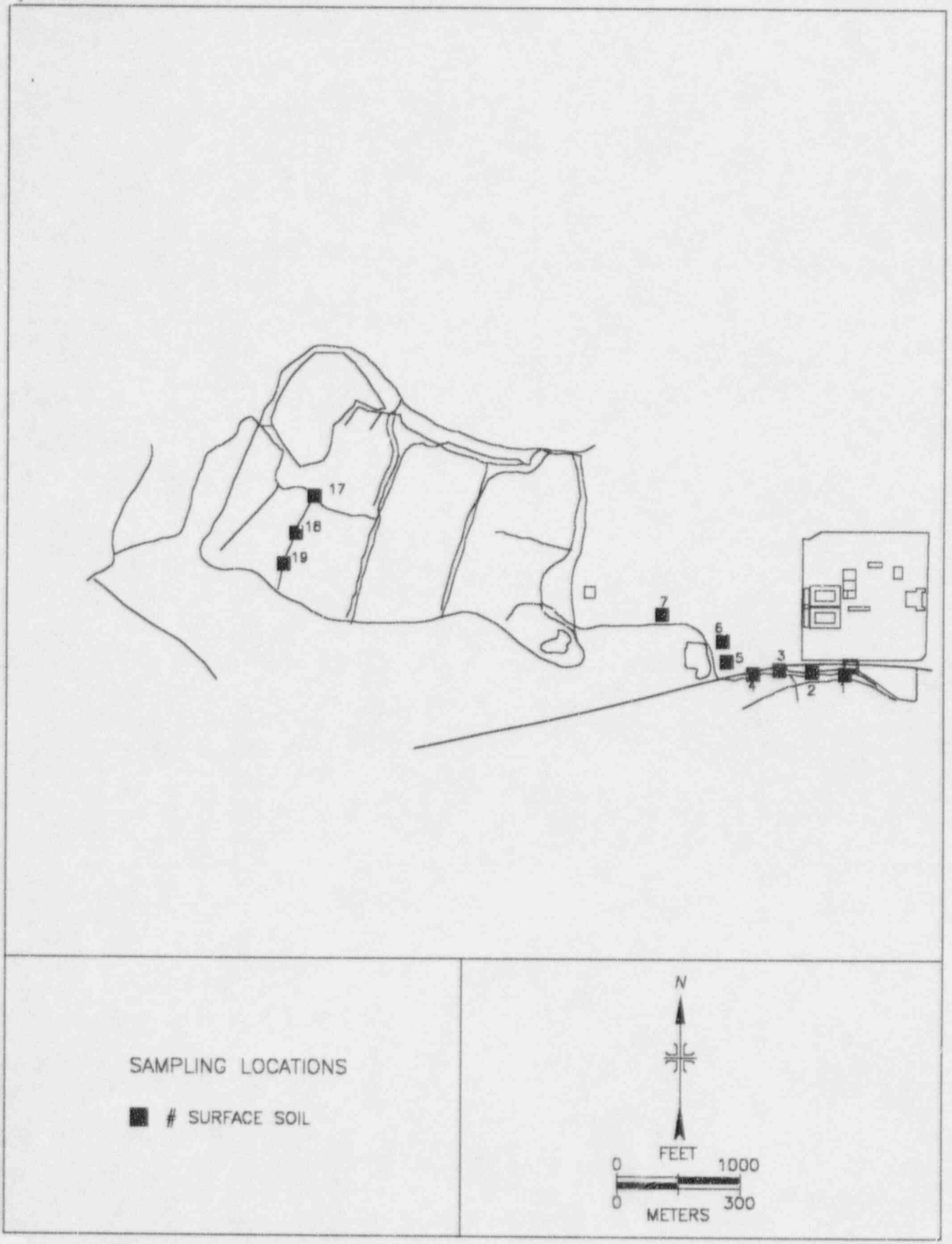



FIGURE 4: Fort St. Vrain Effluent Discharge Pathway – Ditch Sample Locations

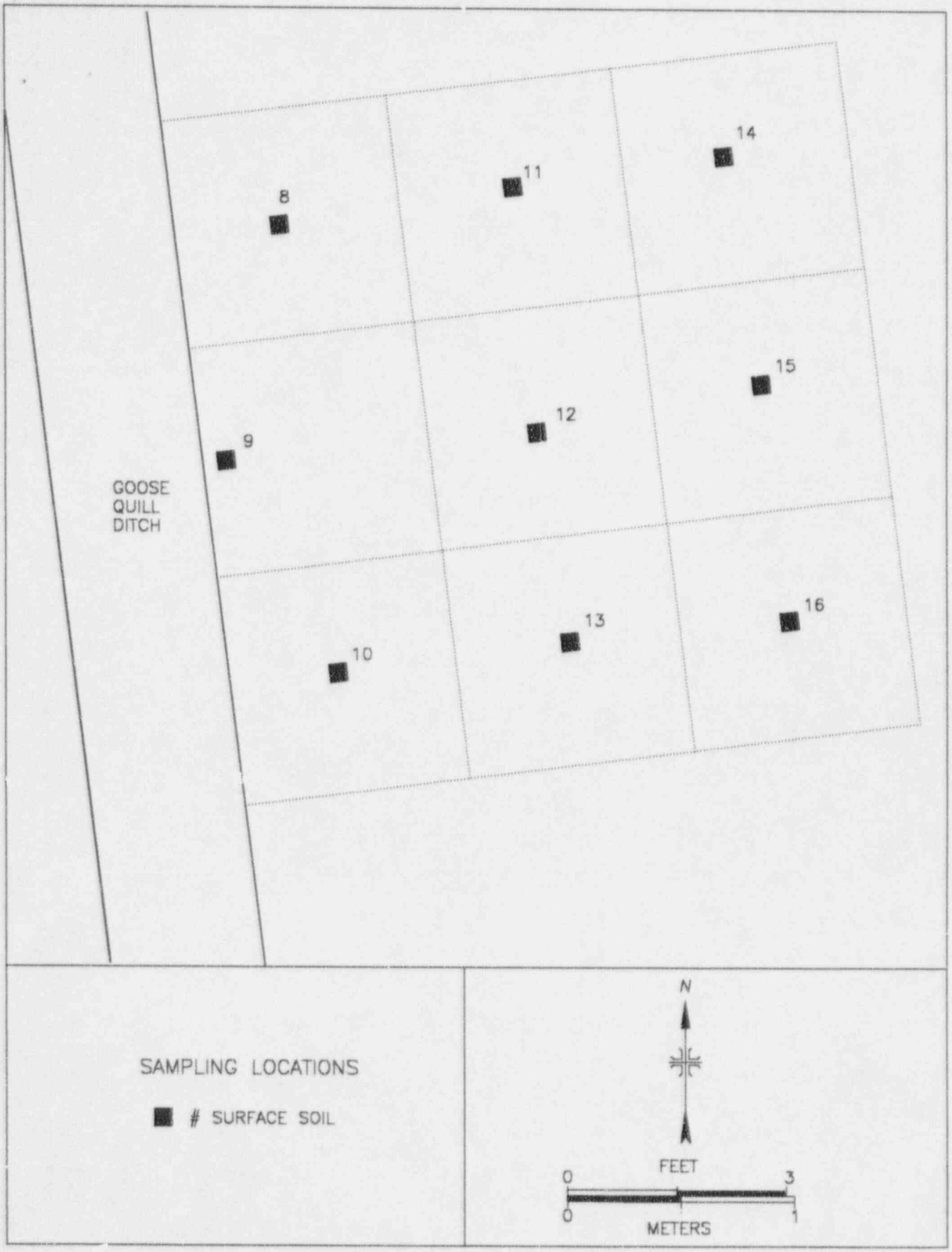



FIGURE 5: Fort St. Vrain Effluent Discharge Pathway – Grid Block Comparison Sample Location

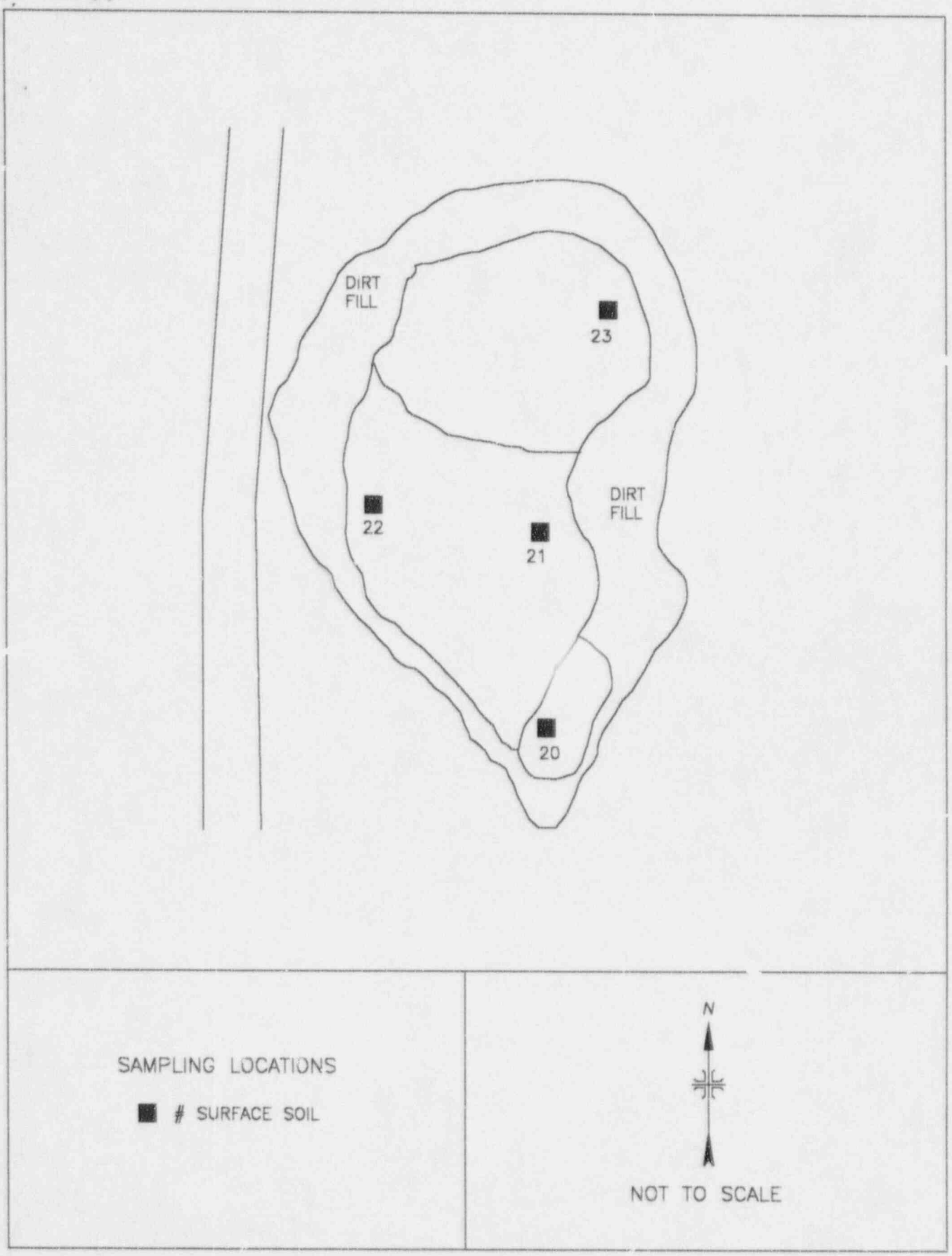



FIGURE 6: Sediment Storage Area – Sampling Locations

# TABLES

## TABLE 1

## RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES FROM ESSAP BIASED LOCATIONS EFFLUENT DISCHARGE PATHWAY FORT ST. VRAIN NUCLEAR STATION PLATTEVILLE, COLORADO

| Sample Number and Location | Radionuclide Concentrations (pCi/g)[a] | | |
|---|---|---|---|
| | Co-60 | Cs-137 | Sum of Ratios[b] |
| **GOOSE QUILL DITCH BANKS** | | | |
| #1 / Section A, Flag 15 | 0.5 ± 0.1[c] | 3.3 ± 0.2 | 0.27 |
| #2 / Section A, Flag 36 | 3.2 ± 0.2 | 1.6 ± 0.1 | 0.66 |
| #3 / Section C, Flag 83 | <0.1 | 0.1 ± 0.1 | <0.1 |
| #4 / Section C, Flag 101 | <0.1 | <0.1 | <0.1 |
| #5 / Section D, Flag 129 | 4.1 ± 0.2 | 4.0 ± 0.2 | 0.95 |
| #6 / Section D, Flag 135 | 1.6 ± 0.1 | 1.1 ± 0.1 | 0.35 |
| #7 / Section D, Flag 157 | 8.8 ± 0.3 | 6.3 ± 0.3 | 1.9 |
| **IRRIGATION DITCH #5** | | | |
| #17 / PSC 25[d] | 0.1 ± 0.1 | 0.5 ± 0.1 | 0.04 |
| #18 / PSC 29[d] | 0.2 ± 0.1 | 1.5 ± 0.1 | 0.12 |
| #19 / PSC 30[d] | <0.1 | 0.5 ± 0.1 | <0.1 |

[a]Background was not subtracted.

[b]The sum of ratios was calculated by dividing the reported concentrations by the site radionuclide guidelines and adding the ratios. The site guidelines for Co-60 and Cs-137 are 5.59 and 18.7 pCi/g, respectively.

[c]Uncertainties represent the 95% confidence level, based only on counting statistics.

[d]Refers to the nearest PSC sampling location.

## TABLE 2

## RADIONUCLIDE CONCENTRATIONS IN SOIL
## ESSAP/PSC COMPARISON SAMPLES
## EFFLUENT DISCHARGE PATHWAY
## FORT ST. VRAIN NUCLEAR STATION
## PLATTEVILLE, COLORADO

| Sample Number and Location[a] | Radionuclide Concentrations (pCi/g) | | | |
|---|---|---|---|---|
| | ESSAP Results[b] | | PSC Results[c] | |
| | Co-60 | Cs-137 | Co-60 | Cs-137 |
| **10 m by 10 m GRID** | | | | |
| #8 / 108 | <1.0 | 0.3 ± 0.1[d] | 0.00 (0.11) | 0.2 (0.09) |
| #9 / 95/109 | 3.2 ± 0.2 | 1.6 ± 0.1 | 5.72 (0.14) | 3.27 (0.13) |
| #10 / 110 | <0.1 | 0.2 ± 0.1 | 0.00 (0.19) | 1.11 (0.10) |
| #11 / 111 | <0.1 | 0.1 ± 0.1 | 0.00 (0.10) | 0.00 (012) |
| #12 / 112 | <0.1 | 0.1 ± 0.1 | 0.00 (0.12) | 0.00 (0.15) |
| #13 / 113 | <0.1 | 0.1 ± 0.1 | 0.00 (0.12) | 0.06 (0.07) |
| #14 / 114 | <0.1 | 0.1 ± 0.1 | 0.00 (0.12) | 0.00 (0.12) |
| #15 / 115 | <0.1 | 0.1 ± 0.1 | 0.00 (0.12) | 0.00 (0.13) |
| #16 / 116 | <0.1 | 0.2 ± 0.1 | 0.00 (0.12) | 0.00 (0.15) |
| **SEDIMENT STORAGE AREA** | | | | |
| #20 / 5 | 0.4 ± 0.1 | 0.8 ± 0.1 | 0.34 (0.07) | 0.87 (0.07) |
| #21 / 17 | 0.2 ± 0.1 | 0.3 ± 01 | 0.15 (0.05) | 0.26 (0.05) |
| #22 / 23 | 0.1 ± 0.1 | 0.2 ± 0.1 | 0.09 (0.05) | 0.14 (0.04) |
| #23 / 32 | 0.4 ± 0.1 | 0.6 ± 0.1 | 1.27 (0.08) | 2.23 (0.09) |

[a]Refers to ESSAP sample number and nearest PSC sample location.
[b]Background was not subtracted from ESSAP results.
[c]The two values indicate the net concentration and the (MDA) reported by PSC.
[d]Uncertainties represent the 95% confidence level, based only on counting statistics.

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