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THE REGIONAL MONITORING PROGRAM

by

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Regional Monitoring Operation
Radiation Protection Operation
Hanford Laboratories Operation

HANFORD ATOMIC PRODUCTS OPERATION
GENERAL ELECTRIC COMPANY
RICHLAND, WASHINGTON

THE REGIONAL MONITORING PROGRAM

I. PURPOSE

The purpose of the Regional Monitoring program is to conduct surveys to detect, measure, and to evaluate environmental radiation, particularly that of HAPO origin. Estimations of total environmental dose and HAPO's contribution to this dose, in units of fraction of public exposure limits, are calculated. Corollary functions include the use of Regional Monitoring data to establish and predict trends in environmental exposure components, and to facilitate correlation of environmental radioactivity with plant processes, process changes, and waste disposal practices.

II. GENERAL PRINCIPLES

For proper evaluation of the environmental radiation exposure, in accordance with National Committee of Radiation Protection recommendations, the various sources of this exposure must be identified. Natural background radiation must be identified so that it can be subtracted from the total environmental dose, since the NCRP recommendations apply to exposure over and above natural background. Bomb debris and other "man-made" radioactive materials must be evaluated and separated from HAPO originated materials, since this latter source is the only one we are directly responsible for and have any direct control over.

III. METHODS AND RESULTS

A. External Radiation Levels in Air

Total environmental external radiation exposure is measured by several methods. Portable ionization chambers, similar in operation to standard pencil type personnel dosimeters, are operated in locations where no electric power is available. (See Figure 1 for locations where these are in use.) Semi-weekly reading of these chambers are necessary to avoid complete discharge between visits. Locations monitored include Army Camps and well-traveled roads where exposure to personnel traveling on the project is of interest. Chambers at these remote locations also aid in measurement of natural background radiation and "bomb fallout". Measurements range from 0.2 to 0.3 mrad/day for natural background radiation. An average of an additional 0.2 to 0.7 for HAPO originated materials is normally found. Fallout adds varying amounts to the daily dosage depending on it's magnitude. In June, 1957, fallout of radioactive bomb debris measured on the project by portable chambers increased the dosages by about 1.5 mrad/day.

The second type of external radiation dose measurement is made by HM Chambers and Integrons. These devices measure dosage rate and accumulate total eight hour dose, respectively. These are located in small air monitoring buildings called 614 Buildings scattered throughout the project and in the nearby communities of Richland, Kennewick, Pasco, and Benton City.

These instruments provide continuous records on strip charts, and weekly visits are made by field personnel to extract the data from the charts and record it on permanent record forms. These readings are used to record daily dosages in the operating areas and in the surrounding towns, and they are located so as to monitor each "area" and each section of an "area" where differing environmental radiation sources and/or meteorological conditions might produce distinct exposure patterns. Figure 2 shows the locations of these monitoring devices.

Film badges, similar to those used for personnel monitoring, are located in each 614 Building as another means of recording external radiation exposure. These film badges are used as an inexpensive means of backing up the HM Chamber and Integrons in event there is a power failure. Results of the 31 HM Chamber and integron measurements range from total exposures of 0.5 to 1 mrad/day at off-project locations to averages of about 5 mrad/day at on-project locations. Film badge measurements range from < 25 mrad/week to 35 mrad/week at off-project and on-project locations, respectively.

B. Internal Radiation Exposure From Air-Borne Materials

Caustic scrubber samplers are used to measure the activity density of I^{131} in the atmosphere. This isotope is contained in the gaseous effluents from the separation stacks. The scrubbers are located in greater number close to and downwind of these stacks. Large variations in I^{131} atmospheric concentrations occur in and near the separations areas due to changing operating conditions. Smaller variations and lower activity density levels at outlying communities permit less concentration of sampling locations. Weekly changes of scrubber samplers are made possible through the use of automatic water feeders which keep the liquid in the scrubber at the desired level.

Figure 3 is a map of the 614 Building locations which contain I^{131} scrubber samplers. Estimation of the atmospheric I^{131} content is necessary to permit evaluation of thyroid dosages and to assist in understanding and correlating changes in vegetation I^{131} activity density. Results of these scrubber measurements range from 10^{-13} µc/cc at residential areas to 10^{-12} µc/cc at 200 East and 200 West Area locations.

Particle filter samplers are located at 32 on-project and 13 off-project locations. The samplers consist of 2" x 4" HV-70 asbestos filter paper through which 2.0 cfm of air is drawn by an electrically driven pump. The filters are counted for gross beta emitters before being autoradiographed for one week on type K x-ray film. The beta counting rate is used to calculate the $d/m/m^3$ of filterable beta activity in the atmosphere and gives a rapid indication of possible large variations in air-borne radioactive particle concentrations. After development, the autoradiograph is used to determine the number of radioactive particles per filter and hence the number per unit volume of air sampled. Knowledge of air-borne particulate concentrations is necessary to permit evaluation of the radiation exposure to the lungs and respiratory tracts of employees and residents of near-by towns. The particle data is also valuable for defining periods of fallout of bomb debris, since the activity density per particle is usually very much less for bomb debris than for HAPO originated materials. At the request of the Atomic Energy Commission, this data is routinely reported to them during bomb testing periods.

Figure 4 illustrates the locations where particle filter samplers are operated. The highest number of samplers are located in and near the 200 Areas, since the separations areas stacks are the main source of the particles. The nine samplers at the Meteorology Tower are operated at 50 foot intervals to test the variations in particle concentration with altitude. Samplers located at various cities throughout the Pacific Northwest are used to define the range of HAPO particulates, and more important, to identify particles which originate from fallout of bomb debris. The samplers located at Seattle and Yakima, Washington, and Klamath Falls, Oregon, are out of range of normal wind patterns from HAPO and only collect particles from natural or other "man-made" sources.

The range of particle concentrations found at the various stations depends greatly on whether bomb fallout is present. Normal values at outlying stations during the absence of fresh bomb debris are in the order of 10^{-3} to 10^{-2} particle per cubic meter. These values range up to 0.1 to 1 particle/m^3 during continental atomic tests. On-project locations in the 100 Areas and locations at nearby communities yield values of 10^{-3} to 10^{-2} particle/m^3 during the absence of fallout, while concentrations near the 200 Areas may reach as high as 1 particle/m^3 for short periods, even in the absence of bomb debris.

Filters on samplers, located near the 200 Areas and a few others scattered downwind of these areas, are changed daily because of wide fluctuations in air-borne particle concentrations. Others are changed weekly, except during periods of atomic tests when off-project samplers are changed daily, also.

Time of arrival of air-borne radioactive particulates and identification of short-lived natural activity is accomplished through the operation of continuously monitored filter samplers. (See Figure 3.) These 1-1/2 inch diameter HV-70 filter papers are mounted over a glass-walled GM tube which in turn is connected to a Decade type scaler and some type of recorder. Four of these probe-mounted filters are located in the project and one is located in Richland at the 700 Area 614 Building. In addition to these five filters, there are thirteen others of the same type, except that they are not monitored in the field.

Both types of filters are changed weekly, and counted in the 329 Building Counting Room, where the activity densities of alpha and beta particle emitters are measured. Normal values are: 10^{-12} μc beta/cc of air near the 200 Areas; 10^{-13} μc beta/cc of air in near-by towns; and $\leq 10^{-14}$ μc of alpha emitters/cc of air at all locations.

C. Internal and External Radiation Exposure From River and Drinking Water Sources

Activity density of various radio-isotopes in river and drinking water supplies must be measured to allow evaluation of external exposures during swimming, boating, and fishing; internal exposures from drinking the water, eating fish caught from the water, or eating crops irrigated with the water. The latter evaluations are best made by collecting a large number of weekly samples for gross beta and alpha emitter analysis and a small number of large volume samples for radio-isotopic analysis. External dosages can be estimated from the isotopic analyses and/or from radiation dosage measuring devices, such as ionization chambers, film badges, and radiation pencils. Figure 5 and 6 illustrate sanitary and river water sampling locations, respectively.

Sanitary water supplies, not derived from the Columbia River, contain no detectable amounts of HAPO originated radioactive materials. Such water supplies include the Richland water system, 300 Area, Benton City and Kiona wells, Headgate Well (at the Yakima River Horn Rapids Dam), Prosser city water, West Richland wells, and various private and farm water wells in locations where the water table is not influenced by the Columbia River or plant waste disposal practices.

Such supplies are sampled weekly, and are analyzed for gross beta and alpha emitters; samples containing detectable alpha emitters are analyzed for uranium. Results range from < 0.5 to 8 x 10^{-7} μc beta/cc and < 5 to 10 x 10^{-9} μc alpha/cc. Uranium accounts for all of the positive alpha measurements obtained for these

All of the HAPO plant sanitary water supplies (except 300 Area), and those of Pasco, Kennewick, McNary Dam, Paterson, and various farms located near the Columbia River are derived from the Columbia River or from water table sources influenced by this river.

Variations in the activity density of various HAPO originated isotopes are measured for gross beta and alpha by collecting weekly water samples from the above mentioned locations. Large volume (6 to 9 gallons) samples are collected weekly from the Pasco Pumping Plant inlet and from 183-F waters for isotopic analyses; spot samples of water supplies of the most upstream farm, along the project stretch of the river, are also collected for isotopic analyses. Comparisons of gross beta activity between samples isotopically analyzed and other samples allows estimates of the exposure received from these other sources.

The results of these sanitary water samples for beta particle emitters are as follows:

> 100-B Area (above the influence of HAPO), McNary Dam, Plymouth, and Paterson (well below the project), 10^{-8} μc/cc; 200 East and 200 West Areas, ranches between Ringold and Pasco, and the cities of Pasco and Kennewick, 10^{-6} μc/cc.

Alpha emitter measurements are below the detection limit of 5×10^{-9} μc/cc at all of the above locations, except for a few scattered locations where natural occurring uranium accounts for the 10^{-8} μc/cc of alpha activity density. Isotopic analyses reveal the exposure from drinking water at 100-F and Pasco is about 1 percent of the occupational MPC_{CI}.

River water samples collected weekly at the Snake and Yakima River mouths and Columbia River points above the project are analyzed for alpha and beta emitters and uranium. These measurements define the natural radioactivity of river waters in the region of the project. Results are normally $< 5 \times 10^{-8}$ μc/cc for beta emitters and $< 5 \times 10^{-9}$ μc/cc for alpha emitters. Uranium measurements indicate 0.5 to 1 $\times 10^{-9}$ μc/cc of natural uranium in the Columbia River, upstream of the project.

Columbia River water samples from shoreline locations are collected weekly at sixteen locations between 100-B Area and Richland, three times per week at four locations in the Pasco-Kennewick region, weekly at three locations in the McNary Dam-Paterson area, and monthly at ten locations between McNary Dam and Portland, Oregon. Frequency of sampling is adjusted to the latitude of variations in the activity density, the average level of activity density, and to the number of people who derive their irrigation and drinking water from the river at the point in question. The volume of the sample collected ranges from 500 cc to one gallon depending on the activity density of the water being sampled. Results of gross beta measurements are: 10^{-5} μc/cc within the project, 10^{-6} μc/cc in the Tri-City Area, and 10^{-8} to 10^{-7} μc/cc at and below McNary Dam. Alpha emitter measurements and uranium measurements parallel each other and range from $< 2 \times 10^{-9}$ to 8×10^{-9} μc/cc.

River mud samples are collected weekly from sixteen locations and analyzed for gross beta particle emitters to monitor the long-term trends in deposition from river water activity density and to establish natural background activities from Snake and Yakima River mud samples. Figure 6 shows the locations selected for river mud sampling.

External gamma radiation dosages to people swimming and boating on the Columbia River are being investigated by placing personnel monitoring devices (pencil meters) in the river at various locations. Absolute calibration of these devices is not yet available for this type of measurement. Positive values (15 - 30 mr/week) have been obtained in the project stretch of the river, while values from the Tri-City Area have been near the detection limit of the radiation pencils (5 - 10 mr/week).

D. Internal Radiation Exposure From Vegetation

Vegetation sampling and analysis measures I^{131} and other fission products deposited on vegetation from HAPO sources and/or the fallout of radioactive bomb debris. Ten 15 gram samples are collected from each of twenty-five zones and composited into one 150 gram sample per zone. Seventeen of these zones are sampled weekly (Figure 7) and eight are sampled monthly (Figure 8).

The 291-A and 291-S separations areas stacks are the main HAPO source of vegetation contamination. One sampling zone represents each of the separations areas; Zone A encloses 200 West Area, and Zone B encloses 200 East Area. The other zones are chosen to enclose vegetation of approximately equal activity density, or to encompass all vegetation samples collected on a special trip (such as Zone Q, which includes samples from the weekly trip to Prosser, Paterson, and McNary Dam).

The weekly frequency of sample collection on and near the project is necessitated by wide variations in the daily stack emissions of I^{131}, the short biological half-life of I^{131} on vegetation (5-6 days), and rapidly shifting wind patterns near the 200 Areas. "Crosswind" and "upwind" directions from these stacks are sampled also, since these locations are occasionally found to contain significant amounts of I^{131} on vegetation. Samples from the more remote regions, which are collected monthly, are rarely found to contain detectable amounts of I^{131}, except in cases of bomb fallout. These remote samples can aid in establishing the existence of this fallout. These are also used to define the insignificant contribution of HAPO originated radioactive materials to these regions.

All zone samples are analyzed by gamma spectroscopy techniques in order to define the activity densities of significant gamma emitting fission products present. These include: I^{131}, Zr^{95}-Nb^{95}, Ru^{103}-Ru^{106}, Ba^{140}-La^{140}, Ce^{141}-Ce^{144}, and, in Zone B only, Cs^{137}. Unusual changes in isotopic ratios, increases in total activity less I^{131}, and/or the appearance of short-lived radioisotopes of iodine on vegetation are indicative of the fallout of bomb debris. (Confirming evidence of fallout is obtained from particle filter measurements. See Section III-P).

Results of vegetation measurements can be used to approximate the internal exposure to the general public from eating produce raised in the areas of the twenty-five zones. The off-project limit for I^{131} on vegetation is 1×10^{-5} μc/gm. Occasional values this high are recorded, although long-term averages are well below this level at all off-project locations sampled. Vegetation limits for other radioisotopes found on vegetation have not yet been officially set. Rough estimates, based on the total allowable daily intake of the radioisotopes detected, indicates that present levels of vegetation radioactivity are within safe limits.

During July, 1957, monthly average vegetation measurements, expressed in units of 10^{-6} μc/gm were: for on-project vegetation - Zr^{95}-Nb^{95}, 29; Ru^{103}-Ru^{106}, 9.1; I^{131}, 2.0; Ba^{140}-La^{140}, 13; and Ce^{141}-Ce^{144}, 53; for off-project vegetation - Zr^{95}-Nb^{95}, 12; Ru^{103}-Ru^{106}, 3.5; I^{131}, <1.0; Ba^{140}-La^{140}, 7.0; and Ce^{141}-Ce^{144}, 23.

Spot measurements of gross alpha emitters are made at five project and two off-project locations by collecting 25 gram vegetation samples on a semi-monthly basis. Results of these measurements indicated that the present concentrations of alpha emitters on vegetation are also within safe values. On-project averages for July, 1957, were (4 to 80) x 10^{-8} μc/gm and off-project averages were < 3 x 10^{-8} μc/gm.

E. Radioactivity in Wastes Discharged to the Environs

Measurements of the amounts and types of radioactive in HAPO waste effluent streams are necessary for four reasons:

1. The waste disposal sites, themselves, are usually part of the "environs" of HAPO employees,

2. Knowledge of the amounts of radioactivity in the wastes enables understanding and prediction of the radioactivity in other environmental samples,

3. The radioisotopic composition of the wastes determines what types of analyses are made on other environmental samples, and

4. More accurate and faster control of environmental contamination can be made through measurement and limitation of radioactivity in the wastes than through similar measurements in the environs.

E-1. Separations Areas Stack Gas Monitoring

Sampling of the 291-A and 291-S stack effluents for gaseous and particulate radioactive substances is maintained on a daily basis to aid in the control of vegetation and ground contamination. In addition, automatic plotting of activity levels in these effluents versus time permits:

1. Evaluation of process steps contributing to the discharge of the radioactivity,

2. Prediction of direction of travel and points of deposition of emitted activity by correlating emission times with meteorological conditions, and

3. On the spot estimates of amounts of activity discharged without the necessity of waiting for detailed laboratory analysis of the collected samples.

Daily scrubber samples for I^{131} are necessary because of the large variations in the amounts of this isotope discharged with time, and the possibility of fairly sudden failure of process equipment designed to control these I^{131} emissions.

At Redox, two parallel samplers are in operation. An automatic sampler, consisting of a continuously moving strip filter ahead of a countercurrent flow caustic scrubber, samples 0.3 cfm of stack gases; monitors the samples for beta and alpha activities by means of scintillation crystals and energy discrimination; and records individual emission rates of I^{131}, Ru^{103}, and Ru^{106}. Pending completion of calibration of this equipment, laboratory analysis of the collected scrubber solution for I^{131} will be continued:

1. To acquire data for assisting in the calibration, and
2. To yield accurate data on the daily I^{131} emission from the 291-S stack.

The parallel system is operated during calibration of the automatic sampler to monitor the stack gases for ruthenium isotopes. About 1.0 cfm of gas is drawn through a 4" x 4" HV-70 filter paper ahead of 2.5 N NaOH scrubber solution. The data from this sampler aids in the calibration of the automatic sampler and supplies accurate values for the daily Ru^{103}-Ru^{106} emission rates. The normal range of measurements at the Redox facility stack is 0.05 to 1.0 curie of I^{131} per day and less than 0.01 curie of ruthenium per day.

At Purex, the 291-A stack effluents are monitored by two separate systems. An intermittently moving strip filter samples 0.5 cfm of gas, filters the radioactive particulates in the gas, and then monitors them with a beta sensitive scintillation crystal connected to a count-rate-meter and a strip chart recorder. Daily emission rates of gross beta emitters are calculated from the strip chart recorded counting rates by means of a calibration established with sources of normally expected isotopic composition. Gross beta emission from the Purex stack ranges from 10^{-3} to 10^{-2} curie per day.

The Purex I^{131} monitoring system consists of a counter current flow caustic scrubber, whose spent caustic solution is monitored by a 1-B-85 Victoreen Thyrode tube connected to a count-rate-meter and a strip chart recorder. The record of counts per minute versus time is used to:

1. Correlate I^{131} emission with process steps,
2. Predict direction of travel of effluents by correlation with meteorological data, and
3. Evaluate stack emissions of I^{131} prior to detailed laboratory analysis.

Purex stack emissions range from 0.1 to 3 curies of I^{131} per day and 10^{-3} to 10^{-2} curie of filterable gross beta emitters per day.

Semi-weekly changes of a 1-1/2" diameter HV-70 filter paper, sampling 2.0 cfm of gas from the 291-U stack, are made to monitor the effluents from the 224-U and 221-U Buildings. The lower activity density of this stack gas and the absence of significant quantities of radioactive gases make this type of monitoring satisfactory.

These filters are counted for gross alpha and beta particle emitters and are then autoradiographed for measurement of radioactive particle concentrations. Results average 10^{-8} curie of alpha emitters per day, 10^{-7} curie of beta emitters per day, and 10^{5} to 10^{6} particles per day discharged from the 291-U stack.

E-2. Reactor Area Stack Monitoring

Semi-weekly filter samples, similar to those collected at 291-U stack, are obtained from each of the eight reactor area stacks. These samples are also analyzed for the same activities as are those from the 291-U stack. The samples monitor the contribution of each of the eight reactor stacks to environmental contamination, especially during periods of unusual incidents (such as burning of an irradiated slug on the rear face or pushing of a ruptured slug). Results average 10^{-5} curie per day of beta emitters; although close to 1 curie per day of this type of activity has been detected during special incidents. Filterable gross alpha emitters discharged average 10^{-8} curie per day, while concentrations of radioactive particles are on the order of 10^{6} per day from each reactor.

Spot samples of reactor stack gases for measurement of C^{14}, S^{35}, and tritium oxide are collected monthly from each reactor stack. These measurements are made to ensure that the low levels of activity previously recorded for these isotopes are not changing. Normally C^{14} and S^{35} measurements remain below the respective detection limits of 5×10^{-3} and 5×10^{-4} curie per day, although occasional values up to ten times these detection limits have been recorded. Tritium oxide emission rates average 0.1 curie per day per reactor, but values up to 1.0 curie per day per reactor have been found.

E-3. Reactor Cooling Water Effluent Monitoring

Sampling of the reactor cooling water at the point of discharge into the Columbia River is maintained on a daily basis for each of the eight HAPO operating reactors. Analysis of these 500 cc samples for gross alpha and beta particle emitters each day and for plutonium and uranium once per week is performed to:

1. Aid in estimating contributions of each reactor to radioactivity in the Columbia River,
2. Predict, correlate, and understand fluctuations in river water activity density, and
3. Correlate activity discharged with reactor operating conditions.

At present, about 10^{4} curies per day of beta emitters and insignificant amounts of alpha emitters are discharged from the eight reactors to the river.

Bi-weekly large volume (3 gallon) samples of reactor cooling water are collected at the inlets to the effluent retention basins for detailed isotopic analyses. The results of these analyses permit calculation of the radioisotopic composition of both the effluent water at time of discharge to the river and of the river itself at various downstream locations. The effluent water isotopic analyses also aid in establishing which isotopes should be analyzed for at downstream river locations, and evaluating public exposure from river water consumption in the absence of radioisotopic analysis of the river itself. The following isotopes are present in the reactor effluent

water four hours after it enters the retention basin in significant quantities: Na^{24}, Si^{31}, P^{32}, Ca^{45}, Sc^{46}, Cr^{51}, Fe^{59}, Mn^{56}, Cu^{64}, Zn^{65}, As^{76}, Sr^{89}, Sr^{90}, Sr^{91}, Sr^{92}, Ba^{140}-La^{140}, Np^{239}, R.E. + Y, and an accounted fraction, which is derived from the difference between the gross beta analysis and the sum of the known isotopic densities.

Because of the possibility of radioactive particulate materials existing in the reactor effluent water, the routine daily samples are filtered prior to analysis and the filter and filtrate are analyzed separately. Normally the filterable gross beta activity amounts to about 1 percent of that in the total sample. Occasionally, the filterable portion may be 75 percent of the total.

E-4. Separations Areas Waste Monitoring

All open ditches, swamps, and ponds in the separations areas are sampled and spot surveyed with portable instruments weekly. The mud and water samples and the surveys are used to determine the radiation exposure in the environs of the waste disposal sites. Analyses of all the samples are made for gross alpha and beta emitters and for plutonium and uranium only where appropriate. The following locations are monitored (See Figure 9): Swamps - "U", "S", "A", and "B"; Ditches - "T", "U", 231, 234-5, Laundry, "B", Purex Chemical Waste, and Purex Process Waste. The analytical results of the sixteen weekly water samples are: 10^{-8} to 10^{-4} μc gross beta per cc; 10^{-9} to 10^{-7} μc of gross alpha per cc; and 10^{-9} to 10^{-7} μc of uranium per cc. The results of measurements of the eleven weekly 1 gram and 10 gram mud samples are: 10^{-5} to 10^{-1} μc gross beta per gram; 10^{-7} to 10^{-2} μc gross alpha per gram; and 10^{-6} μc plutonium per gram.

E-5. Animal Farm and 300 Area Wastes

These two waste streams are either discharged directly to the Columbia River or reach the river shortly after release to the environs. They are sampled daily to help define river water activity density.

Samples of Animal Farm waste liquid are collected on a shift-wise basis by operators at the 100-F Area Animal Farm. The samples are brought to the 329 Building by Regional Monitoring personnel daily for I^{131} analysis. Results are as follows: 10^{-6} μc I^{131} per cc of waste, and 50 - 100 μc I^{131} per day discharged to the river.

The 300 Area wastes are discharged to open ponds along the bank of the Columbia River. The waste water contains 10^{-5} μc uranium per cc of water and seeps through the soil to the river. Concentration of uranium, at point of seepage to the river, is about 5×10^{-9} μc uranium per cc of river water, compared to 6×10^{-10} μc uranium per cc of river water upstream of the 300 Area Ponds. Regional Monitoring no longer samples the 300 Area Ponds, but has access to data on samples collected by the Fuels Preparation Department.

F. Test Well Monitoring

Test wells drilled to the water table under the project, are sampled to follow the movements of high activity density liquid wastes discharged to cribs, reverse wells, and caverns in the 100 and 200 Areas.

Although the water table, itself, is not strictly "environs", it will be a source of environmental contamination when, in the future, underground movement of radioactivity from the 200 Areas reaches the Columbia River or some portion of the water table is used for a sanitary water well.

Figure 10 illustrates the test wells which are sampled. In 200 East Area, 42 weekly, 24 semi-monthly, and one quarterly sample are collected from a total of 67 wells. In 200 West Area, 7 weekly and 42 semi-monthly water samples are obtained from 49 test wells. Only 16 test wells, monitoring 100 Area crib sites, are sampled on a quarterly basis.

Sixteen test wells inside of and in the immediate vicinity of 300 Area and 78 test wells scattered throughout the remainder of the project are sampled on a weekly to monthly frequency. Gross beta analysis is performed on all test well samples. Samples showing sufficient radioactivity are analyzed for various isotopes depending upon the composition of the wastes discharged in their vicinity. Supplemental analyses for sodium and nitrate ions give further clues to the movements of underground wastes. The test well program is maintained at the request of Chemical Effluents Technology, who determine the sampling frequency and analyses desired and who evaluate the data collected.

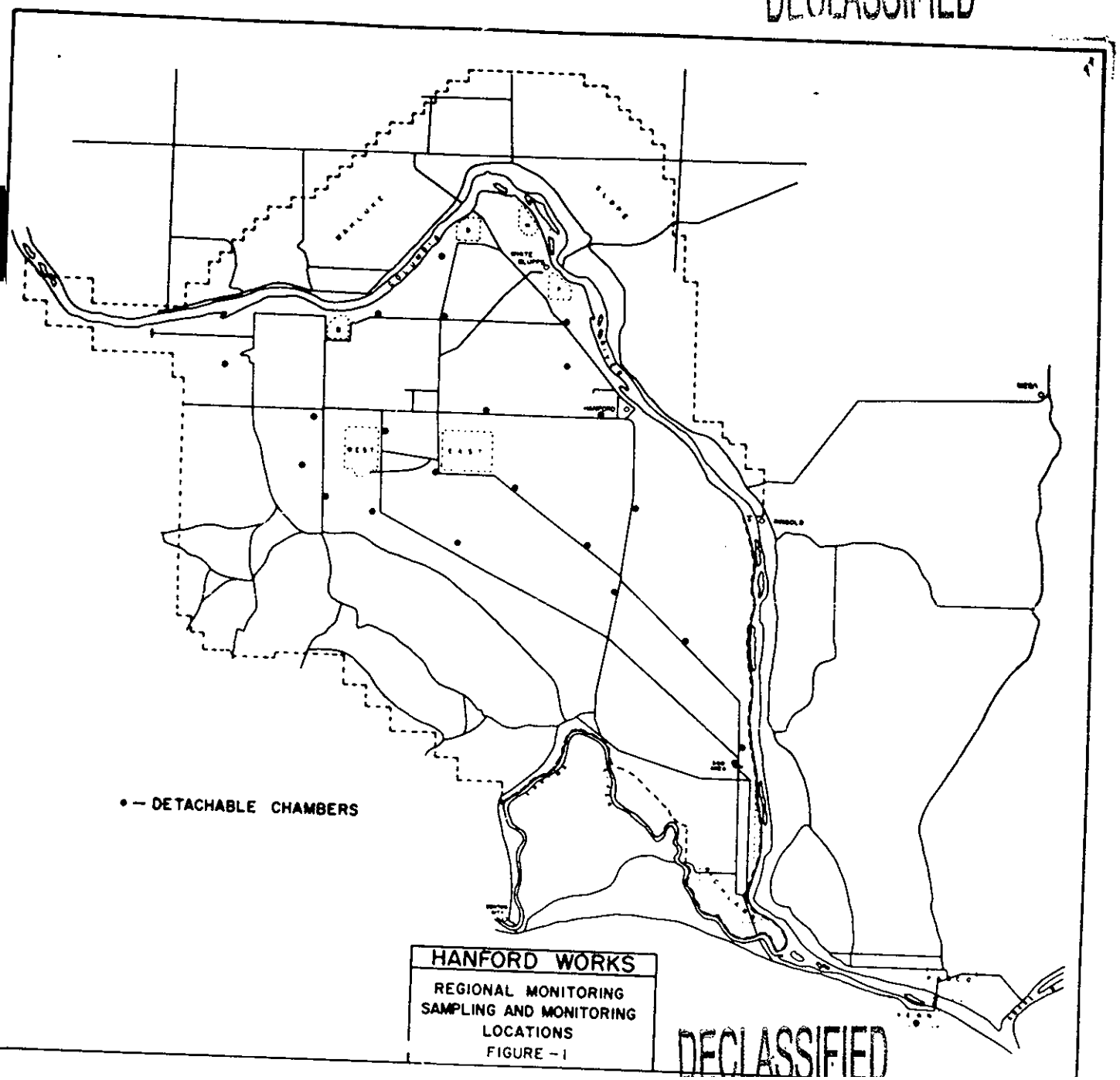
G. Ground Surveys

Surveys of radioactive particulate contamination on the ground are made with portable radiation survey instruments. These measurements yield information on the probability of persons inhaling or ingesting radioactive particles while working in or traveling through the environs. Also, the results of these surveys define the deposition and movement of the radioactive particles from the 291-S and 291-A stacks, which are their main sources.

Figure 11 shows control plots established around the 291-S stack and Figure 12 shows the locations of the control plots around the 291-A stack. These control plots are spot surveyed so that about 50 percent of them are covered each quarter. Repetitive surveys at these definite locations record changing deposition of particulates. In the project, itself, surveys are made monthly at every mile of each well-traveled roadway and monthly to quarterly at every second or third mile of less traveled roadways, such as Wahluke Slope, Rattlesnake Mountain, and Goose Egg Hill; 2000 square feet is surveyed at each of these locations. Monthly surveys of established locations in Richland, Kennewick, Pasco, and between Pasco, Mesa, and Ringold, define particle concentrations on the ground in these regions.

Results of these surveys are: 0 to 50 particles per 2000 square feet in the immediate vicinity of the 200 Areas, 0 to 10 particles per 2000 square feet in the rest of the project, and 0 to 0.5 particle per 2000 square feet in the Tri-City region.

Glass wool pads, 10" x 14", are placed at selected locations downwind of the 291-A and 291-S stacks and near some of the 200 Area "Tank Farms". Deposition and movement of radioactive particulates from these sources are monitored by these pads as an inexpensive supplement to ground monitoring methods. Figures 11 and 12 illustrate glass wool pad locations, in addition to the control plot locations in 200 West and 200 East, respectively. Autoradiographing of the pads permits definition of much lower activity density particles than can be detected through instrument surveys



HANFORD WORKS

REGIONAL MONITORING SAMPLING AND MONITORING LOCATIONS

FIGURE – 1

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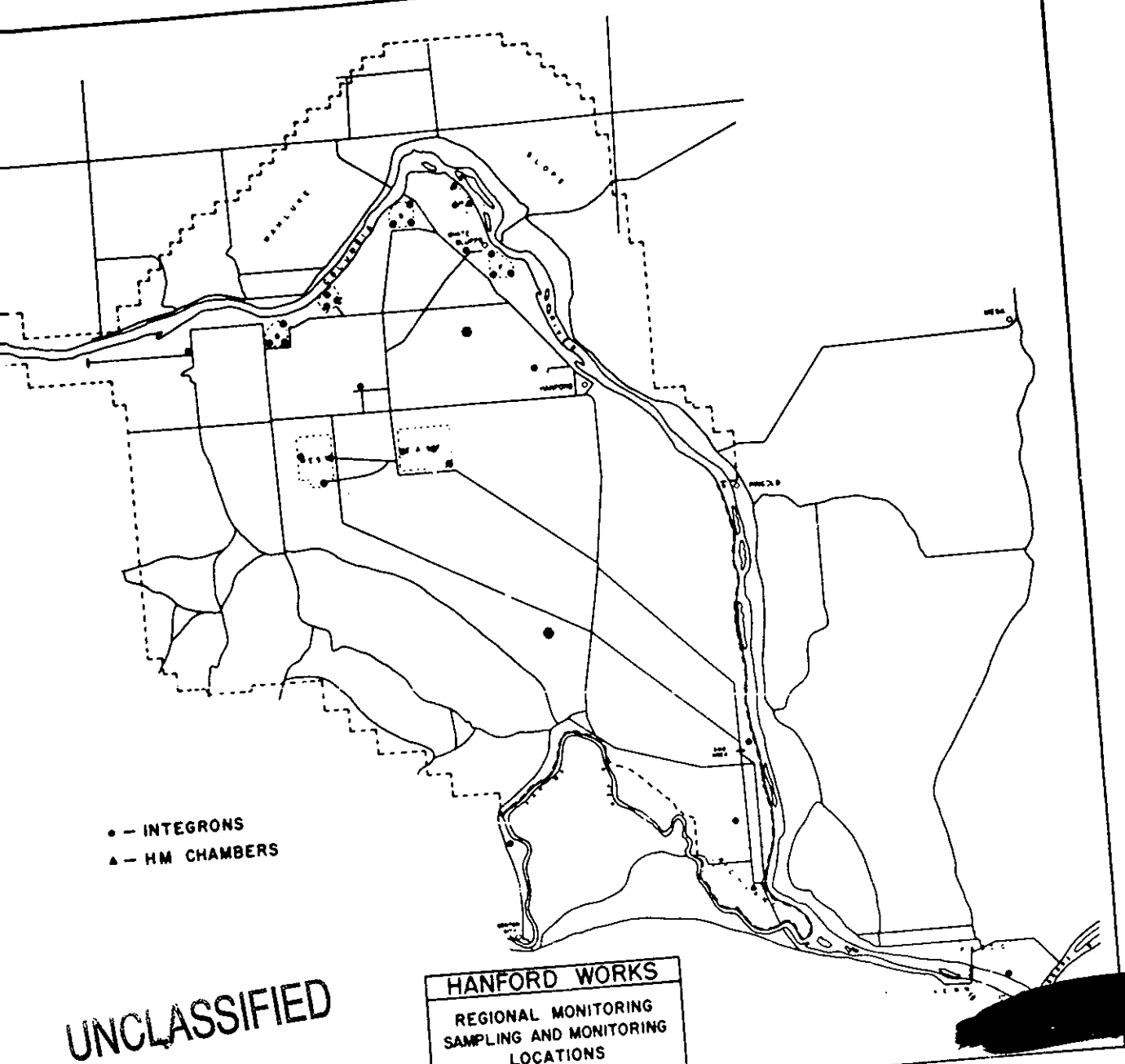

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HANFORD WORKS

REGIONAL MONITORING
SAMPLING AND MONITORING
LOCATIONS
FIGURE - 2

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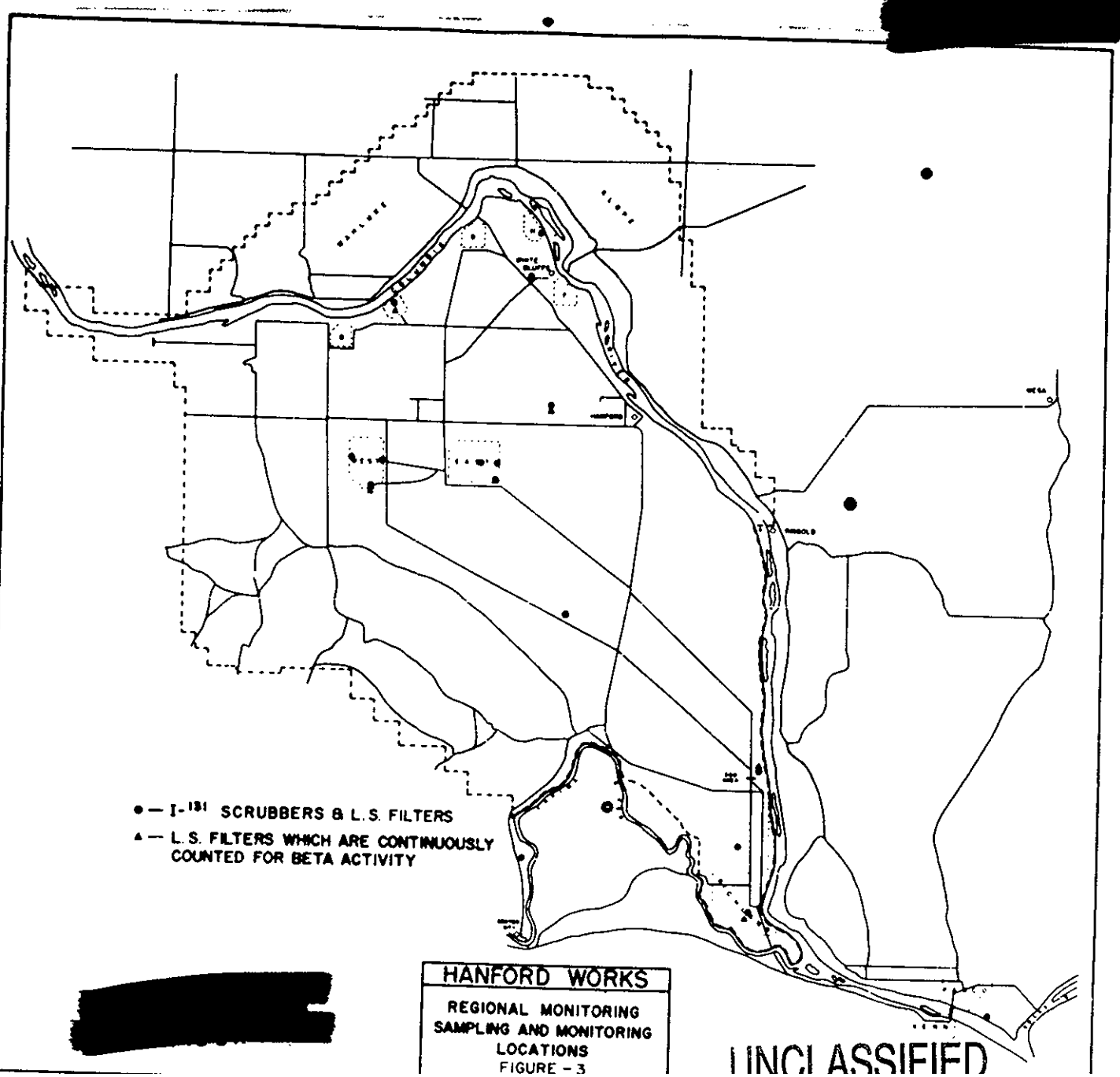

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HANFORD WORKS

REGIONAL MONITORING SAMPLING AND MONITORING LOCATIONS

FIGURE - 3

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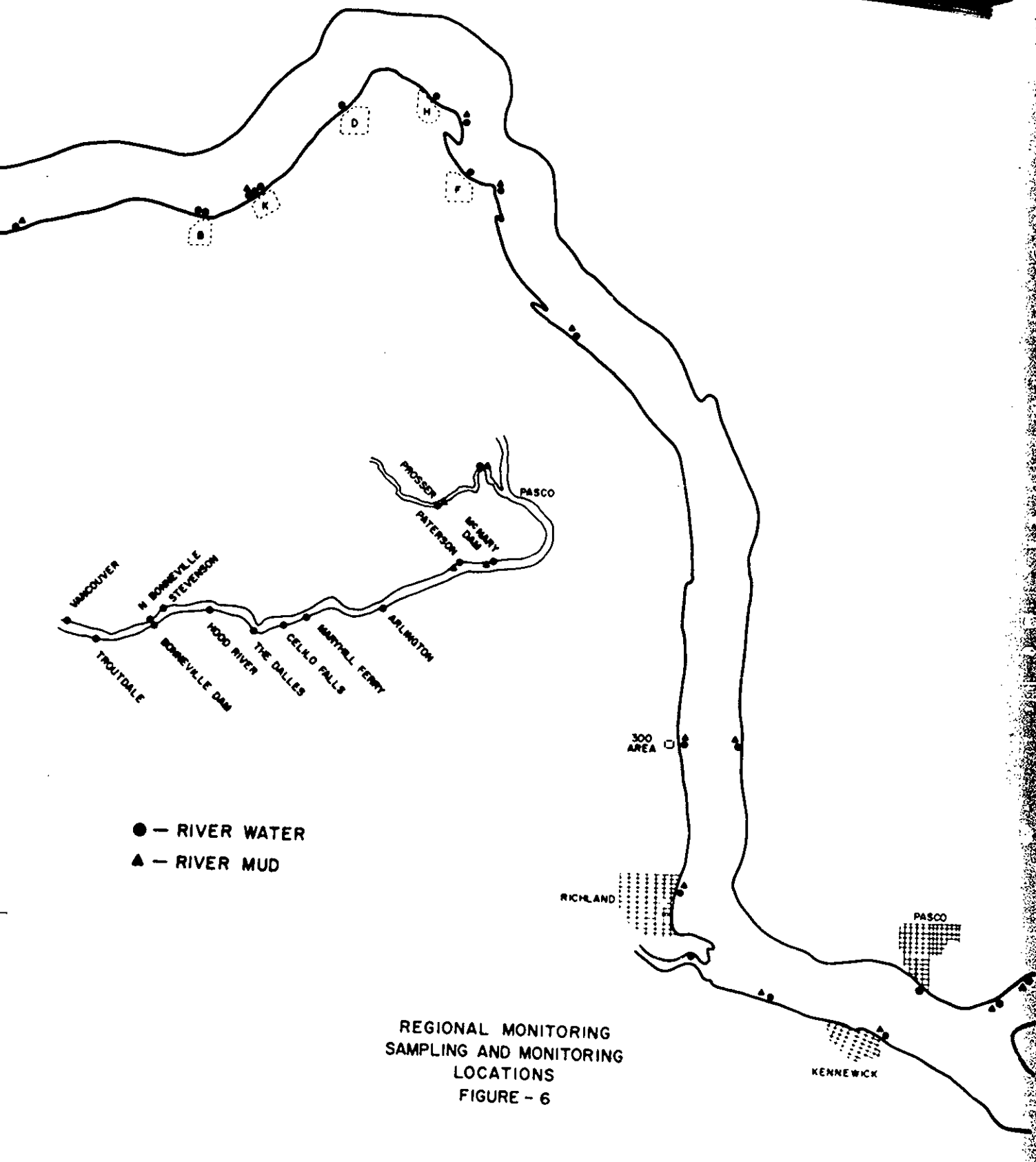

REGIONAL MONITORING
SAMPLING AND MONITORING
LOCATIONS
FIGURE - 6

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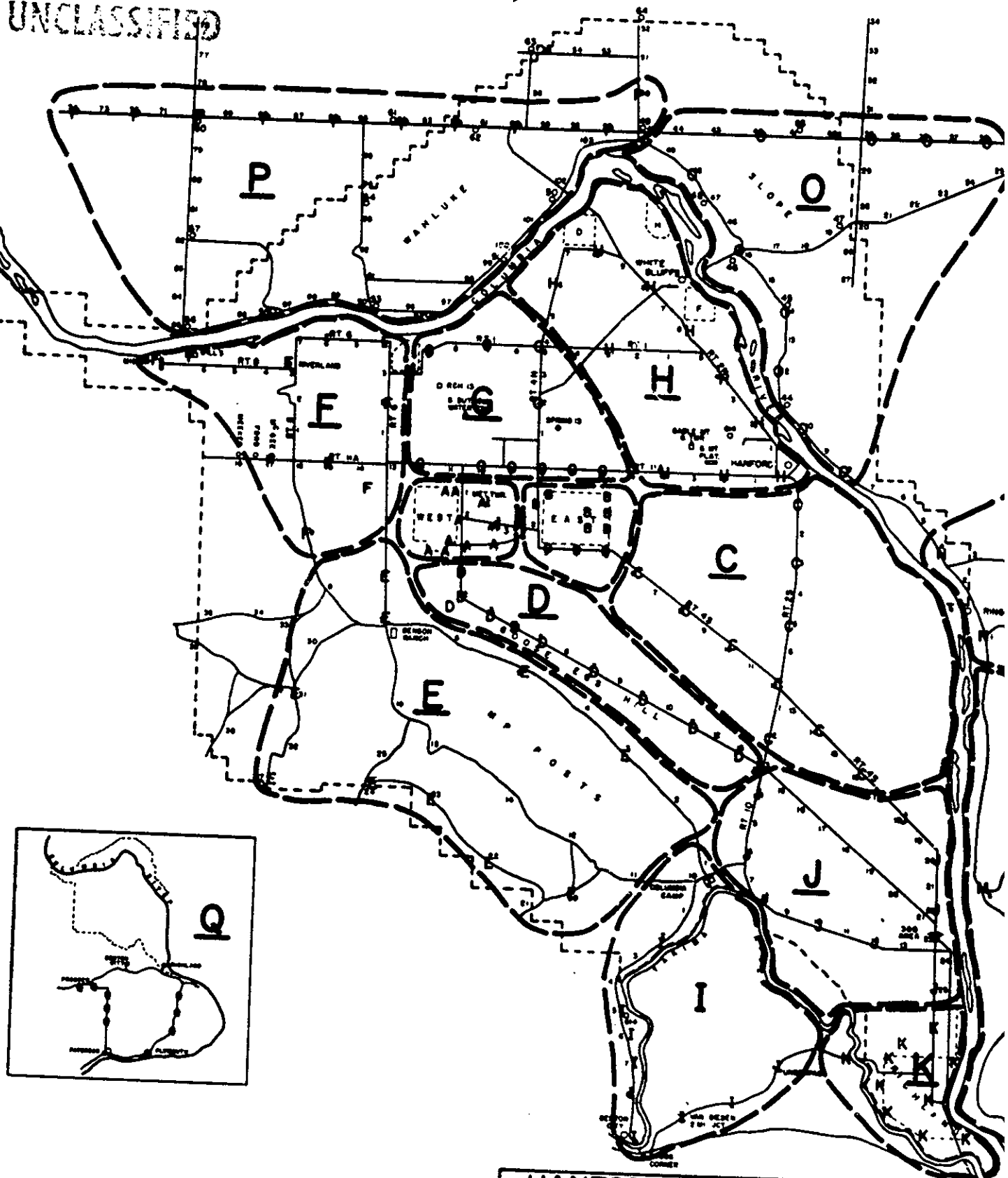

HANFORD WORKS

REGIONAL MONITORING
VEGETATION SAMPLING ZONE LOCATIONS

10 SAMPLES PER ZONE

FIGURE

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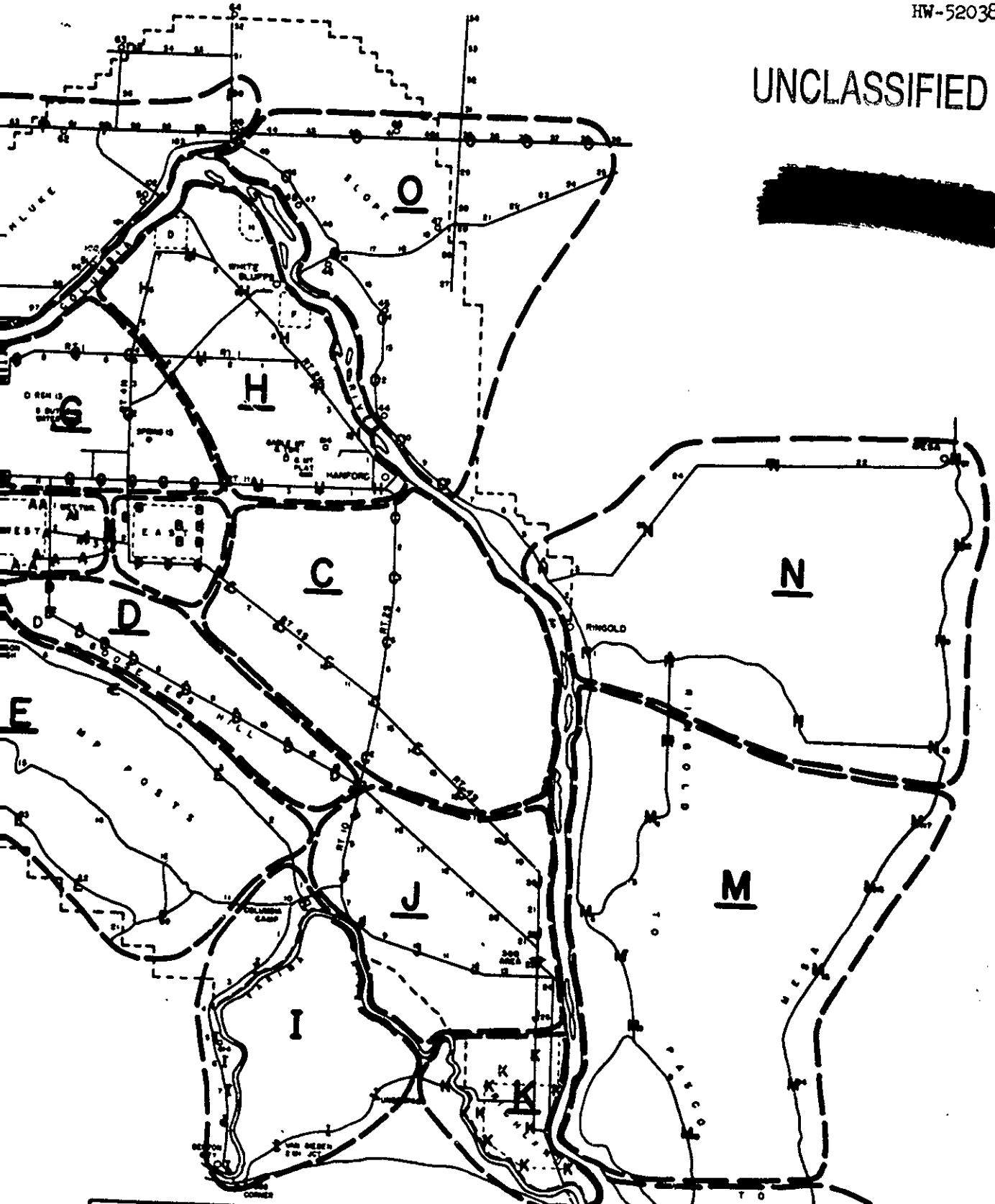
[redacted]



HANFORD WORKS

REGIONAL MONITORING
VEGETATION SAMPLING ZONE LOCATIONS

10 SAMPLES PER ZONE

FIGURE - 7

[redacted]

UNCLASSIFIED

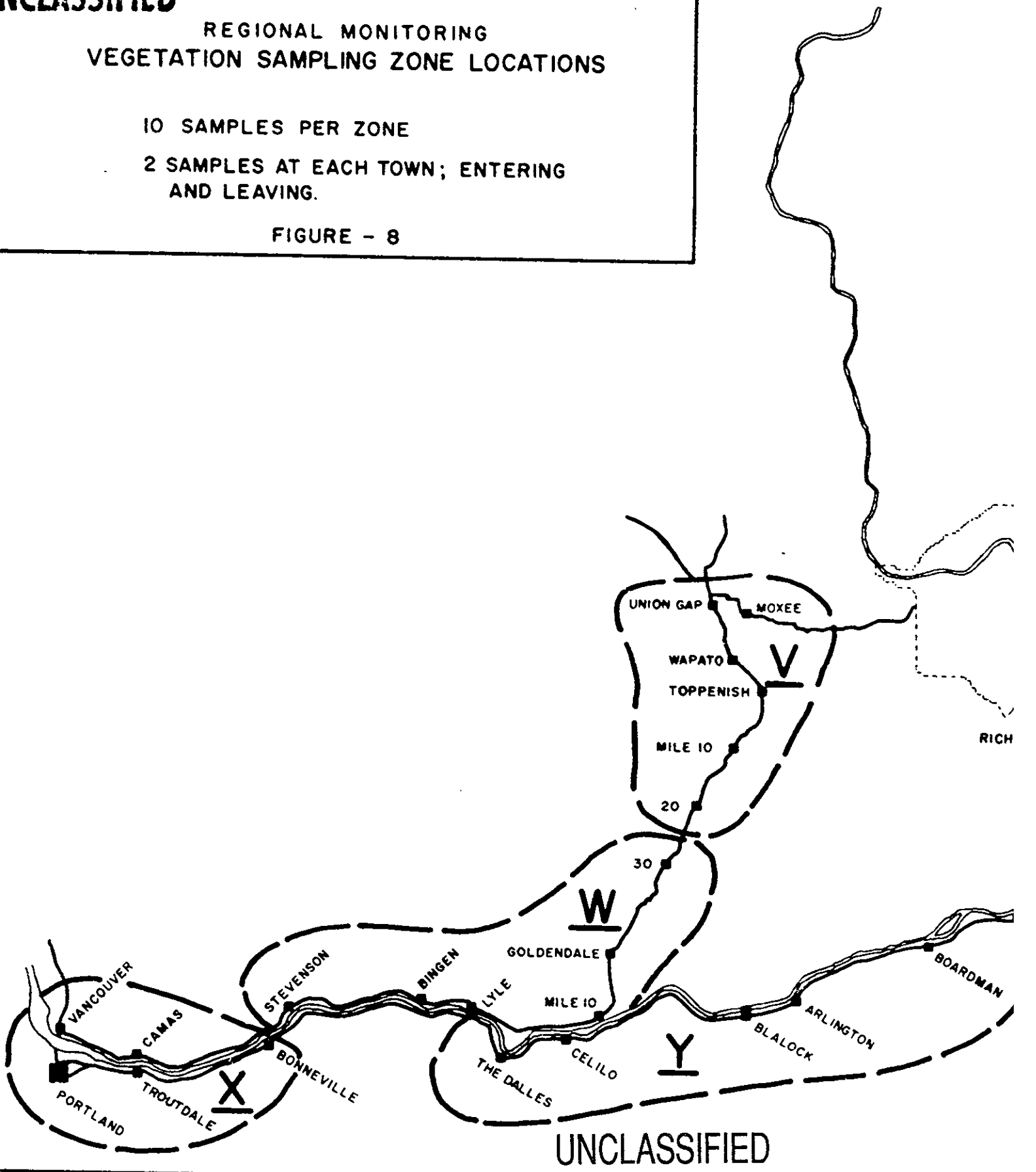
UNCLASSIFIED

REGIONAL MONITORING
VEGETATION SAMPLING ZONE LOCATIONS

10 SAMPLES PER ZONE

2 SAMPLES AT EACH TOWN; ENTERING AND LEAVING.

FIGURE - 8



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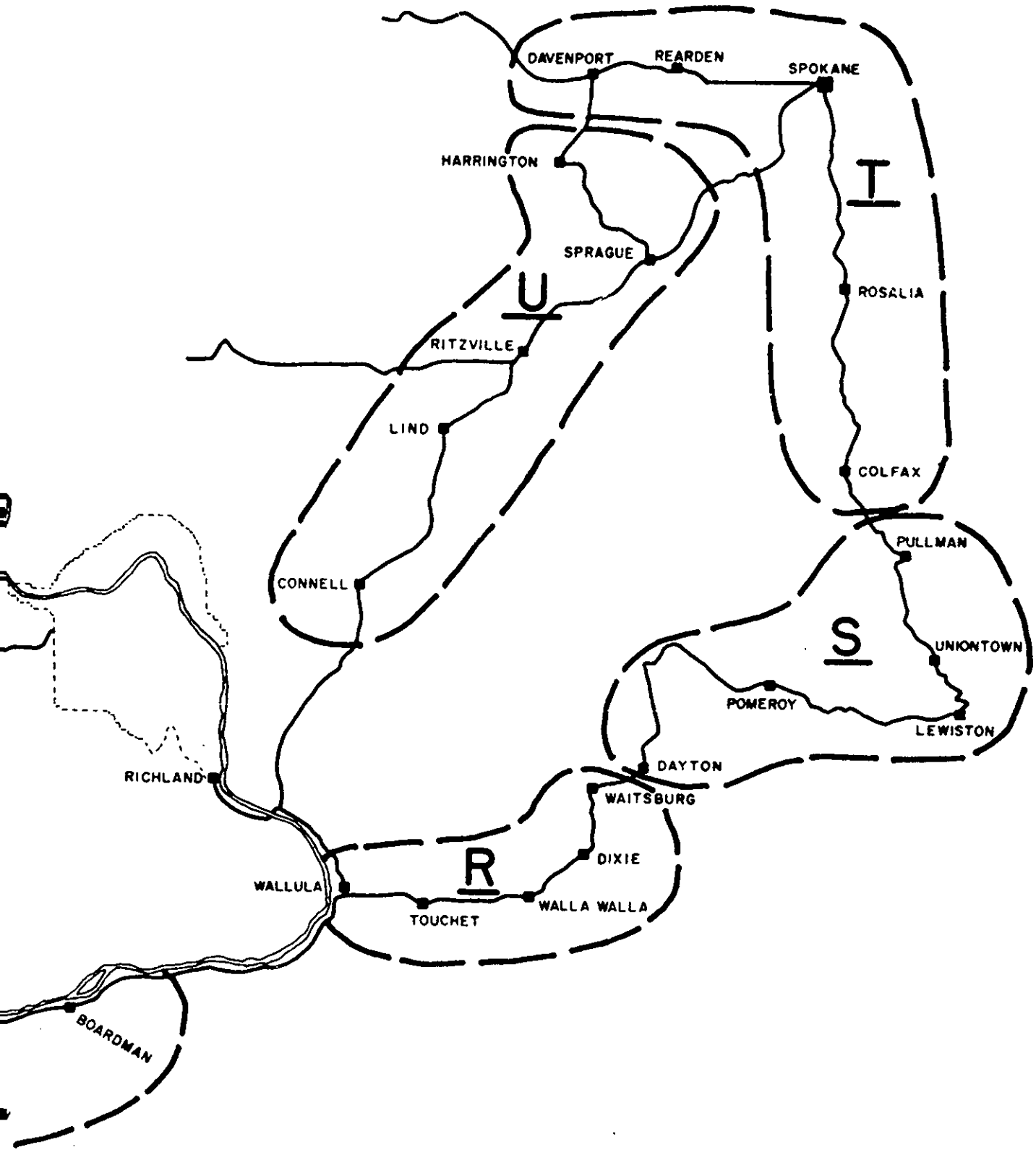
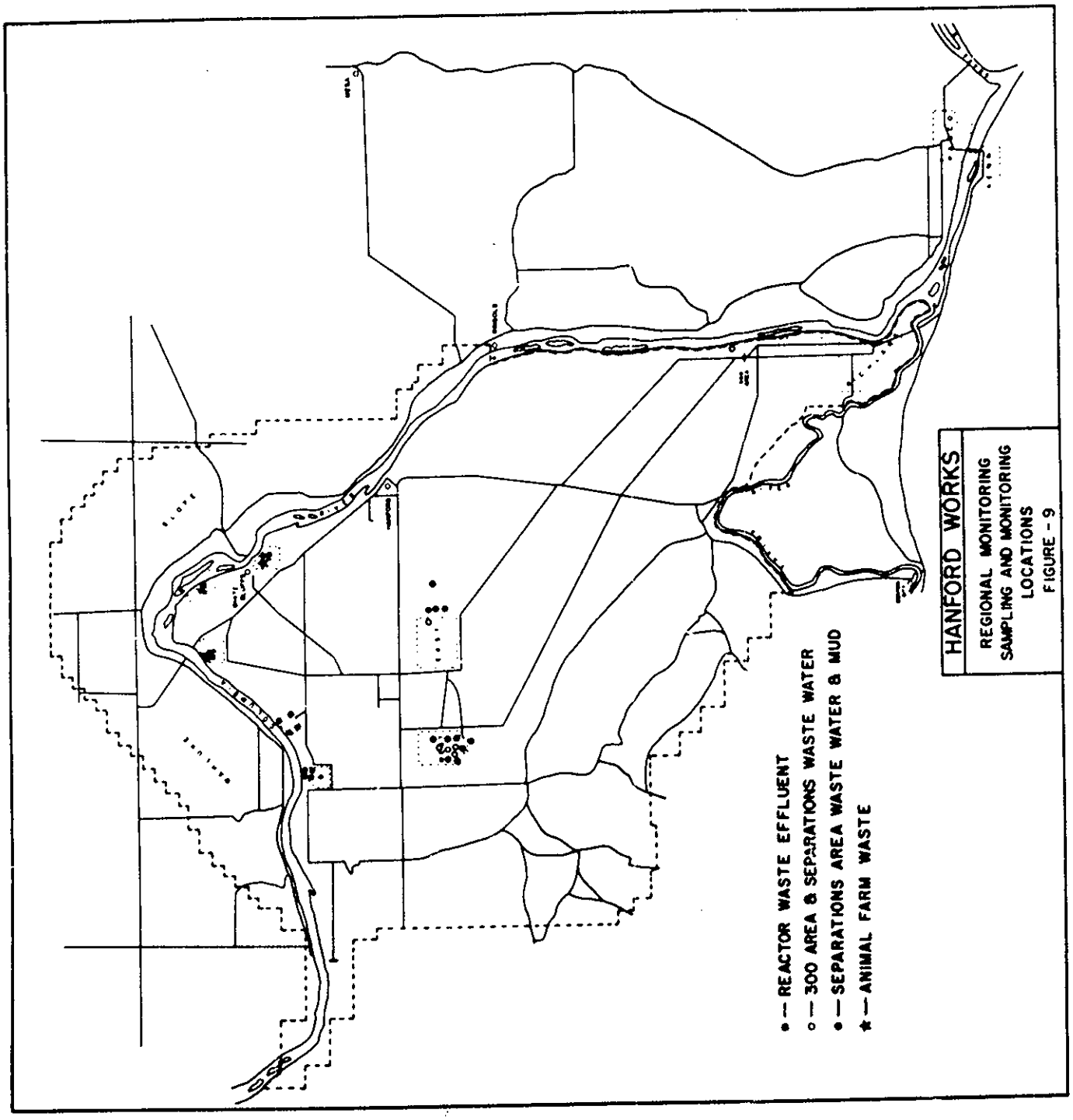
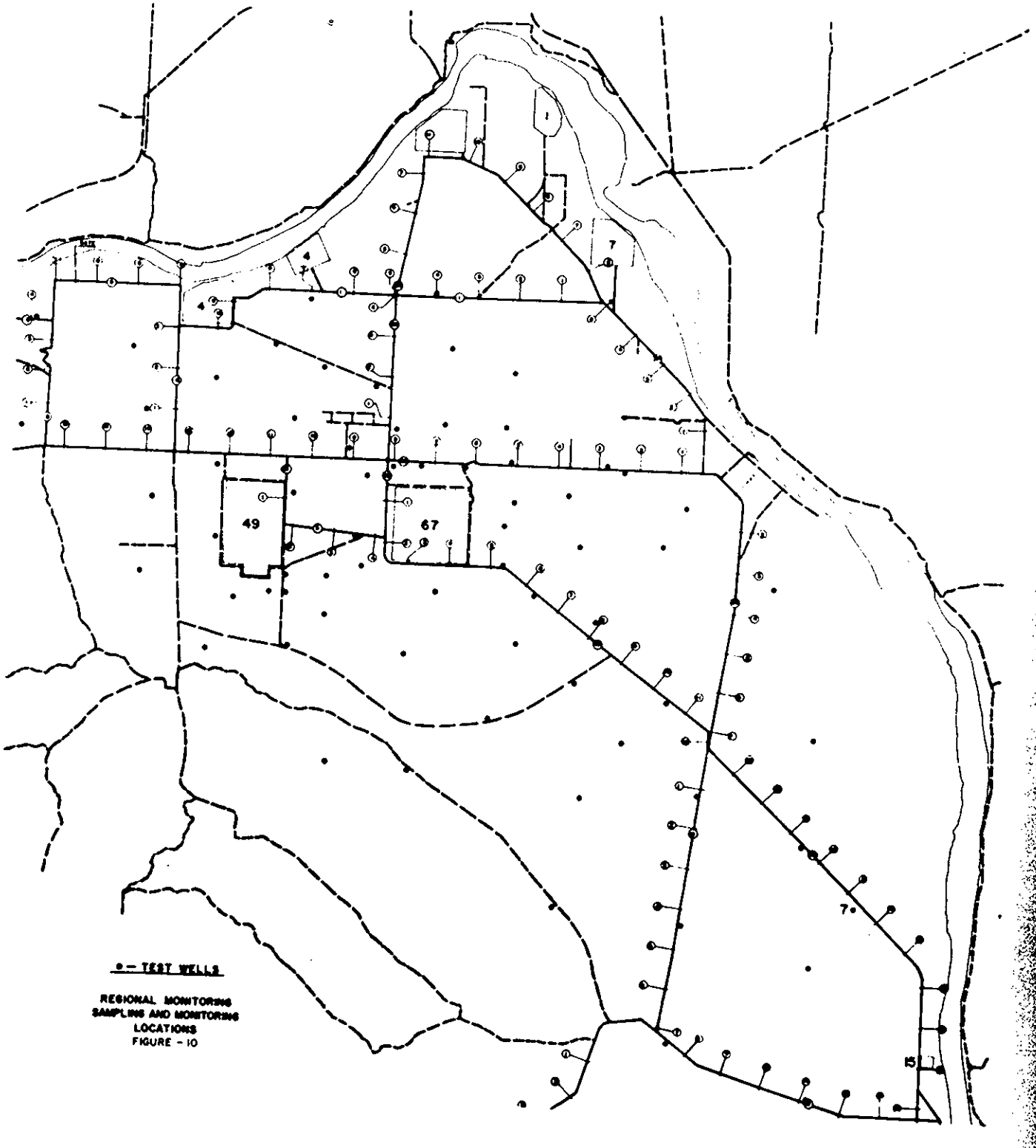
HW-52038


DAVENPORT
REARDEN
SPOKANE
HARRINGTON
T
SPRAGUE
U
ROSALIA
RITZVILLE
LIND
COLFAX
PULLMAN
CONNELL
S
UNIONTOWN
POMEROY
LEWISTON
DAYTON
RICHLAND
WAITSBURG
R
DIXIE
WALLULA
WALLA WALLA
TOUCHET
BOARDMAN


HANFORD WORKS
REGIONAL MONITORING
SAMPLING AND MONITORING
LOCATIONS
FIGURE - 9
● — REACTOR WASTE EFFLUENT
○ — 300 AREA & SEPARATIONS WASTE WATER
● — SEPARATIONS AREA WASTE WATER & MUD
★ — ANIMAL FARM WASTE



o — TEST WELLS

REGIONAL MONITORING SAMPLING AND MONITORING LOCATIONS
FIGURE - 10

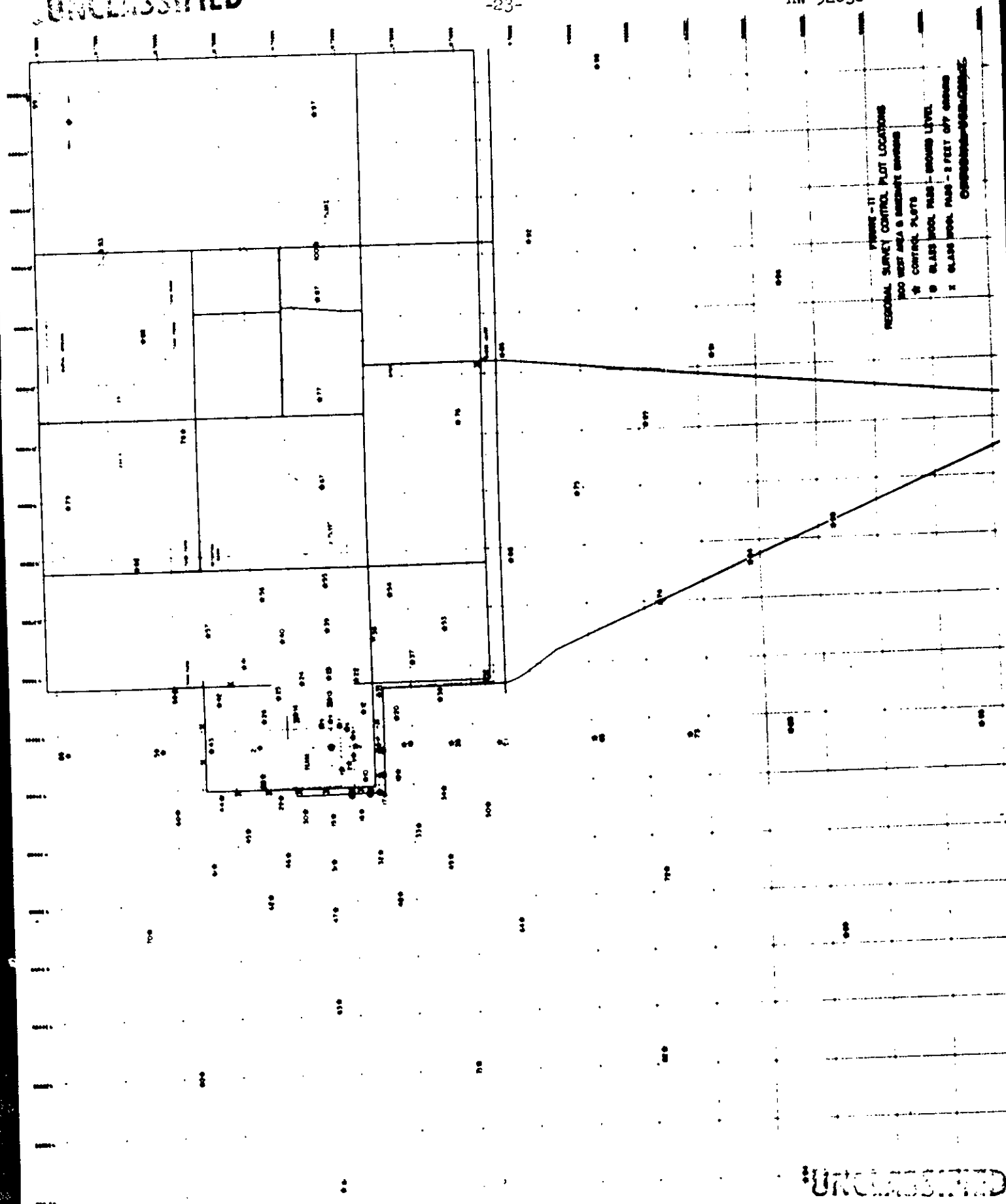
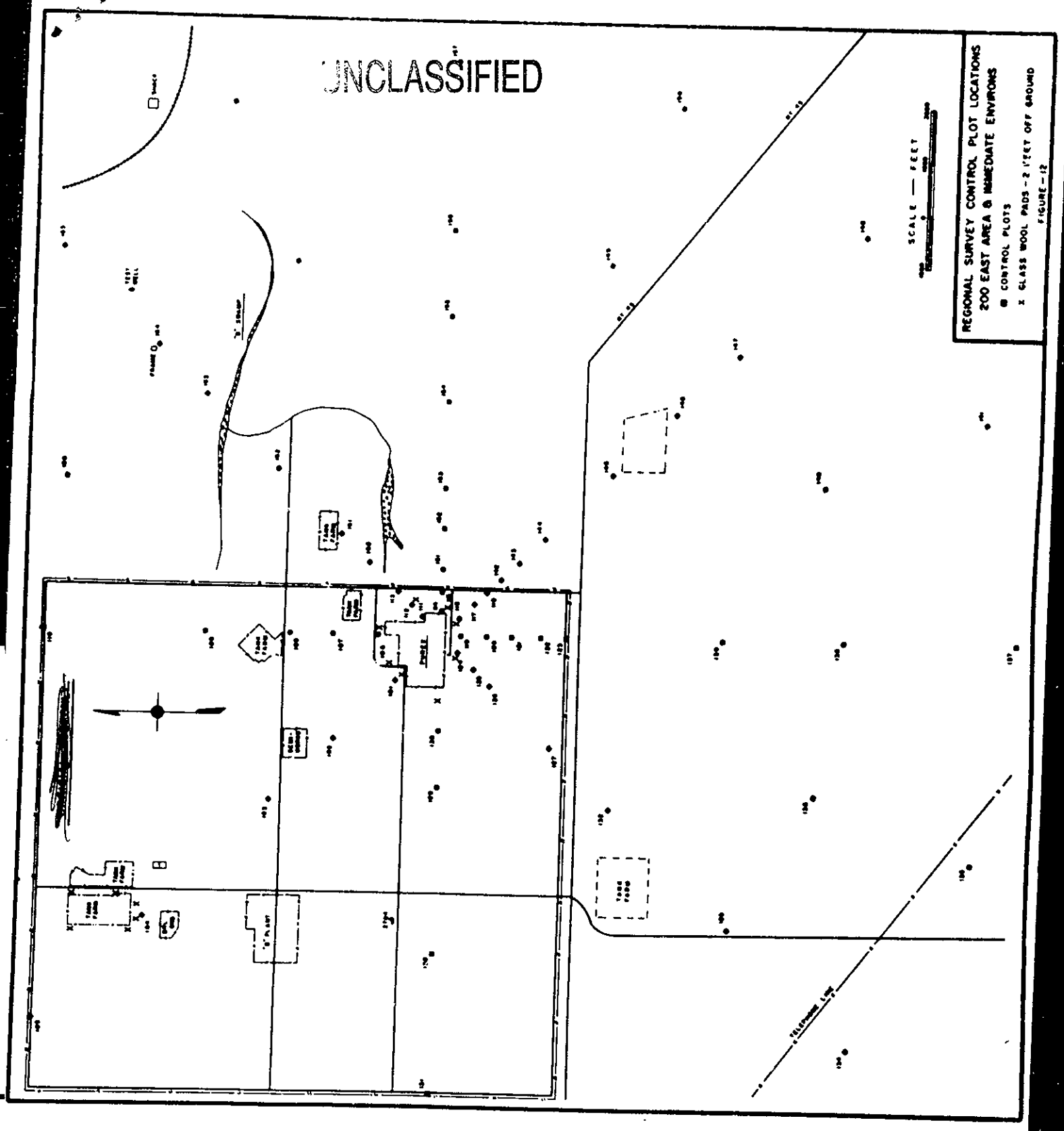


FIGURE - 11
REGIONAL SURVEY CONTROL PLOT LOCATIONS
200 WEST AREA & VICINITY MAPPING
CONTROL PLOTS
BLACK STEEL PAGE - GROUND LEVEL
BLACK STEEL PAGE - 2 FEET OFF GROUND
CORRESPONDENCE/WORK


UNCLASSIFIED
REGIONAL SURVEY CONTROL PLOT LOCATIONS
200 EAST AREA & IMMEDIATE ENVIRONS
CONTROL PLOTS
X GLASS WOOL PADS - 2 FEET OFF GROUND
FIGURE - 12
SCALE — FEET
TELEPHONE LINE