9.1 PURPOSE

This section describes the requirements for assuring that special processes, such as welding/brazing, heat treating, cleaning, and Nondestructive Examination (NDE) are controlled and accomplished by qualified personnel using qualified procedures in accordance with applicable codes, standards, specifications, criteria, and other special requirements. Figure 9-1 delineates the control process.

9.2 RESPONSIBILITIES

9.2.1 **SFSO Engineering components** are responsible for the following:

a. Establishing and/or identifying special processes to be used for fabricating procured equipment. Requirements may be established in the form of criteria, specifications, instructions, and procedures as appropriate.

b. Developing special processes, whenever appropriate, in accordance with national codes and standards or other recognized data.

c. Approving special processs and procedures developed by others.

9.2.2 The **Quality Assurance Organization** is responsible for the following:

a. Reviewing special processes and personnel qualification requirements to assure that special processes and personnel can achieve stated quality requirements for a specific task.

b. Reviewing qualification data on personnel prior to utilization of any special process.

c. Approving special process procedures prior to use.

9.2.3 The **Quality Assurance Function at Morris Operation,** is responsible for verifying that qualified procedures and personnel are used for special processes.

9.3 SPECIAL PROCESS PROCEDURES

9.3.1 Special process requirements are specified on drawings or other design media. The required information includes the applicable procedure and the standard to which the procedure must be qualified.

9.3.2 Each special process is qualified using a written procedure according to the requirements of national standards or codes (where applicable) in specifications incorporating these requirements.

9.3.3 Applicable special process procedures are utilized at the applicable work location.

9.3.4 Samples for process qualification are taken by or under the control of the Quality Assurance Organization

9.3.5 The use of special process materials is controlled by procedures. For example, weld filler metal and fluxes are segregated and maintained in a controlled area. These, or similar materials, are also identified and controlled throughout all stages of fabrication.

9.3.6 Equipment which controls special processes (such as heat controls, electrical controls and recording equipment) are calibrated on a planned frequency and the results are documented.

9.3.7 All other records reflecting on the quality of the process and procedure, such as heat treating furnace certification, furnace charts, welding records, and NDE test data are maintained as documentation of the fabrication/test process.

9.3.8 The Quality Assurance Organization provides a review of the fabrication/test process, control of process qualification samples, review of process parameters and test result documentation, and in-process inspection for assuring the quality of the special process.

9.4 SPECIAL PROCESS PERSONNEL

9.4.1 Each special process is performed by a qualified operator according to the performance requirements of the applicable specification. The operator who successfully performs the "Procedure Qualification" is automatically qualified for performance.

9.4.2 NDE inspection is performed by an operator qualified to the applicable portion of American Society for Nondestructive Testing Standard SNT-1C-1A, "Recommended Practice for Nondestructive Testing Personnel Qualifications and Certification" (or other applicable documents) as a Level II (or higher) Inspector and is qualified to examine and evaluate indications to the applicable acceptance criteria.

9.4.3 Samples for operator qualification/requalification are taken by or under the control of the Quality Assurance Organization.

9.4.4 Requalification of personnel is performed according to the requirements of the applicable process requirements.

9.5 RECORDS

9.5.1 The Quality Assurance function at MO maintains a list of qualified procedures and records to substantiate operator qualifications for all operations performed at MO. The records include name, type of certification, education, and experience backgraounds as well as results of the qualifying examination.

9.5.2 Contractor/vendor process procedures and records are reviewed and approved prior to initiating work at contractor/vendor locations.

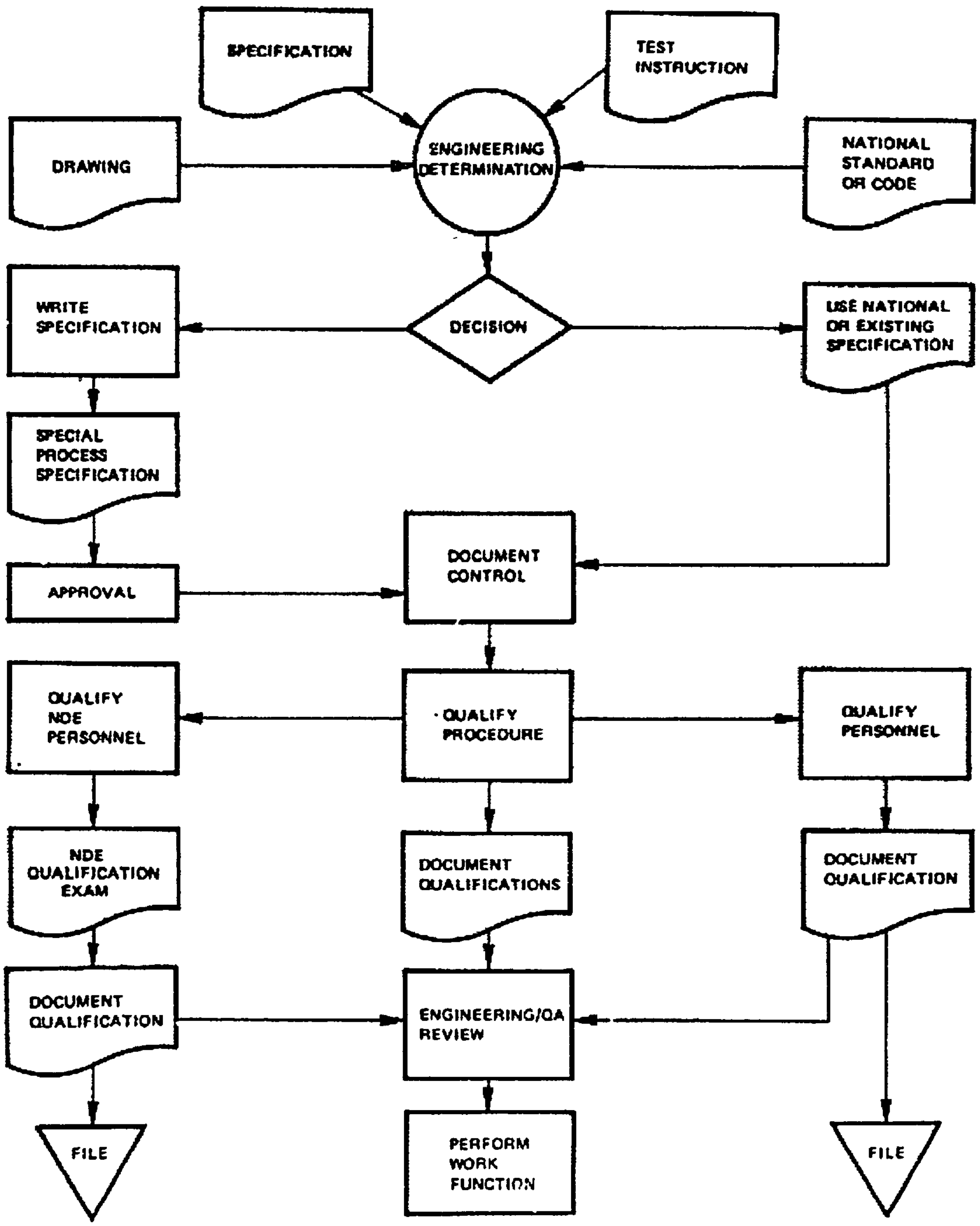


Figure 9-1. Control of Special Processes

QUALITY ASSURANCE PLAN

SUBJECT

10.0 INSPECTION

NUMBER

NEDO-20776

10.1 PURPOSE

This section describes the inspection program for verifying conformance of organization activities with documented instructions, procedures, and drawings.

10.2 GENERAL

10.2.1 Inspection procedures are prepared from drawings and specifications by the Quality Assurance Organization prior to performing the inspection.

10.2.2 Examinations and measurements or tests of materials, components, or products, are performed for each work operation when required by the classification system.

10.2.3 Inspection activities are performed using preplanned check lists which specify the value of the characteristic which must be verified. After measurement, the results of the inspection are certified by the inspector's symbol (stamp, name, etc.) which is traceable to each inspector.

10.2.4 Inspection activities are performed by personnel other than those who performed the actual work activity.

10.2.5 Inspectors are qualified by appropriate training or experience to perform the required inspections.

10.2.6 Nondestructive Examination (NDE) personnel are certified in accordance with the American Society for Nondestructive Testing Standard SNT-TC-1A, "Recommended Practice for Nondestructive Testing Personnel Qualifications and Certification," or with other applicable requirements.

10.2.7 Current inspectors' qualifications and certifications are maintained in Quality Assurance Organization files and are available for review and reference by regulatory and Company personnel.

10.2.8 Contractor's/vendor's inspection procedures are evaluated by the Quality Assurance Organization to ascertain compliance with these requirements.

10.3 RESPONSIBILITIES

10.3.1 **The organization(s) preparing procedures, specifications and drawings** is responsible for specifying Classification for equipment and identifying significant quality characteristics and the required Quality Assurance Effort Required (QAER) Levels (see Section 2.0 for Classification and QAER definitions).

10.3.2 The **Quality Assurance Organization** is responsible for:

a. Reviewing equipment Classification to determine whether the QAER will provide the level of quality expected.

b. Planning and establishing the frequency and methods of inspection to be used to attain required quality levels and how quality levels are verified.

c. Verifying that inspectors (both SFSO and contractor/vendor personnel) are qualified (through training or experience) to perform the inspection function.

d. Assuring that appropriate requirements for process monitoring are established and that quality inspection process(es) meet these requirements.

10.4 IMPLEMENTATION

The Quality Control function of the Quality Assurance Organization performs the required inspection in accordance with Quality Assurance Organization instructions, using established inspection forms or other documentation.

10.4.1 **Source Inspection.** Requirements for items, to be inspected by Quality Assurance personnel at a vendor or subcontracting source, are specified on a Source Inspection Report (SIR). The SIR (stating the characteristics and values) may be prepared by the Quality Assurance Organization when the Material Request is reviewed or after the Purchase Order has been let, or the SIR may be prepared by the SFSO Representatitve in residence at the vendor.

10.4 2 **Receiving Inspection.** Receiving inspection is performed using an Incoming Material Report (IMR). The IMR (as does the SIR) defines the inspections to be performed and methods of accomplishment for the sequence of activities performed during receiving and receivinginspection. The IMR, SIR, certification, test reports and other quality-related records of receiving are maintained in the Quality Assurance Organization Files.

10.4.3 **In-Process Inspection.** In-process inspection mandatory hold points are established by the responsible engineering organization using established work documents. When in-process inspections are performed, the responsible individual signs and dates the appropriate work documents, indicating whether the item is acceptable or nonconforming.

10.4.4 **Testing.** Testing is conducted where appropriate to ensure quality. Testing is performed in accordance with written and approved test procedures. Section 11.0 describes the test control requirements.

10.4.5 **Process Monitoring.** Process monitoring is used to control quality related activities when an inspection is not possible. When appropriate, an integrated program or process monitoring and inspection is used

10.4.6 **Nonconformances.** Nonconformances detected during performance of quality-specified inspections or process monitoring are documented and processed as described in Section 15.0.

11.0 TEST CONTROL

11.1 PURPOSE

This section describes the test programs used for demonstrating that structures, systems, and components perform satisfactorily in service, and are identified and performed in accordance with approved procedures which incorporate the requirements and acceptance limits of applicable design documents.

11.2 APPLICABILITY

Test control is applicable to all SFSO or external contractor organizations which are required to perform a test function in conjunction with work activities as specified in design documents, contracts, or material codes.

11.3 GENERAL

11.3.1 Test programs include, as applicable, manufacturing tests prior to installation, installation tests, equipment verification tests, operational tests, and developmental engineering tests.

11.3.2 Testing is conducted by appropriately qualified personnel in accordance with documented and approved test procedures.

11.3.3 Testing procedures include provisions for assuring that all prerequisites for the given test have been met, that adequate test instrumentation is available and used, and that the test is performed under suitable environmental conditions.

11.3.4 Test results (test data) are documented and evaluated by responsible Engineering and/or Operations Components to assure that all test requirements have been satisfied.

11.4 RESPONSIBILITIES

11.4.1 The **Engineering and/or Operations Components** are responsible for the following.

a. Incorporating testing requirements and acceptance limits in applicable design documents.

b. Preparing the basic test instructions and/or procedures

11.4.2 **Fuel Storage Projects** is responsible for the following:

a. Planning and scheduling all tests by contractors and Morris Operation (MO) which are related to project design and construction activities for which Projects has responsibility.

b. Reviewing and approving applicable test procedures as specified in (a) above, including test status and results.

c. Directing MO activities related to performing applicable tests as specified in (a) above (also see subparagraph 11.4.3).

11.4.3 MO is responsible for the following:

a. Conducting Equipment Verification Tests (EVT's) to verify operational condition of new, repaired, or modified equipment. EVT procedures are prepared by MO Operations personnel (or by the Project Responsible Engineer) and are approved as in 11.4.2.b.

b. Conducting operational tests (procedures prepared by MO Operations and approved as in 11.4.2.b) and providing instructions and training to operating personnel.

c. Coordinating with Fuel Storage Projects in establishing test schedules.

11.5 **IMPLEMENTATION**

11.5.1 Responsible organizations perform testing in accordance with written and approved procedures.

11.5.2 The Quality Assurance organization performs audits and surveillance for adherence to the test program for activities affecting quality in accordance with Sections 15.0, 16.0, 17.0 and 18.0.

11.5.3 The Quality Assurance organization reviews applicable test procedures and results to assure activities affecting quality are controlled and that quality requirements of the applicable design documents have been met.

12.0 CONTROL OF MEASURING AND TEST EQUIPMENT

12.1 PURPOSE

This section describes the measures used for ensuring that tools, gages, scales, and other measuring and testing devices (instruments) used during fabrication, inspection, construction, maintenance, operation, and modification are properly controlled, calibrated, and adjusted at specified periods to maintain accuracy within necessary limits.

12.2 GENERAL

12.2.1 Measuring and test equipment used for determining compliance with specifications, are adjusted and calibrated at prescribed intervals using certified equipment having known valid relationships to nationally recognized standards. If no national standard exists, the basis for calibration is documented.

12.2.2 When non-calibrated measuring and test equipment is found, a nonconforming inspection report is prepared and an evaluation is made of the validity of previous inspection or tests results and the acceptability of system or items inspected or tested since the last calibration check.

12.2.3 Each organization provides an area where calibrated measuring and test equipment is stored. Environmental conditions of storage areas are appropriate to the type of calibration performed. Use of out-of-calibration instrumentation is precluded by controlled access or administrative control as appropriate

12.2.4 Personnel responsible for calibration tasks are trained to perform these duties. Overall direction is assigned to a responsible management individual (e.g., foreman, supervisor, manager) with authority to issue and recall.

12.3 RESPONSIBILITIES

12.3.1 **Each organization possessing measuring and test equipment** is responsible for control and calibration of electrical, mechanical, or other types of measuring and test equipment used during fabrication and inspection, construction, operation, or maintenance work. The same organization is responsible for identifying all equipment that requires calibration, the frequency of calibration, and issuance control.

12.3.2 **A specific management individual within each organization** is assigned responsibility to ensure that measuring and test equipment is controlled, calibrated and issued to authorized groups is a systematic manner. This individual is responsible (directly or by delegation) to ensure that calibrations are recorded, instruments have current calibration stickers attached, and that instruments are recalled for periodic recheck.

12.3 3 **Users of equipment** are responsible for returning instruments for periodic recheck and/or recalibration if damage or malfunction is suspected.

12.3.4 **Each organization** is responsible for ensuring that personnel using measuring and test equipment are appropriately trained as required for installation, checkout, use, and understanding of data readout used in recording data.

12.3.5 The **Quality Assurance Organization** is responsible for the following:

a. Resolving nonconformances resulting from suspect instruments or equipment discovered not in calibration.

b. Auditing and surveillance of these activities as well as for complying with all requirements (if it is the "user" organization).

c. Ascertaining that appropriate corrective action of nonconformances is accomplished.

d. Ascertaining that contractor's or vendor's calibration programs comply with SFSO requirements.

12.4 CONTROL SYSTEM

12.4.1 **Standards.** Instruments (standards) used to calibrate production instrumentation and other tools requiring calibration have an uncertainty (error) of no more than 1/4 of the tolerance of the equipment being calibrated. A greater uncertainty may be acceptable when limited by the "state-of-the-art". These standards are calibrated by the National Bureau of Standards or from a certified source having traceability to the National Bureau of Standards. These standards are checked and calibrated on an annual basis.

12.4.2 **Production Instruments.** Mechanical and electrical instruments and tools used to control a critical processor used to test components, subassemblies, or final products are identified with a "Calibration" label and calibrated according to a specific time schedule.

13.1 PURPOSE

This section describes the measures used for controlling the handling, storage, and shipping of nuclear and non-nuclear material in compliance with license requirements and in accordance with instructions, procedures, or drawings to prevent damage, deterioration, or loss.

13.2 APPLICABILITY

This section applies to all organizations that participate in the packaging, shipping, storage, and handling of items to be incorporated or used in construction or operation of a nuclear fuel storage facility. These items include, but are not limited to, irradiated nuclear fuel, shipping casks, construction materials, fabricated assemblies, and parts.

13.3 GENERAL

13.3.1 Nuclear Materials

a. Nuclear safety is of prime concern in the handling and shipping of nuclear materials The use of approved procedures and training of personnel to follow such procedures during handling and shipping activities are required. Items of specific concern include the following:

   1. Maintaining, testing, handling, and decontaminating irradiated fuel shipping casks.

   2. Transporting and in-transit handling of irradiated fuel shipping casks.

   3. Removing irradiated fuel from the shipping casks at the Morris Operation (MO).

   4. Transferring irradiated fuel assemblies into basin storage baskets and/or casks

   5. Handling, compacting and storage of nuclear waste materials.

b. Nuclear safety is of prime concern in the storage of nuclear materials. The use of approved containers or equipment, placing in authorized storage areas,use of approved procedures for fuel identification and operations, and monitoring to assure compliance to procedures are required Primary storage features include the following:

   1. Storing irradiated fuel assemblies in baskets or racks designed for criticality safety within the fuel storage pools.

   2. Verifying the nuclear safety of storage continuously by using instruments and/or by personnel observations to maintain surveillance of the degree of containment of nuclear materials

   3. Maintaining and testing fuel handling equipment.

13.3.2 **Non-Nuclear Materials**

a. Handling, shipping, and packaging is performed in accordance with requirements specified in specifications, drawings, and/or special instructions to prevent damage or degradation of quality

b. The identification (and status) of items during handling (including subdivision or joining in the fabrication process), packaging, and shipping are described in Section 8 0 and Section 14.0

c. Storage activities include retention of identification, inspection status of items (Section 14 0) through tagging or marking, controlled distribution, preservation of the item from environmental deterioration, and unauthorized access or modification.

13.4 **RESPONSIBILITIES**

13.4.1 **Fuel Storage Projects** is responsible for the following:

a Incorporating requirements for handling, storage, and shipping into design documents such as drawings, specifications, special instructions, and where applicable, Material Requests (MR's).

b. Incorporating requirements for project-related handling, storage, and shipping into Purchase Orders, contract documents, including directing related fabrication/construction activities performed by major and subtier contractors.

13 4.2 **Licensing and Transportation** is responsible for shipping of irradiated fuel casks in conformance with licensing requirements.

13.4.3 **Morris Operation (MO)** is responsible for handling, storage, and shipping activities performed by MO personnel as part of routine fuel storage operation and maintenance of the facility as well as for maintenance and testing of equipment in accordance with licensing requirements.

13 4.4 The **Quality Assurance Function at MO** is responsible for reviewing proper handling, storage, and shipping procedures.

13.4.5 The **Quality Assurance Function in San Jose** is responsible for surveillance and audit of activities pertaining to handling, storage, and shipping of items for SFSO.

13.5 **IMPLEMENTATION**

13.5.1 The requirements for cleaning, marking packaging, preservation methods, shipping, storage and handling are incorporated in design documents, special instructions, and the MR by the responsible engineer These requirements are reviewed and approved by appropriate management

13.5.2 Organizations performing specific tasks (such as Licensing and Transportation in cask design and licensing, and MO in their shipping and storage activity) implement these tasks by the development and/or use of detailed procedures.

13 5 3 Specific procedures for irradiated fuel handling and storage are developed by MO in accordance with the Quality Assurance Program.

13.5.4 Fuel Storage Projects coordinates and directs handling, storage and shipping between major contract organizations during the design, procurement and construction phases of SFSO projects

13.5.5 The Quality Assurance function in San Jose reviews SFSO handling, storage and shipping activities using detailed procedures which cover their audit and surveillance activities

14.1 PURPOSE

14.1.1 This section describes the measures used to indicate the status of inspections and tests performed upon individual items during fabrication and assembly, and subsequently used in a nuclear fuel storage facility. Such measures preclude the use of nonconforming items due to inadvertent bypassing of inspections and tests.

14.1.2 This section also describes the measures used to indicate the operational status of structures, systems, and components of a nuclear fuel storage facility to prevent inadvertent operation while these structures, systems, and components are not in conformance with licensing requirements.

14.2 GENERAL

14.2 1 Inspection and test status of individual items are indicated by stamps, tags, labels, routing cards, or other suitable documentation. The using organization ascertains that the status of the equipment is indicated by this type device prior to use.

14.2.2 Such documentation provides for the identification of items which have satisfactorily passed required inspections and tests.

14.2.3 Operational status of the plant, which is dependent on the operational status of the structures, systems, and components, is indicated by tagged valves, tagged switches, lockouts, etc., in conjunction with log book entries that document status to prevent unauthorized adjustment or operation.

14.3 RESPONSIBILITIES

14.3.1 The **Manager, Morris Operation (MO)** is responsible for detailing documentation of plant operational status. This includes the following:

a. Plant Engineering and Maintenance (in conjunction with Engineering Components in San Jose) is responsible for all engineered items, pipe, fittings, valves, instruments, pumps, blowers, etc., used in facilities assigned to MO.

b Plant Operations is responsible for using approved operating procedures and for plant readiness as well as providing an interface with Fuel Storage Projects.

c. The Quality Assurance function at MO is responsible for the inspections and test requirements of facility parts and components used in plant operations and maintenance.

14.3.2 **Fuel Storage Projects** is responsible for procedures detailing project related documentation of test and inspection status of items, structures, systems, and components during construction or modification.

14.3.3 **Vendors** are responsible for procedures (approved by GE) detailing documentation of test and inspection status of items under their control.

14.3.4 The **Quality Assurance Organization** is responsible for verifying that procedures for the status of inspections, tests, and operations are utilized by applicable organizations.

14.4 IMPLEMENTATION

14.4.1 Inspection, test, and operating status of incoming irradiated fuel is covered in part in Section 13.0.

14.4.2 Inspection, test, and operating status of incoming and in-process maintenance and construction items are covered in Sections 7.0 and 13.0. Functional Class 1, 2, or 3 items are identified by a Material Control Tag or a readily recognized identity such as a heat number or serial number (see Section 2.0 for definitions of Classifications).

14.4.3 Nonconforming material and items are handled in accordance with Section 15.0.

14.4.4 The operating status of all systems is controlled by Lock and Tag procedures. The use of these procedures prevents inadvertent operation of a system undergoing maintenance or repair. Basic "Lock-out" tags used are as follows:

a. DANGER—DO NOT OPERATE tags placed on pieces of equipment that are not in service due to maintenance or processing reasons and if operated could result in a hazardous condition to personnel and/or equipment.

b. CAUTION or status tags placed on valves, switches, or controls that indicate condition of applicable systems. The instructions, contained on the tag, specifv steps that must be taken in sequence to operate the equipment in question.

14.4.5 Status of functional tests of structures, systems, and components are covered in Section 11.0.

14.4.6 The Quality Assurance Organization verifies inspection, test, and operating status by surveillance of the fabrication, receiving, test, and inspection processes, and audits of the processes, documentation produced, and equipment utilized in design, fabrication, inspection, and test of equipment used by SFSO.

15.1 PURPOSE

This section describes the measures used for controlling materials, parts, systems and structures which do not conform to requirements and which are normally detected through inspection, test, operation, or audit. Additionally, the measures used to document and control nonconformances discovered during process operations are described as well as the vehicle for deviating from the original contract.

15.2 NONCONFORMING ITEM RECORD (NIR) AND QUALITY HOLD TAG

15.2.1 Nonconformances noted by SFSO in material, parts, or components, systems and structures are documented in NIR's

15.2.2 The nonconforming item is identified by a "Hold Tag" and the affected organization is notified. Where practical, the item is segregated in a quarantine area to prevent its inadvertent use.

15.2.3 The item remains on hold, properly tagged until restored to an acceptable condition or scrapped. Only QA has the authority to effect a release from quarantine or removal of the "Hold Tag."

15.2.4 In certain instances, items may be nonconforming only from the standpoint of the type of service for which the item is purchased, but may be acceptable for other services. In such instances, the Quality Assurance Organization signs the NIR releasing the item for a service to which the item conforms

15.2.5 The Material Review Board (MRB) may authorize continuing processing of an assembly pending disposition of a nonconforming component.

15.2.6 Vendor Quality Assurance Programs contain requirements equivalent to those of SFSO, consistent with their scope of work.

15.3 RESOLUTION OF A NONCONFORMANCE

15.3.1 Nonconforming materials, parts, or components are identified, dispositioned, and restored in accordance with the following:

a. **Level 1**

1. Disposition is by the first supervisory level performing work that detected the nonconformance. The authority for disposition at Level 1 is restricted to the following:

   (a) Part, item, or assembly may be reworked to meet existing specifications.

   (b) New scheduling or revision to design or fabrication documentation is not required

2 The Quality Control function of the Quality Assurance Organization signs Level 1 dispositions

3. If the nonconformance cannot be corrected within the limits of Level 1 authority, the NIR is referred to Level 2 or Level 3 by the supervisory or Quality Control personnel.

4. Level 1 correction is reinspected for conformance to stated requirements

b. **Level 2**

1. Disposition authority for Level 2 requires the Quality Assurance Organization (Quality Engineering) and SFSO Engineering approval as a minimum. Disposition is to rework, scrap, return to supplier, repair, or "use as is." Disposition to "use as is" or "repair" may be made at this level provided such disposition does not adversely affect function, fit-up, safety, or basic design requirements of the manufacturing plan, supporting documents, design documents or contractual agreements.

2. Nonconformances which cannot be resolved by the Level 2 Quality Assurance and Engineering Organizations are referred to Level 3.

3. Level 2 correction is reinspected for conformance to dispositioned requirements.

c. **Level 3 Material Review Board (MRB)**

1. Level 3 involves any of the unresolved nonconformances from Level 2. Disposition authority for Level 3 is referred to a MRB and requires approval of this Board.

2. As a minimum, the MRB consists of representatives from Fuel Storage Projects, the Quality Assurance Organization, and other Engineering Organizations as determined by the Manager, Fuel Storage Projects or the Manager, Morris Operations, as applicable. Representatives from Purchasing and other groups (such as Operations) are included in the MRB as appropriate.

3. Level 3 correction is reinspected for conformance to MRB requirements.

15.3.2 The Quality Assurance Organization closes the NIR when all appropriate actions are taken and maintains appropriate records of the NIR.

15.4 DEVIATION DISPOSITION REQUEST (DDR)

15.4.1 The DDR is the vehicle by which the vendor requests changes to the original contract or purchase order.

15.4.2 Disposition of the DDR requires the signed concurrence of SFSO Project Management, project Engineering or Licensing and Transportation and SFSO-QA Engineering.

15.5 Potentially significant safety deficiencies are reported to the Nuclear Energy Projects Division and the NRC (if appropriate) according to procedures.

15.6 CORRECTIVE ACTION

15.6.1 The Quality Assurance function in San Jose is responsible for the correction of generic deficiencies that exist in either the Quality Assurance Program or its implementation

15.6.2 The Corrective Action Request (CAR) is prepared to implement corrective action (see Section 16.0).

15.6.3 The action requested is directed to the Manager who is responsible for correction. Upon the satisfactory completion of action initiated by the CAR, the request is closed by the initiator and filed by the Quality Assurance Organization. The Quality Assurance Organization is responsible for authorizing closure of all CAR's.

15.7 SUMMARY OF NONCONFORMING ITEM RECORDS

15.7.1 A periodic summary of applicable open and closed NIR's is provided to the SFSO Manager and the Managers of Morris Operation (MO), Fuel Storage Projects, and major contracts by the Quality Assurance function in San Jose or MO. Such reporting may be part of routine management reports to the SFSO Manager covering SFSO design and construction status related to facility changes, major projects, and tasks.

16.1 PURPOSE

This section describes the measures used for ensuring that conditions adverse to quality and deficiencies in the Quality Assurance Program, design, fabrication, construction and modification or their implementation or in plant operation are promptly identified and corrected. In the case of significant conditions adverse to quality, the measures ensure that the cause of the condition is determined and corrective action is taken to preclude repetition. The identification of significant conditions adverse to quality, the cause of the conditions, and the corrective action are documented and reported to appropriate levels of management.

16.2 SYSTEM DESCRIPTION

16.2.1 Corrective action is requested and documented on a Corrective Action Request (CAR) when conditions are detected that have or may have an adverse affect on quality. CAR's may be initiated as the result of a Nonconforming Item Record (NIR) or to document deficiencies found in a quality audit CAR's may be written against vendors as well as the internal organization.

16.2.2 A CAR may be requested by anyone but only Quality Assurance may initiate the form

16.2.3 A CAR is initiated when any of the following conditions exist:

a. A condition exists which could jeopardize the quality of a product or service, although there has been no specification violation. (Cases involving specification violations are reported on a NIR)

b. An audit discloses the need for corrective action.

16.3 RESPONSIBILITIES

16.3.1 The **Quality Assurance Organization** is responsible for coordinating specific activities relating to the corrective action. This includes the following:

a. Determining whether the reported or observed condition or incident warrants corrective action.

b. Initiating CAR's.

c. Providing copies of completed CAR forms to responsible components

d. Determining which organizational component is accountable for corrective action and requesting investigation(s) and documenting the action plan.

e. Reviewing and approving the action plan.

f Providing assistance in investigations when requested by an involved component(s)

g. Performing followup to ensure that corrective measures are implemented.

h. Maintaining files of all completed CAR forms

16.3.2 The **Accountable Organizational Component** is responsible for the following:

a. Conducting an investigation for the cause of the incident or condition.

b. Documenting investigation results and corrective action on the CAR form and returning to the Quality Assurance Organization.

c Determining the method for resolving the CAR.

d. Consulting with the Quality Assurance Organization when investigative assistance is needed.

e. Initiating corrective action as required.

16.4 IMPLEMENTATION

16.4.1 Corrective action is documented on a CAR in accordance with established procedures.

16.4.2 The procedures detail CAR preparation, Quality Assurance Organization and management review, investigation, resulting documentation, reporting of corrective action to prevent recurrence, follow-up audit procedure, and CAR distribution.

17.1 PURPOSE

This section describes the measures for ensuring that sufficient records are maintained to furnish evidence of activities affecting quality, and that such records are stored, maintained, and safeguarded for an adequate period utilizing a systematic means of retrieval. The requirements of this Plan, and those record-keeping requirements established by regulatory agencies, specify the logs, records, and reports required to ensure that comprehensive records of design, fabrication, construction, and operation are maintained.

17.2 APPLICABILITY

This section is applicable to all activities for which SFSO is responsible and which provide evidence of quality in the design, fabrication, construction, and operation of nuclear storage facilities

17.3 GENERAL REQUIREMENTS

17.3.1 Documents which furnish evidence of the quality of items and provide information relating to activities affecting quality are maintained by the originating or otherwise responsible component as specified herein until completion of a task or project when the originating (or otherwise responsible) component transfers these records into the SFSO document control system.

17.3.2 Records pertaining to the quality of items or activities of the plant facility are retained in accordance with regulatory requirements.

17.3 3 A documentation indexing system assures that all records are readily identifiable and retrievable. It is the responsibility of organizations that generate quality-related records to identify and index such records with appropriate cross references in accordance with document control procedures presented in Section 6.0 Inspection and test records identify the inspector or tester, the date, the type of observation, the results, the acceptability, and the action taken in connection with any deficiencies noted (Section 15 0)

17.3.4 All records are legible (in original or reproduced form) and adequately identifiable to the item or activity involved.

17.4 RESPONSIBILITIES

17.4.1 During the interim generation of records, the **originating organization** is responsible for providing control of such documents commensurate with their ability to replace them

17.4.2 The **Quality Assurance Function in San Jose** is responsible for the establishment of specific record-keeping requirements applicable to inspection, tests, operation, and other quality-related activities as well as for the establishment and implementation of surveillance and audit procedures to verify that other SFSO organizations are complying with these requirements.

17.4.3 **Document Control in San Jose** is responsible for the system for storage, retention, and retrieval of all quality assurance records.

17.5 INTERIM GENERATION OF RECORDS

17.5.1 **Fuel Storage Projects** maintains all design-related documents, including the following:

a. Drawings, specifications.

b. Vendor information files.

c. Tests, procedures, and reports.

d. Procurement data for design and construction projects and tasks.

e. Engineering change notices.

f. Engineering Review memorandum.

17.5.2 **Licensing and Transportation** maintains documents such as:

a. Official responses to regulatory and licensing correspondence.

b. Regulatory and licensing regulations.

c. Calculations in support of cask licensing.

d. Licenses, permits, and amendments.

17.5.3 The **Quality Assurance Organization** maintains documents such as the following:

a. Inspection reports and acceptance test reports.

b. Nonconformance Item Records (NIR's).

c. Deviation Disposition Requests

d. Corrective Action Requests (CAR's).

e. Audit reports.

f. Material certifications and test reports.

g. Secial process records.

h. Special process personnel training and certification records (inspection processes).

i. Accountability records.

17.5.4 Documentation specifically concerned with plant maintenance, repair, and operations is maintained at Morris Operations (MO).

a. MO Plant Engineering and Maintenance maintains records such as the following:

1. Plant drawings.
2. Facility Change Notices (FCN's).
3. Instrument calibration records.
4. Radioactivity exposure records.
5. Accident reports.
6. Records of unusual events and abnormal occurrences.
7. Maintenance records.

b. Plant Operations maintains records such as the following:

1. Plant operation logs, reports, and procedures.
2. Qualification records for personnel.
3. Operational, Equipment Verification Test (EVT), and similar results.

17.6 RECORDS HANDLING AND STORAGE (PERMANENT)

17.6.1 Records are maintained in a vault, or in Record Centers in San Jose as well as at the MO. Storage of two complete sets of records at remote facilities complies with regulatory requirements concerning the permanency of Quality Assurance Records. Permanent records are maintained for the lifetime of the item (or facility).

17.6.2 Storage is accomplished by retention of complete (hard copy) documentation, microfilm, or other reproductions. Items such as radiographs are not reproduced, but retained as originals.

17.6.3 An index system for ease of retrieval is established for all records being stored in the Record Centers.

17.6.4 Records (document) control is established so that permanent records, originals, and/or copies of documents are retained in the Records Centers. A master list of such records is maintained by Document Control in San Jose. The Record Center at MO utilizes the identical indexing system used in San Jose.

17.7 QUALITY ASSURANCE ORGANIZATION RECORDS ACTIVITIES

In addition to the responsibilities of the Quality Assurance Organization pertaining to the generation of records unique to its activities (see sub-paragraph 17.3.2), the Quality Assurance function in San Jose verifies compliance of other SFSO organizations with regulatory record requirements through surveillance and audit.

18.1 PURPOSE

This section describes the system and responsibilities for conducting planned and periodic reviews (audits) of activities related to the design and fabrication, construction, and operation of a nuclear fuel storage facility by the assessment of performance of quality assurance and quality control and compliance with stated requirements. Quality Assurance Organization surveillance is a routine activity to verify performance of activities affecting quality (may be unscheduled).

18.2 GENERAL

18.2.1 Types of Quality Audits

a. Customer Audit—Audits may be conducted by customers to assure that SFSO is in compliance with contractual agreements.

b. SFSO Audit—The Quality Assurance function in San Jose audits SFSO organizational elements in San Jose and at Morris Operation (MO) to verify that objectives of the Quality Assurance Program are being met.

c. Division Quality Assurance Audit—Audits are conducted to verify compliance to applicable Division and Department policies and procedures.

d. MO Quality Assurance Audit—Audits by MO of the Quality Assurance Program as implemented by their own organization and audits of selected vendors may be performed by MO.

e. Vendor Audit—Audits of vendor's facilities may be conducted by either of the Quality Assurance functions (located in San Jose or at the MO)

18.2.2 Audits

a. Audits are formal, they are scheduled by advance notification which specifies the general area and/or specific activities and documents to be investigated.

b. Audits are conducted utilizing a written procedure (checklist) to assure thoroughness of the review. Checklists may be standardized (for review of compliance to the Code of Federal Regulations, Title 10, Part 50, Appendix B, for example), or they may be prepared for specific audits.

c. Audits are performed by qualified personnel; these personnel do not have direct responsibility in the area being audited.

d. The responsible management of the function being audited is apprised of the details of the pending audit by the auditing team prior to the investigation.

e The findings of the audit team are discussed with the responsible management of the audited function; this management receives a formal notification of the audit findings and areas requiring correction and establish appropriate measures to effect the changes.

f. Deficiencies are reaudited until corrective action has been accomplished.

g All activity during audits is documented in the Quality Assurance Organization files This includes audit notices, minutes of meetings, audit team composition, audit findings, corrective action, and subsequent follow-up activity.

h Frequency of audits is determined by the need and importance of activities being reviewed.

18.2.3 **Surveillance**

a. The degree of surveillance, the areas of investigation and depth of review, observation, and evaluation are not structured, but are determined by need and importance of the activities being performed.

b Surveillance activity and findings are documented and retained in the Quality Assurance Organization files. These reports are forwarded to appropriate management for information and required action.

c. Correction of deficiencies is verified by reinspection (by the Quality Assurance Organization) to ascertain satisfactory correction of deficiencies.

18.3 **QUALITY ASSURANCE ORGANIZATION AUDIT RESPONSIBILITIES**

The Quality Assurance Organization is responsible for conducting quality audits. This does not preclude the appointment of a technical and/or administrative representative to participate directly in the audit or to serve as a consultant. Specific Quality Assurance Organization responsibilities include the following:

a. Scheduling, coordinating and reporting customer, vendor, and Division quality audits.

b. Establishing an audit schedule.

c. Generating audit checklists which define the requirements.

d. Conducting, or coordinaing the performance of, audits as planned.

e. Issuing audit reports.

f. Initiating Corrective Action Requests (CAR's) as required.

g Conducting follow up audits to determine the implementation and effectiveness of corrective action(s) taken on significant quality problems.

h Analyzing audit findings to detect quality trends and effectiveness of the Quality Assurance Program.

18.4 **REPORTS**

The Quality Assurance Organization may include significant audit findings in periodic reports to management or in special reports.

END

REPORT

FAULT INVESTIGATION AT THE
MIDWEST FUEL REPROCESSING PLANT
NEAR MORRIS, ILLINOIS

FOR THE GENERAL ELECTRIC COMPANY

October 1, 1974

General Electric Company
175 Curtner Avenue
San Jose, California 95114

Attention: Mr. Francis Shadel

Gentlemen:

We are pleased to transmit seven copies of our "Report of Fault Investigation at the Midwest Fuel Reprocessing Plant near Morris, Illinois, for the General Electric Company".

The scope of our studies was planned in co-ordination with Mr. Francis Shadel of the General Electric Company, San Jose, California. The investigation was performed in accordance with the specifications listed in our proposal, dated July 10, 1974, under the General Electric Purchase Order No. 334-Cl H64-X, and Dames & Moore Job No. 1674-087.

The field investigation has confirmed the existence of, and delineated a northwest trending fault to the southwest of the Main Process Building. Based on the evidence found in the borings and trenches, we feel that faulting occurred sometime between depositions of the Ordovician Ft. Atkinson Formation and Pennsylvanian Pottsville Formation, 300 to 400 million years ago. Since deposition of the Pottsville Formation, the area has been subjected to weathering, erosion, and glaciation. Due to this extensive erosion and glaciation, no conclusive evidence was found to positively date the age of faulting. Our recommendations for further investigations to date the most recent faulting are found at the end of this report.

Should you have any questions regarding the contents of this report, please do not hesitate to contact us.

Sincerely,

DAMES & MOORE

Douglas J. Lootens
Associate

RJS

DL:hd

REPORT OF FAULT INVESTIGATION AT THE

MIDWEST FUEL REPROCESSING PLANT NEAR MORRIS, ILL.,

FOR

THE GENERAL ELECTRIC COMPANY

I. SCOPE

This report presents the results of the fault investigation performed by Dames & Moore at the Midwest Fuel Reprocessing Plant, near Morris, Illinois. The purpose of the investigation was to confirm the existence and to delineate the location of a suspected fault to the southwest of the Main Process Building. The fault was originally indicated in borings made during the investigations for the plant foundations in 1967. A detailed description of the characteristics of the fault is also included.

After the preliminary research, field investigation was conducted which consisted of soil sampling, rock core drilling, and trenching perpendicular to the fault to expose its features and exact location. The results of these investigations, which form the basis of our conclusions, are presented in Part III and Appendices A and B of this report.

II. INVESTIGATIVE PROCEDURES

A. Preliminary Investigation

A review of existing publications, Dames & Moore reports, aerial photographs, and maps of the area was performed to determine the regional, local, and site geologic characteristics. This was followed by a general reconnaissance of the plant site to determine tha approximate area of faulting, and to locate the proposed boreholes.

B. Field Procedures

The field investigation, consisting of the site reconnaissance, the drilling of nine boreholes, and the excavation of four trenches, was performed from August 23 through September 5, 1974. The drill rig and crew were supplied by Raymond International, Elk Grove Village, Illinois, and the backhoe and operator were supplied by Dale Starks Construction, Morris, Illinois. A Dames & Moore field geologist directed and supervised these men and equipment, and carried out the investigation.

The exact locations and elevations of the boreholes were surveyed by George Reiter and Associates, Joliet, Illinois, on September 3 (Appendix A, Figure 1, Plot Plan).

Soil sampling and rock coring were done in nine boreholes to depths ranging from 23 to 63 ft; these borings generally delineated the location and direction of the fault. Four of these boreholes were located on the downthrown (southwest) side of the fault, with the remaining five boreholes on the upthrown side (northeast). A detailed description of the subsurface materials encountered can be found in Part III, Results of Investigation, and on the boring logs in Appendix B.

After completion of the drilling, four trenches were excavated perpendicular to the fault to more precisely determine its location. A detailed description of these trenches is presented in Part III, Results of the Investigation, and in Appendix A, Trench Cross Sections.

On September 4, 1974, Dr. Thomas Bushbach, Paul Du Montelle, David Gross, and Dennis Kolata of the Illinois State Geological Survey, and a senior geologist with Dames & Moore made a detailed inspection of the trenches and rock core taken from the borings. Samples of the materials in the trenches were taken by the Illinois State Geological Survey personnel for laboratory analysis.

The trenches were backfilled on September 5, and the field investigation was complete.

III. RESULTS OF THE INVESTIGATION

A. Site Conditions

The Midwest Fuel Reprocessing Plant is situated on the highest portion (approximately 530 ft MSL) of a 1 mile northwest-trending ridge, approximately 20 to 25 ft above the Kankakee-Illinois rivers' floodplain. The location of the fault lies within the plant boundary south of the Main Process Building. The ground surface is level, with elevations varying 2 to 3 ft. The only relief within the plant boundaries is due to shallow drainage ditches.

Trenches T2, T3, and Borings A2, A3, A4, and A5 were located on a graded, gravel-covered-level area while Trench T1 and Borings A6, A7, A8, and A9 were located on a grass-covered area with relatively undisturbed soil. Trench T4 and Boring A1 lie outside the plant boundary in a field. To the west of these locations, the ground surface drops off approximately 10 to 15 ft.

B. Description of Geologic Materials

The subsurface conditions in the area of the fault were determined by drilling nine test borings and excavating four trenches perpendicular to the fault (Appendix A, Figure 1, Plot Plan). A detailed description of the geologic materials, elevations and depths is presented in Appendix A, Trench Cross Sections, and Appendix B, Boring Logs.

Unconsolidated Materials - The borings and trenches revealed that approximately 1 to 2 ft of soil overlie an undulating, erosional, bedrock surface. The soil generally consists of 3 to 8 in. of dark brown silt topsoil, and extremely weathered sandstone or limestone bedrock. However, in Boring A2 and A6 (Appendix B) and Trenches T1, T2, and T3 (Appendix A, Trench Cross Sections) 1 to 5 ft of glacial till is present. This material consists of a mottled brownish-yellow and gray clay with an unsorted mixture of rounded to angular rock fragments of limestone, sandstone, and metamorphic materials. Clay mineral analyses done by the Illinois State Geological Survey show that the till consists primarily of materials derived from the bedrock in that vicinity. Embedded, disoriented blocks of sandstone varying from a few inches to several feet wide (Appendix A, Figure 12, Photos 1-3 30, 31) and occasional small pieces of wood are also found within the till.

A modern soil profile has developed in the glacial deposits to a depth of 2 to 3 ft.

The till has a very irregular contact with the underlying sandstone, and generally does not extend across the fault to cover the limestone bedrock. In Trench T3 (Appendix A, Figure 4) and Boring A2, (Appendix B), till was found wedged between the sandstone bedrock and underlying unit.

Fill material, 8.5 ft thick and composed of blocks of gray, silty shale, with fresh limestone fragments, was found in Boring A4 (Appendix B). Three feet of this material was also seen in Trench T3 (Appendix A, Figure 4 and Figure 12, Photo 1-3).

<u>Bedrock Units</u> - The bedrock units encountered in the borings and trenches were, in descending order: Pottsville sandstone of Pennsylvanian age; Ft. Atkinson limestone and Scales shale, both of Ordovician age.

<u>Pottsville Formation</u> - The Pennsylvanian Pottsville sandstone is found only on the southwest side (downthrown) of the fault. It is a light gray, fine to medium grained, and thin to medium bedded sandstone. The sandstone contains mica and some clay, shown to be chiefly authigenic kaolinite by the Illinois State Geological Survey analyses. In both the borings and the trenches varying amounts of highly weathered, disoriented slabs, and loose sand with 25 to 50 percent carbonaceous material were encountered. This material was found along bedding planes, and in irregular, angular concentrations up to 2 ft. Boring A1 (110 ft southwest)

of the fault) (Appendix A, Figure 1 Plot Plan), indicated there was approximately 7 ft of moderate-to-well-cemented, horizontal, bedded sandstone. However, in Borings A2 and A6 (15 to 20 ft southwest of the fault) and in Trenches T1 and T2, only 1 to 3 ft of poorly-cemented-to-loose sand was found intermixed and interbedded with glacial till (Appendix A, Figures 2 and 3; Appendix B). The sandstone was totally absent in Boring A8 (approximately 2 to 4 ft southwest of the fault) although it was found at the surface several feet away.

Trenches T1, T2, and T3 indicated that the Pottsville sandstone lies unconformably on a silty clay-limestone "rubble" (Appendix A, Trench Cross Sections). In Trench T4, this rubble was missing, and the sandstone lay directly on an irregular limestone surface (Appendix A, Figure 13, Photos 2-31, 32). Both the sandstone-rubble contact, and the bedding of the sandstone generally dip 25 to 35° southwest (Appendix A, Figure 12, Photo 1-2). The angle of dip is generally greatest within several feet of the fault and lessens as this distance increases and in Boring A1, the bedding is nearly horizontal. In Trenches T1 and T4, sandstone was found interbedded with a 0.5 to 1.5 ft thick discontinuous layer of gray silty shale (see Part III, Description of Fault). In Trench T3, the dip varied considerably across the 2 ft width of the trench (Appendix A, Figure 12; Photos 1-1, 30 and 31). According to the Illinois State Geological Survey, this bedding variation is attributable to the introduction of till during glaciation.

Limestone-silty clay "Rubble" - On the downthrown (southwest) side of the fault, and directly underlying the sandstone, is a medium-dense body of brownish-yellow and gray silty clay (Appendix A, Trench Cross Sections). According to the Illinois State Geological Survey mineral analyses, the clays are almost 100 percent illite. The clay contains 25 to 75 percent angular limestone fragments, which vary from less than 1 inch to 1 foot in diameter. Occasional fossil fragments were also found.

The rubble varied randomly throughout its exposures in clay, silt, limestone content, color, and compaction, from loose to dense. For example, in any trench, one small spot may have been a brownish-yellow, loose silt with 50 percent small limestone fragments, while immediately adjacent to that, it would consist of a gray silty clay with 25 percent angular limestone cobbles. In Trench T3, the rubble was a brownish-yellow, silty and sandy clay, with occasional preserved vein calcite fragments near the fault. In Trench T1, it was a gray-green silty, slightly plastic clay, as well as a brownish-yellow silty, sandy clay with limestone fragments (Appendix A, Figure 10, Photo 2-8).

The rubble was present in Trenches T1, T2, and T3 and in Boring A2, but was not found in Trench T4 (Appendix A, Trench Cross Sections; Appendix B, Boring Logs). The unit is best developed adjacent to the fault and is probably not found more than 25 ft from it. The fault generally did not appear to affect the rubble lithologically, with the exception of an occasional fragment of vein calcite incorporated along with the limestone fragments. However, in Trench T1, a 1-to-2 ft square area of green-gray clay, at the sandstone-limestone-clay interface contains 75 percent angular limestone fragments (Appendix A, Figure 8, Photos 1-26, 27, and 28).

Ft. Atkinson Formation - The Ft. Atkinson Formation underlies the Pottsville sandstone away from the fault, and the silty clay-limestone rubble near the fault on the downthrown side. On the upthrown side of the fault, this formation forms the uppermost bedrock unit. To the southwest, or the downthrown side of the fault (Appendix B, Borings A1, A2, A6, and A8), this formation is composed of two units: interbedded gray shale and limestone, and light gray to white crystalline limestone. On the northeast side of the fault, only the lower unit is present (Appendix B, Borings A3, A4, A5, A7, and A9; and Appendix A, Figures 6 and 7, Boring Cross Sections).

This interbedded shale-limestone unit ranges from approximately 7.5 to 11 ft thick. The shale is dark gray, silty, slightly calcareous, and thin to medium bedded. The limestone is gray, coarsely crystalline, and fossiliferous and is characterized by irregular layers up to 3-in. thick, with sub-horizontal, rounded, fossil and limestone fragments. The unit is slightly weathered and contains occasional thin layers of yellow-brown and gray silty clay. It was not present in Boring A8.

Below the interbedded shale-limestone unit is a gray to white, thick-bedded to massive, crystalline limestone. On the downthrown side, this unit varies from 29 ft in Boring A6 to 34 ft in Boring A2 (Appendix B). The contact between the upper and lower units is transitional for 3-to-6 in. with decreasing fossil fragments downward. Generally the limestone is slightly fossiliferous and contains intersecting 45° or higher angle fractures, with pyrite and green clay filling. Green clay and pyrite were also noted in pinhole- to 1/2-in.-diameter open vugs, along bedding planes, joints, styolites, and as nodules up to 1/2 in. Also, Boring A1 contains 2 ft of green clay at 41 ft. The clay was in a 45° contact with the overlying limestone and contained 45° fractures throughout with major slickensiding.

In Boring A8, only 26 ft of the Ft. Atkinson were found. The fault plane was encountered at a depth of approximately 27 ft. At this point, this boring passed into the Scale's shale on the upthrown (northeast) side of the fault (Appendix B, Boring A8; and Appendix A, Boring Cross Sections).

On the northeast side of the fault (Appendix B, Borings A3, A4, A5, A7, and A9) approximately 10 to 11 ft of the lower Ft. Atkinson were encountered, the upper sequences having been removed by erosion. Approximately the upper 3 ft of this formation were exposed in the trenches. At the location of Boring A4 (Appendix B) 8.5 ft of overlying fill were present. Therefore, the boring penetrated only 2 ft of the Ft. Atkinson.

On the upthrown side of the fault, this unit varies from dark reddish-brown to gray, reflecting the degree of weathering. It is usually coarsely crystalline and irregularly medium-to-thick-bedded (Appendix A, Figure 11; Photos 1-7). The bedding exhibits minor gentle folding (Appendix A, Figure 11, Photo 2-5). The limestone contains broken zones with green clay and pyrite filling, and pinhole or larger vugs throughout.

In the trenches, irregular masses of gray-green silty clay were found interbedded with the limestone; this clay varied from a few inches to 1.5 ft thick. Also, some bedding planes and joints contained yellow-brown and gray silty clay with limestone fragments, a phenomenon attributed to solution activity.

In Trench T2, northeast of the fault, there is a 1.0 to 1.5 ft thick vertical zone of yellow-brown and gray silty clay with limestone fragments. Due to irregular bedding and solution of the limestone, a definite trace across this zone, or detection of any displacement was not possible. Therefore, this could be either a joint filling or gouge material along a fault with unknown displacement.

Scales Formation - The lowest stratigraphic unit encountered during the boring program was the Scales Formation. This unit directly underlies the Ft. Atkinson limestone. The borings were all carried 5 to 10 ft into this unit to assure a positive stratigraphic correlation across the fault.

Two lithologic units were encountered in the borings (Appendix A, Figures 6 and 7, Boring Cross Sections; and Appendix B). The upper 1 to 2 ft consist of a dense green limestone, with traces of pyrite crystals, fossils and/or rounded limestone particles. The upper contact is a 2 to 3 in. transition zone from argillaceous limestone with siltstone lenses to green siltstone with calcareous inclusions. The siltstone is slightly calcareous and varies from fresh to extremely weathered layers of green silty clay. In Boring A3 this zone was 3.5 to 4.0 in. thick and was broken throughout on irregular slickensided 45° or higher angle fractures. This zone was interpreted to be an indication of faulting with little displacement.

Below the green limestone is gray-dark shale, which varies from dense and very silty (>50 percent) to thinly-bedded with less silt content (25 to 50 percent). The pyrite, limestone, and/or fossil fragments found in the overlying siltstone continue 1 to 2 ft into this unit. The unit is characterized by highly broken zones with 1 to 2 in. gray-brown silty clay layers and intersecting 45° or higher angle fractures, most of which exhibit slickensides.

C. Description of the Fault

The exact location of the fault was determined by trenching perpendicular to a position estimated by the information obtained in the nine borings. The fault line is curvilinear, striking essentially northwest through the plant area (Appendix A, Figure 1, Plot Plan). It is a high angle (approximately 15° -off vertical) normal fault, dipping to the southwest. The southwest side has been dropped down in relation to the northeast side, with displacement of 35 to 40 ft as indicated from the borings (Appendix A, Figures 6 and 7, Boring Cross Sections). Trenches T1, T2, and T3 show a definite fault contact and change in lithologies (Appendix A, Trench Cross Sections). However, to the northwest in Trench T4, an abrupt drop-off of the limestone with Pottsville sandstone overlying it is present. A definite fault, with offset, could not be found in this area (Appendix A, Figure 13, Photos 2-31 and 32).

In the trenches, the fault generally separated limestone on the upthrown side and the silty clay-limestone rubble on the downthrown side. However, in Trench T1, a limestone-sandstone fault contact which had not been completely removed by erosion was visible. A mass of fill material in T3 covered much of the fault contact (Appendix A, Figure 12, Photo 1-3) and in T2, glacial till covered the fault zone (Appendix A, Figure 3, Trench Cross Section).

On the upthrown (northeast) side, the limestone is characterized by gentle, small folds, and moderate solution activity along bedding planes, joints and fractures (Appendix A, Figure 11, Photos 1-7 and 2-5). The limestone is moderately to highly weathered, with brownish-yellow silty clay filling in solution openings and occasionally larger masses of green-gray silty clay as previously described.

Either fracturing or accompanying faulting with little displacement was also indicated in the limestone bedrock exposed in the trenches. In Trench T2, a 1.0 to 1.5 ft vertical clay-limestone zone on the northeast side of the main fault was present. Also, in the immediate vicinity, the limestone was highly fractured or jointed with irregularly dipping beds (Appendix A, Figure 11, Photo 2-5).

At the fault in T3, the limestone had a 2 to 4 mm coating of limonite and a thin layer of calcite. In T2, the fault was characterized primarily by broken limestone-clay gouge in contact with the rubble and very little mineral development or crystallization was apparent. In Trench T1, a 1.0 to 1.5 in. vein of re-crystallized calcite occurred along the fault contact.

The presence of faulting was most evident on the downthrown (southwest) side in Trenches T1, T2, and T3 (Appendix A, Trench Cross Sections). In Trenches T2 and T3, the silty clay-limestone rubble was found immediately adjacent to the fault (Part III, Description of Geologic Materials). The lithology of the rubble did not appear to be affected by the fault, with the exception of an occasional fragment of re-crystallized vein calcite, and slight concentrations of limestone fragments (Appendix A, Figure 8, Photo 1-28) near the fault contact.

Trench T1 was the only area examined where erosion had not completely removed the limestone-sandstone fault contact (Appendix A, Figure 2, Trench Cross Section). A 1 to 1.5 in. vein of re-crystallized calcite separates the Ft. Atkinson and silty clay, but stops at the limestone-clay-sandstone junction visible on the north side of the trench (Appendix A, Figure 8, Photo 1-27). At this point, the limestone-sandstone contact is separated by 1 to 2 in. of a gray-green clay and loose brown sand mixture (Appendix A, Figure 8, Photo 2-9). However, the mixture extends for only 6 to 7 in. above this, at which point dipping sandstone is in direct contact with limestone. A 3-in. thin-bedded layer of highly weathered sandstone with transverse cracks appears to be arching downward from this point (Appendix A, Figure 8, Photo 1-26).

On the south side of Trench T1, sandstone interbedded with a 3 to 4-in. layer of gray non-calcareous clay was found partially overlying calcareous fault gouge (Appendix A, Figure 9, Photos 2-13, 14, 15, 16, 17). The clay layer tapered out 4 to 5 ft to the southwest. Unfortunately, erosion and soil development have altered the complete contact. Also, on the southwest side of the fault, there were several small limestone boulders which have undergone solution.

Deposition of Pottsville sandstone on these smooth surfaces is indicated (Appendix A, Figure 9, Photo 2-13), with a thin layer of brown silty plastic clay along the contacts.

Trench T4 was dug approximately 250 ft northwest of T1 (Appendix A, Figure 1, Plot Plan and Figure 5, Trench Cross Section). At T4, no definite fault break could be found. Instead, the limestone drops off abruptly to the southwest (Appendix A, Figure 13, Photos 2-31 and 32). The floor of the trench sloped gradually to the southwest rather than a definite stairstep as in Trenches T1, T2, and T3 (Appendix A, Trench Cross Sections). Although very irregular, the beds could generally be followed through the area of the drop-off. No vertical gouge zone or body of rubble was present. Folding of the bedding was apparent, along with transverse cracks in some of the thinner beds at the crest of the fold.

Directly overlying the dipping limestone is a body of sandstone interbedded with 1.0 to 1.5 ft of the same type of clay found in T1. The sandstone under the clay is slightly to very carbonaceous, and poorly bedded. Generally the dip of these units is the same as the limestone surface, with the beds thickening away from it.

Toward the bottom of Trench T4, the limestone exhibited the results of extensive solution activity (Appendix A, Figure 13, Photos 2-31 and 32). Slightly to moderately plastic, brown clay, with silt and sand, was found as bedding plane and joint filling in this area. On the south side of the trench, a 1-ft section of thinly bedded sandstone could be seen which had been deposited on a smooth limestone surface (Appendix A, Figure 13, Photo 2-35). Generally, the lower portions of the limestone-sandstone contact were irregular and incomplete due to solution activity and mechanical destruction during excavation. The upper contact area was absent because of a thickened soil horizon at the crest of the fold (Appendix A, Figure 5, Trench Cross Section), although some thin-bedded random layers of highly weathered sandstone persisted.

IV. CONCLUSIONS

The investigation carried out has delineated the fault trace through the plant area (Appendix A, Figure 1, Plot Plan).

In addition, it has allowed a detailed description of the affected geologic materials and their interrelationships with the fault (Appendices A & B; and Part III, Results of the Investigation).

Unfortunately, much of the near-surface view of the fault obtained in the trenches was altered by erosion, soil development, or glacial activity. The existing ground surface lies just below the projected sandstone-limestone fault contact, which is most important in determining the age of faulting. However, it is our opinion, and that of the Illinois State Geological Survey that the main faulting occurred sometime between deposition of the Ft. Atkinson limestone and the Pottsville sandstone, or between the late Ordovician (400 million years ago) and early Pennsylvanian (300 million years ago) times. Although the Pottsville sandstone was probably not involved in this faulting, no immediately conclusive evidence exists to assure stability since its deposition. If faulting did occur after glaciation, the till and modern soil profiles are too thin to preserve any indication of it. Frost action, biological activity, and re-working of the soil by man have modified the soil structure thereby distroying any evidence associated with dating the fault. Our conclusions are based on the following interpretations of the evidence obtained during the field investigation.

The most conclusive evidence for sandstone deposition over a pre-existing fault was found in Trench T1 (Appendix A,

Figure 9, Photos 2-14 thru 17). Here, interbedded Pottsville sandstone and clay directly overlie calcareous limestone-clay fault gouge, dipping away from the fault to the southwest. Also, on the down-dropped side of the fault, there are sub-angular boulders which have been subjected to groundwater solution. Sandstone deposited on these surfaces is evident. In the area of Trench T-4 where the fault becomes a fold, sandstone deposited on a smooth block of limestone could also be seen (Appendix A, Figure 13, Photo 2-35).

In addition, Trench T1 exhibited a good exposure of the 1 to 1.5 in. vein of re-crystallized calcite along the fault plane. This vein stops at the limestone-sandstone-rubble contact. (Appendix A, Figure 8, Photos 1-26, 27, and 28). If faulting occurred after deposition of the sandstone, this vein would most likely extend upward along the limestone-sandstone contact. In contrast, it appears that the calcite vein has been eroded away and that the sandstone was deposited on the erosional surface. However, at the limestone-sandstone contact the two are separated by a slightly plastic clay and sand mixture (Appendix A, Figure 8, Photos 1-26 and 2-9). The clay is essentially the same as that found just below the fault (Appendix A, Figure 2, Trench Cross Sections) and appears to be an upward extension of it.

The limestone-clay rubble, found in Trenches T1, T2, and T3 (Appendix A, Trench Cross Sections), appears to be material which has accumulated in the topographic lows along the base of the fault scarp. The trench cross-sections show the rubble tapering out to the southwest, and it was not present in Boring A1 (Appendix B).

Differential compaction of the rubble, and slumping of both the sandstone and rubble was indicated in the trenches. The rubble varied randomly from loose to dense (Part III, Description of Materials). The contact with the overlying sandstone was characterized by disoriented bedding and a very irregular shope away from the fault (Appendix A, Figure 10, Photo 1-24 and Figure 12, Photo 1-2). Also, the loose sand-clay mixture at the mixture at the fault in Trench T1 and the nature of the sandstone bedding indicated compaction and slumping of the rubble (Appendix A, Figure 8, Photos 1-26 and 2-9). In Trench T3, an abrupt change in the dip of the bedding across the trench was indicated (Appendix A, Figure 12, Photos 1-1, 30, and 31). This is attributed to slumping, as well as glacial disruption of the bedrock, evidenced by till underlying the sandstone. Since no fault scarp existed in the area of Trench T4 (Appendix A, Figure 5, Trench Cross-Section) the rubble did not accumulate, or was eroded prior to sandstone deposition.

Geologic History

The evidence obtained indicates that faulting occurred sometime after deposition of the Ordovician-age Scale shale and Ft. Atkinson limestone, raising the ground surface 35 to 40 ft (Appendix A, Figure 14, Part A). This newly formed limestone scarp was subjected to erosion and groundwater solution. The limestone-clay rubble accumulated as a residuum and in topographic lows at the base of the scarp (Appendix A, Figure 14, Part B). The rubble was then eroded, except for the concentrations along the fault, and deposition of the Pennsylvanian sandstone took place. Either during deposition, shortly thereafter, or at both times, differential compaction and slumping of the rubble took place with the Pottsville sandstone sagging into the rubble (Appendix A, Figure 14, Part C). Erosion of the sandstone and continued solution of the limestone followed and local slumping of the rubble due to solution of the underlying limestone probably occurred (Appendix A, Figure 14, Part D). The next known event occurred during the Pleistocene, with the advance of continental glaciation, which covered the area (Appendix A, Figure 14, Part E). Ripping of large blocks of bedrock and injection of till along weakened surfaces or open cavities took place. Since then, post-glacial meltwaters and recent erosion have removed the glacial deposits except in topographic lows, resulting in the present topography (Appendix A, Figure 14, Part F, and Trench Cross Sections) This sequence of events does not attribute any movement along the fault to post-Pennsylvanian time. However, no conclusive evidence has yet been found to eliminate the possibility of faulting after deposition of the Pennsylvanian sandstone.

V. DISCUSSION AND RECOMMENDATIONS

The investigation described on the previous pages has shown the existence of a fault to the southwest of the

Main Process Building. During the investigation, the delineation of the fault and a description of its characteristics were accomplished in accordance with our proposal of July 10, 1974. Although the investigation presented a geologic interpretation of the most probable age of faulting, no positive proof was found.

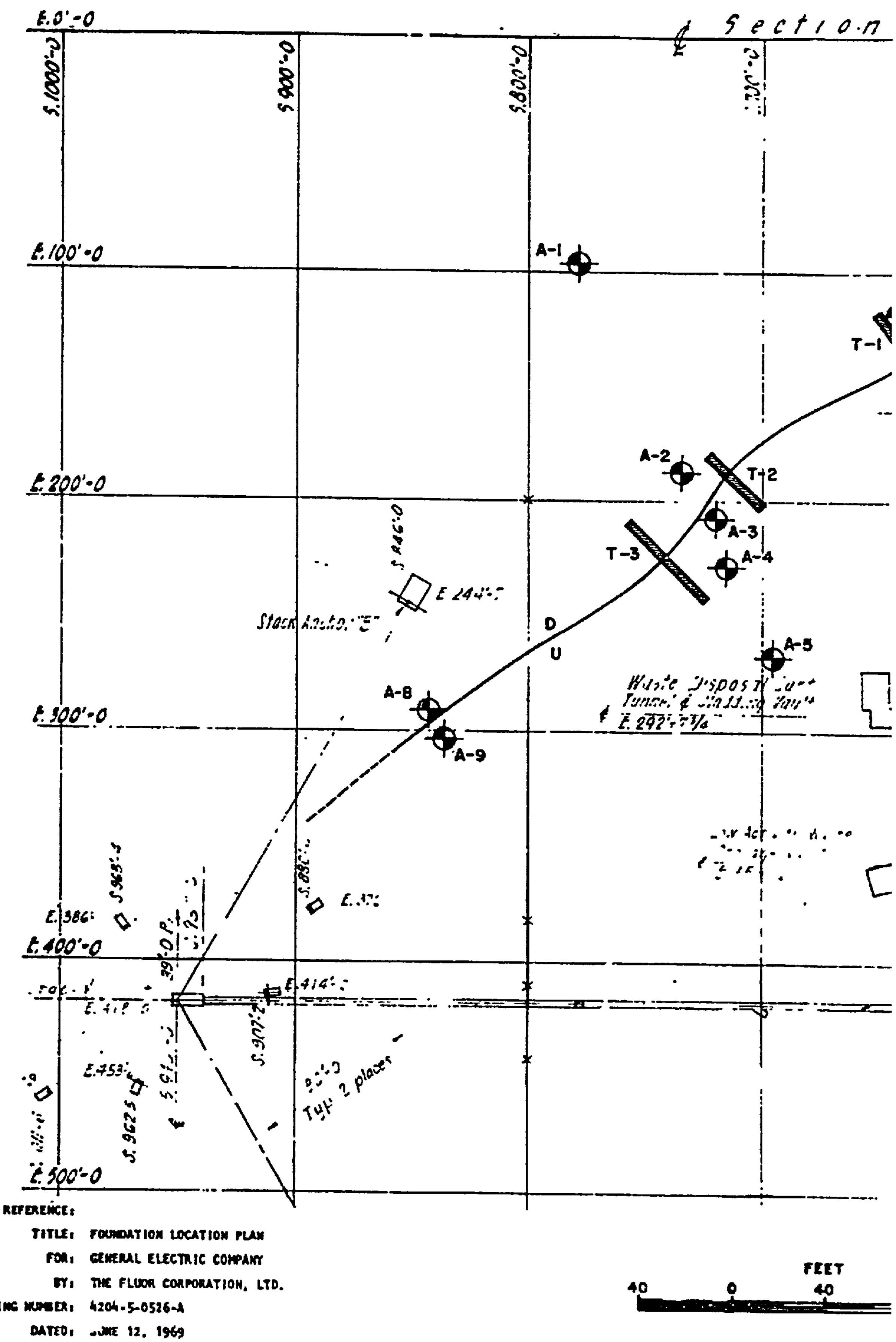
Within the area of interest, Pennyslvanian bedrock units were found to be absent on the upthrown side of the fault, and only in Trench T1 were they visible at the fault contact. Glacial deposits and modern soils were so thin that any evidence of faulting would have been altered by frost action, agricultural activity and biological breakdown.

Due to the nature of the material in the gouge zones, its nearness to the surface (resulting in weathering and groundwater activity) and the inherent problems involved in current dating methods, radioactive dating of the fault does not appear to be feasible.

It is our opinion that the best method for dating the fault would be to find undisturbed Pleistocene or Pennsylvanian deposits, continuous across the fault, or to fine a cross-cutting fault zone where these relationships could be demonstrated. A series of shallow geophysical investigations could be undertaken perpendicular to the fault trace with portable equipment. This could better delineate extensions of the fault and could possibly also locate areas where Pennsylvanian or Pleistocene deposits are continuous across the fault trace and are thick enough to preserve evidence to date the fault.

These areas could then be further investigated by a program of borings and trenching.

With an expanded program in the area (geophysical investigations and additional trenching and borings), we feel that the criteria necessary to conclusively date the fault could be found and that it would prove our interpretation of pre-Pennsylvanian faulting.



DRAWING REFERENCE:

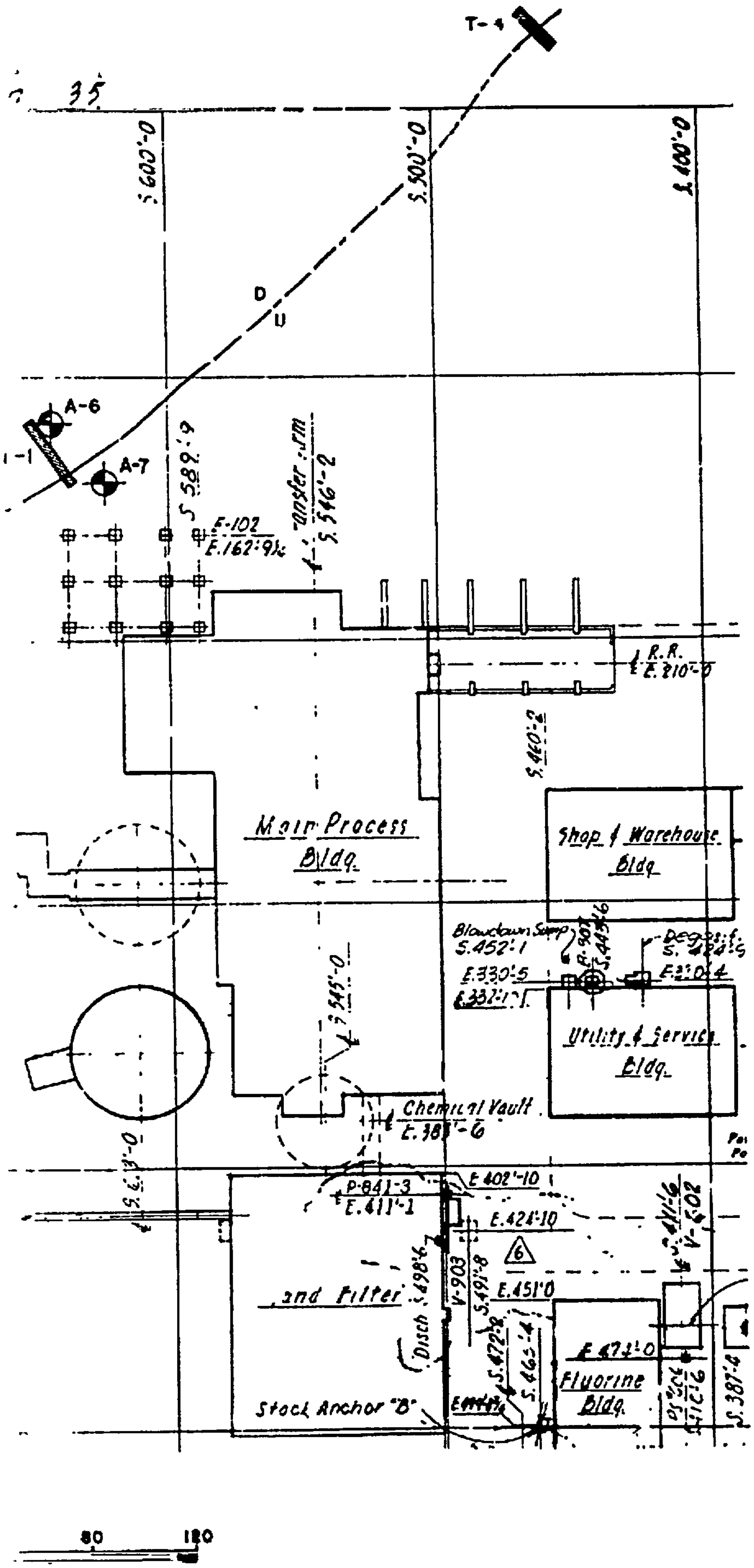
TITLE: FOUNDATION LOCATION PLAN

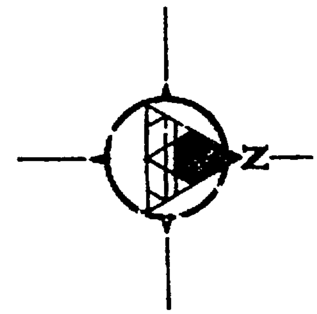
FOR: GENERAL ELECTRIC COMPANY

BY: THE FLUOR CORPORATION, LTD.

DRAWING NUMBER: 4204-5-0526-A

DATED: JUNE 12, 1969





PLANT GRID CO-ORDINATES AND ELEVATIONS (

A-1	S778.55	E97.11	529.7
A-2	S735.93	E187.61	531.7
A-3	S726.11	E208.99	532.2
A-4	S716.38	E228.69	532.1
A-5	S696.19	E268.65	532.4
A-6	S644.55	E115.63	531.8
A-7	S623.96	E140.24	531.2
A-8	S843.56	E291.25	531.9
A-9	S835.93	E304.63	532.1

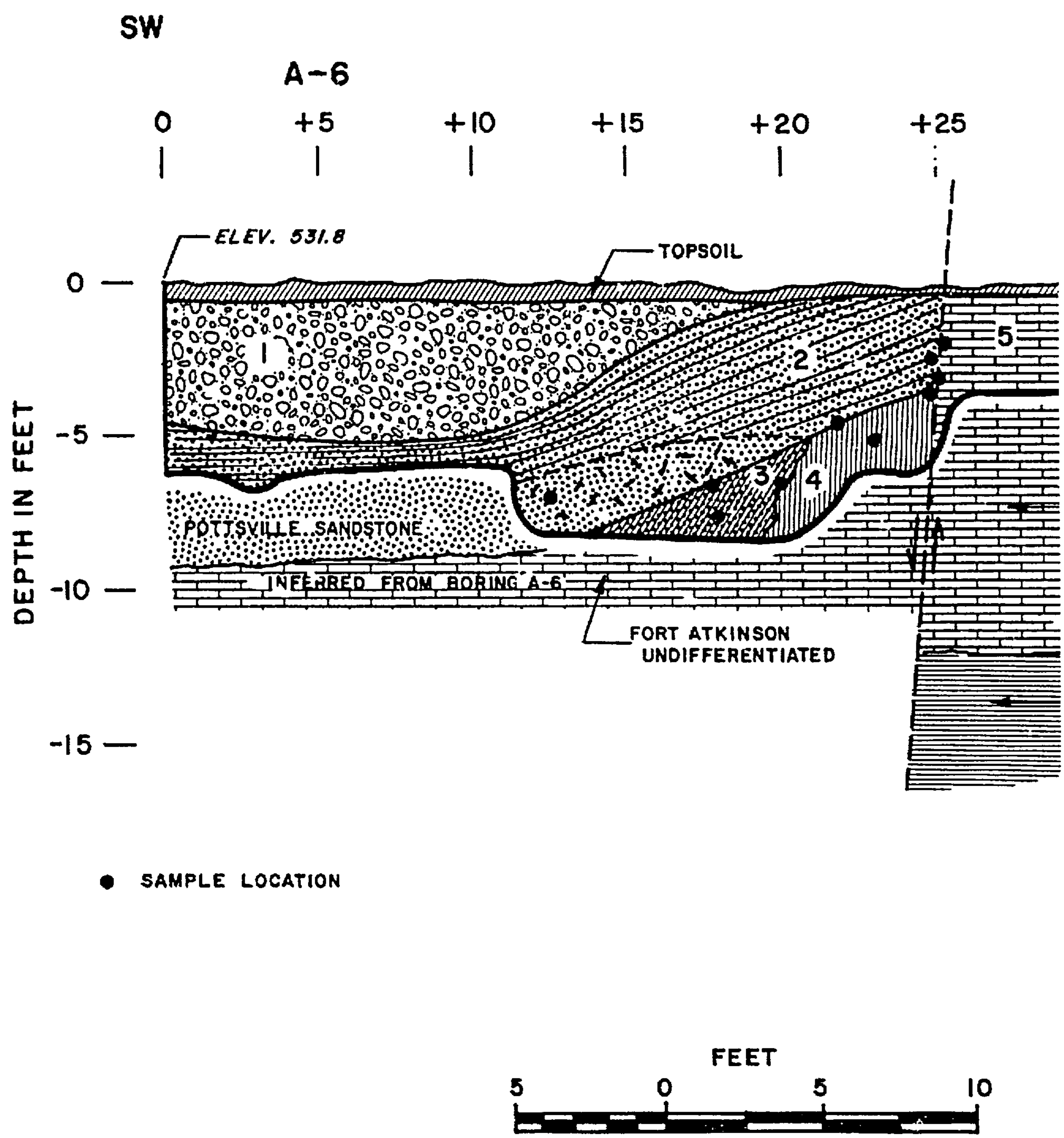
LOCATION OF TRENCHES

T-1	SW EDGE IS 5' FROM A-6. BEARING OF 195°; STRIKE 055° FOR 29.0' LENGTH
T-2	SW EDGE IS 16' FROM A-2, BEARING OF 325°; STRIKE 045° FOR 32' LENGTH
T-3	SW EDGE IS 20' FROM A-2, BEARING OF 135°; STRIKE 045° FOR 48' LENGTH
T-4	SW EDGE IS 154' FROM E 100, S 400, BEARING 245°; STRIKE 045° FOR 18' LENGTH

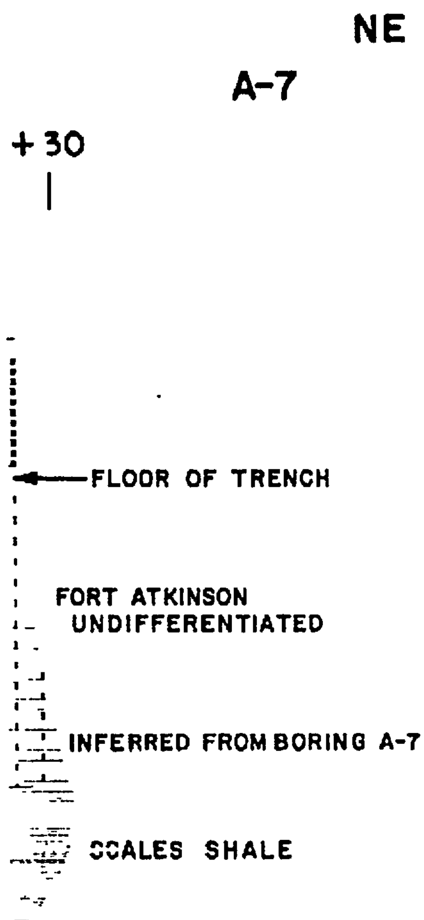
PLOT PLA

DAMES & M

FIGURE I



SW
A-6
0
+5
+10
+15
+20
+25
ELEV. 531.8
TOPSOIL
0
-5
-10
-15
DEPTH IN FEET
1
2
3
4
5
POTTSVILLE SANDSTONE
INFERRED FROM BORING A-6
FORT ATKINSON UNDIFFERENTIATED
SAMPLE LOCATION
FEET
5
0
5
10



LEGEND

UNIT 1 - TILL: DARK REDDISH-BROWN TO REDDISH-YELLOW, SILTY, SANDY CLAY MATRIX; 35-40% ANGULAR SANDSTONE SLABS, AND ROUNDED PEBBLES AND COBBLES; DENSE; POORLY SORTED; ROUNDED GRAVELS ARE WELL GRADED; ANGULAR FRAGMENTS ARE POORLY GRADED. IN DIRECT LATERAL CONTACT WITH BLOCKS OF SANDSTONE, BROKEN OR JOINTS.

UNIT 2 - SANDSTONE: LIGHT GRAY WITH YELLOWISH-RED LAMINATIONS; MEDIUM GRAINED, MICACEOUS; FINE-THIN BEDDED; FRESH TO HIGHLY WEATHERED UPPER SOIL CONTACT. IRREGULAR WEATHERED UPPER CONTACT WITH SOIL AND TILL, WITH DISORIENTED SLABS OF SANDSTONE, SURROUNDED BY BROWN SILTY CLAY MATRIX. DIPS 30° SW, VARIABLE S TO SSW, DIP OF BEDDING NOT CONTINUOUS ACROSS TRENCH. AT +12' TO +16', -7' AN ISOLATED, IRREGULAR MASS OF EXTREMELY WEATHERED SANDSTONE AND LOOSE BLACK CARBONACEOUS MATERIAL.

UNIT 3 - CLAY: BROWN TO LIGHT YELLOWISH-BROWN SILTY, SANDY CLAY; CALCAREOUS; SOME PRESERVED CALCITE VEINS AND SMALL LENSES OF GREEN CLAY. VARIALBE TO BROWNISH-YELLOW SILT WITH LESS CLAY CONTENT, MODERATELY CEMENTED.

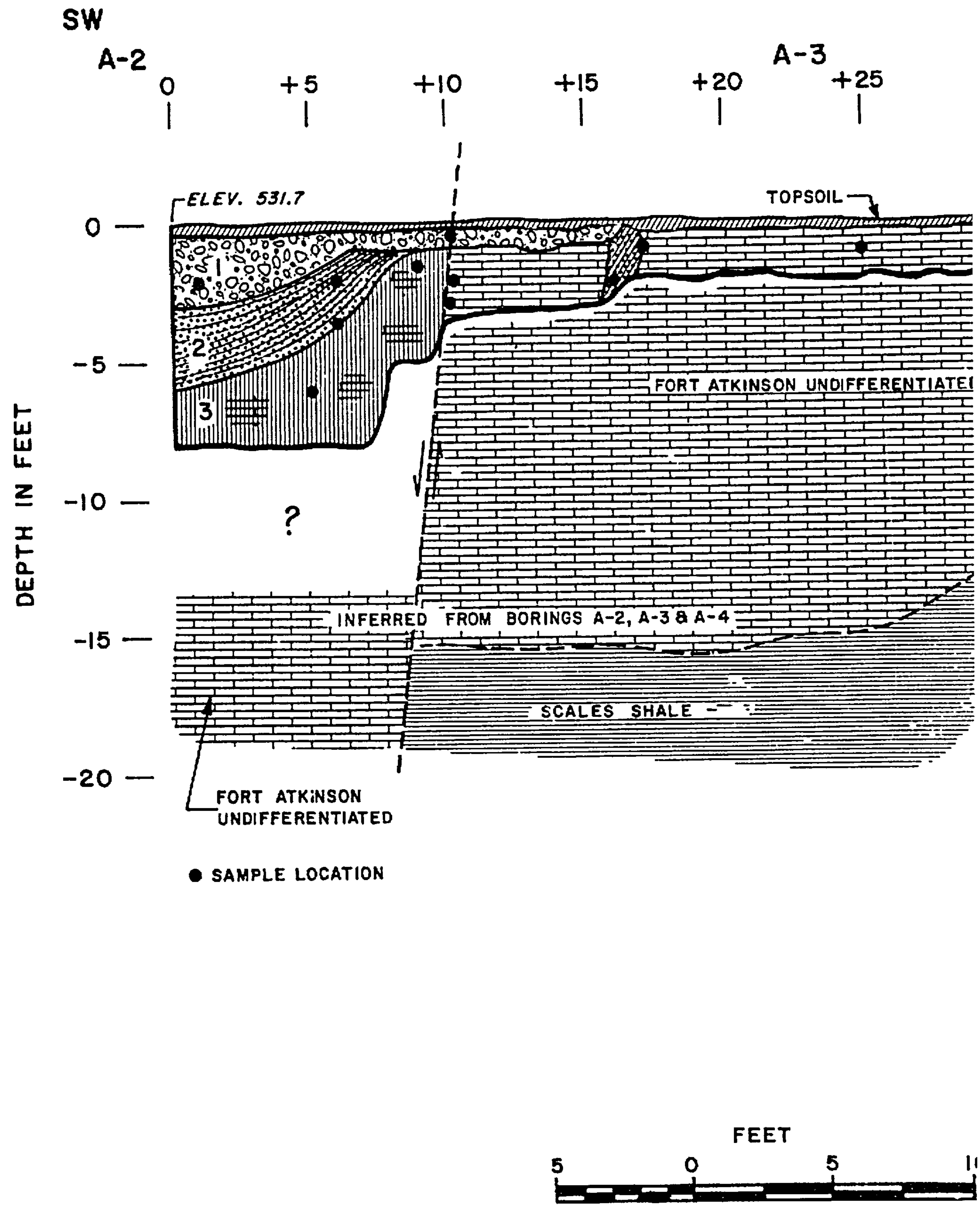
UNIT 4 - CLAY: GRAYISH-GREEN, SILTY; WITH 20% SUB-ROUNDED AND IRREGULAR, ANGULAR FRAGMENTS OF HIGHLY WEATHERED LIMESTONE. OCCASIONALLY SLIGHTLY PLASTIC. CONTACT WITH UNDERLYING LIME-STONE VERY IRREGULAR.

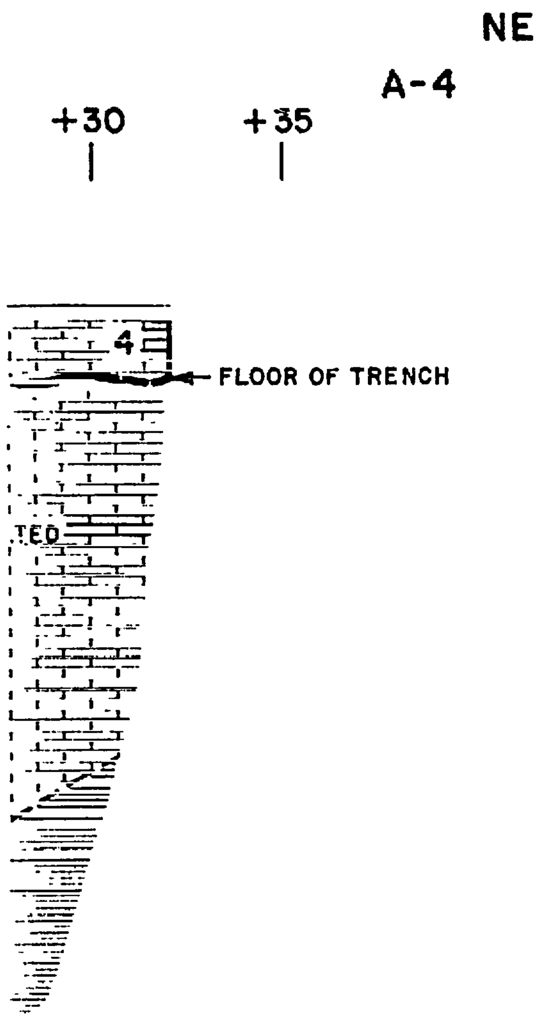
UNIT 5 - LIMESTONE: LIGHT GRAY; FINE-MEDIUM CRYSTAL-LINE; MEDIUM-THICK BEDDING; WEATHERS TO RED, COARSI CRYSTALLINE OR COARSE GRAINED TEXTURE. AS FOUND II T-2 AND T-3 AND DESCRIBED IN A-7.

TRENCH CROSS-SECTI(
T-1

DAMES & M(

FIGURE :


SW
A-2
A-3
0
+5
+10
+15
+20
+25
ELEV. 531.7
TOPSOIL
0
-5
-10
-15
-20
DEPTH IN FEET
1
2
3
?
FORT ATKINSON UNDIFFERENTIATED
INFERRED FROM BORINGS A-2, A-3 & A-4
SCALES SHALE
FORT ATKINSON UNDIFFERENTIATED
SAMPLE LOCATION
FEET
5
0
5



LEGEND

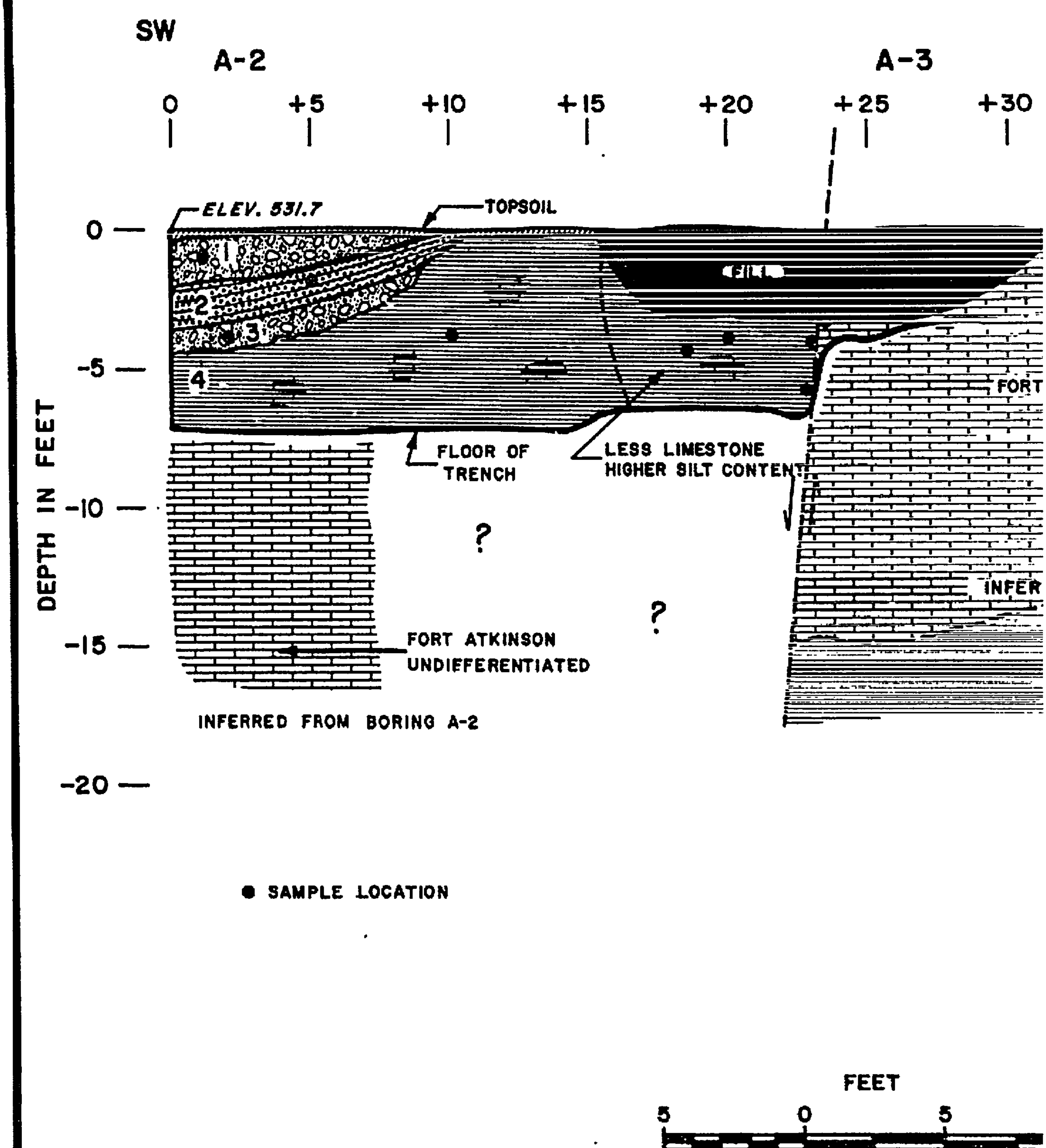
UNIT 1 -TILL: DARK BROWN AND BROWNISH-YELLOW CLAY MATRIX; WITH 40% ROUNDED GRAVELS; POORLY SORTED, WELL GRADED, OCCASIONAL ANGULAR AND SUB-ANGULAR SANDSTONE SLABS; NEAR FAULT, SANDSTONE SLABS ARE GENERALLY HORIZONTAL.

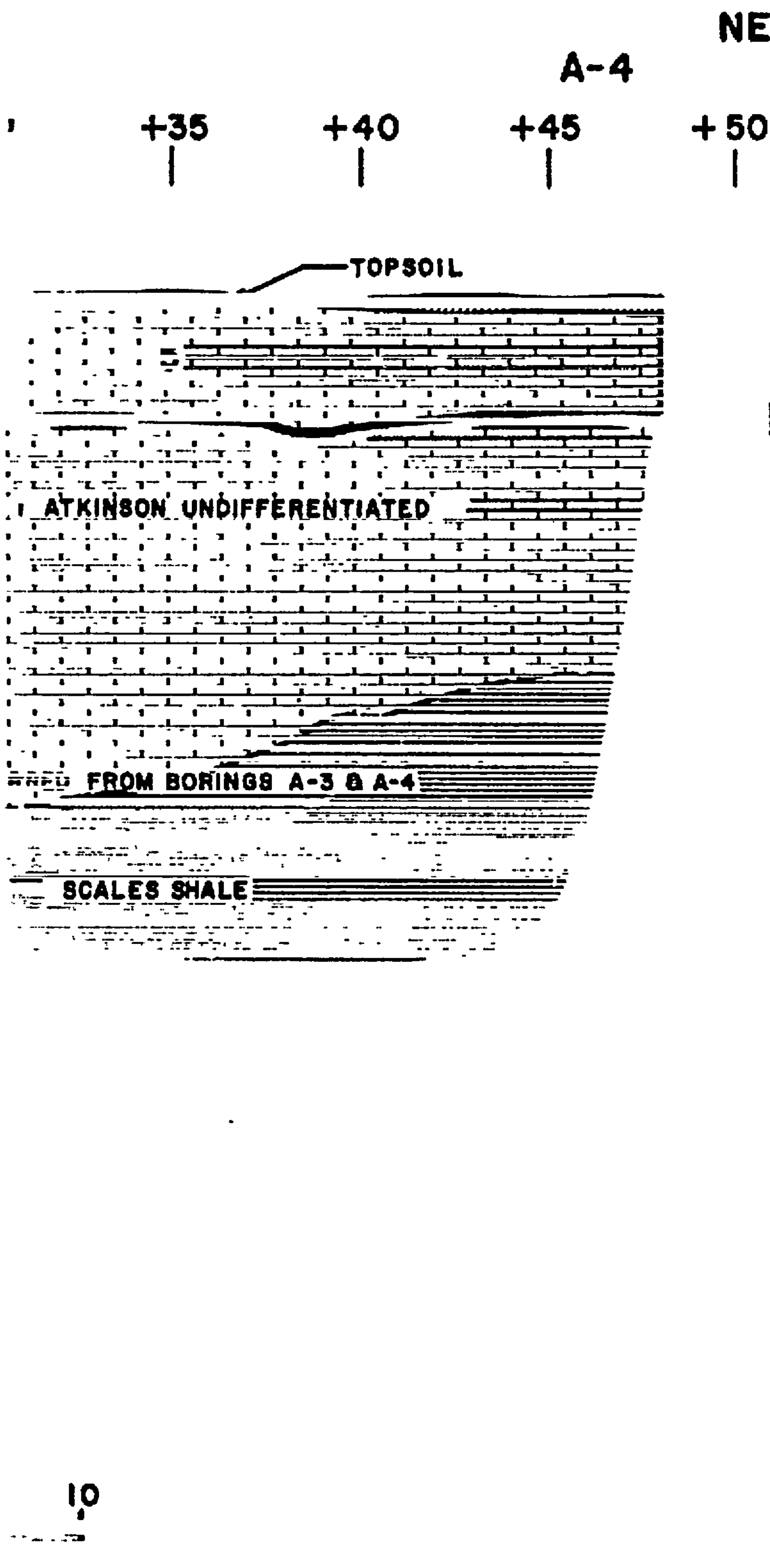
UNIT 2 - SANDSTONE: LIGHT GRAY WITH YELLOWISH-RED LAMINATIONS; FINE-MEDIUM GRAINED, MICACEOUS; FRESH TO MODERATELY WEATHERED; DRAPES 30° SW FROM IMMEDIATE VICINITY OF FAULT. IN IRREGULAR CONTACT WITH TILL ABOVE AND LIMESTONE RUBBLE BELOW POTTS-VILLE +6 -4.

UNIT 3 - LIMESTONE CLAY 'RUBBLE': LIGHT GRAY SILTY CLAY MATRIX WITH ANGULAR FRAGMENTS OF LIMESTONE UP TO 3"; VERY CALCAREOUS; POORLY SORTED, POORLY GRADED; LIMESTONE FRAGMENTS CONCENTRATED AT THE SAME LEVELS IN THE WALLS AS THE STEPS OF THE FLOOR. OCCASIONAL WEATHERED CHERT FRAGMENTS.

UNIT 4 - LIMESTONE: LIGHT GRAY; COARSE CRYSTALLINE; THICK BEDDED TO MASSIVE; WEATHERS TO RED, COARSE CRYSTALLINE OR COARSE GRAINED TEXTURE. IRREGULAR BEDDING AND JOINT SURFACES COMPLICATED BY SOLUTION ACTIVITY. AT +16, A 1.0-1.5' NEAR VERTICAL GRAY-ISH-BROWN CLAY MATRIX WITH LIMESTONE FRAGMENTS TO 2" MORE CLAYEY THAN RUBBLE (JOINT FILL OR FAULT GOUGE). BEDDING AND WEATHERING ARE TO IRREGU-LAR TO TRACE ACROSS THIS ZONE; DISPLACEMENT IS NOT DETECTABLE. FAULT IS CHARACTERIZED BY GOUGE AND RUBBLE ONLY, WITH MINOR TRACE LIMONITE IN BROWN CLAY.

TRENCH CROSS-SEC
T-2


SW
A-2
A-3
0
+5
+10
+15
+20
+25
+30
ELEV. 531.7
TOPSOIL
FILL
1
2
3
4
0
-5
-10
-15
-20
DEPTH IN FEET
FORT
FLOOR OF TRENCH
LESS LIMESTONE HIGHER SILT CONTENT
?
?
INFER
FORT ATKINSON UNDIFFERENTIATED
INFERRED FROM BORING A-2
● SAMPLE LOCATION
FEET
5
0
5



LEGEND

UNIT 1 - TILL: DARK REDDISH-BROWN SANDY CLAY MATRIX; DENSE, WITH 40% ROUNDED COARSE SAND AND PEBBLES; POORLY SORTED, WELL GRADED; SOME ANGULAR FRAGMENTS; LARGER PEBBLES TO 4". CONTAINS DISORIENTED SLABS OF SANDSTONE; NOT FOUND OVERLYING LIMESTONE IN THE TRENCH.

UNIT 2 - SANDSTONE: LIGHT GRAY WITH YELLOWISH-RED LAMINATIONS; FINE-MEDIUM GRAINED; MICACEOUS; THIN BEDDED; FRESH TO SLIGHTLY WEATHERED; SLOPES GENTLY SW, BUT VARIES ACROSS TRENCH. CONTACT WITH UNDERLYING LIMESTONE 'RUBBLE' VERY IRREGULAR. POTTSVILL

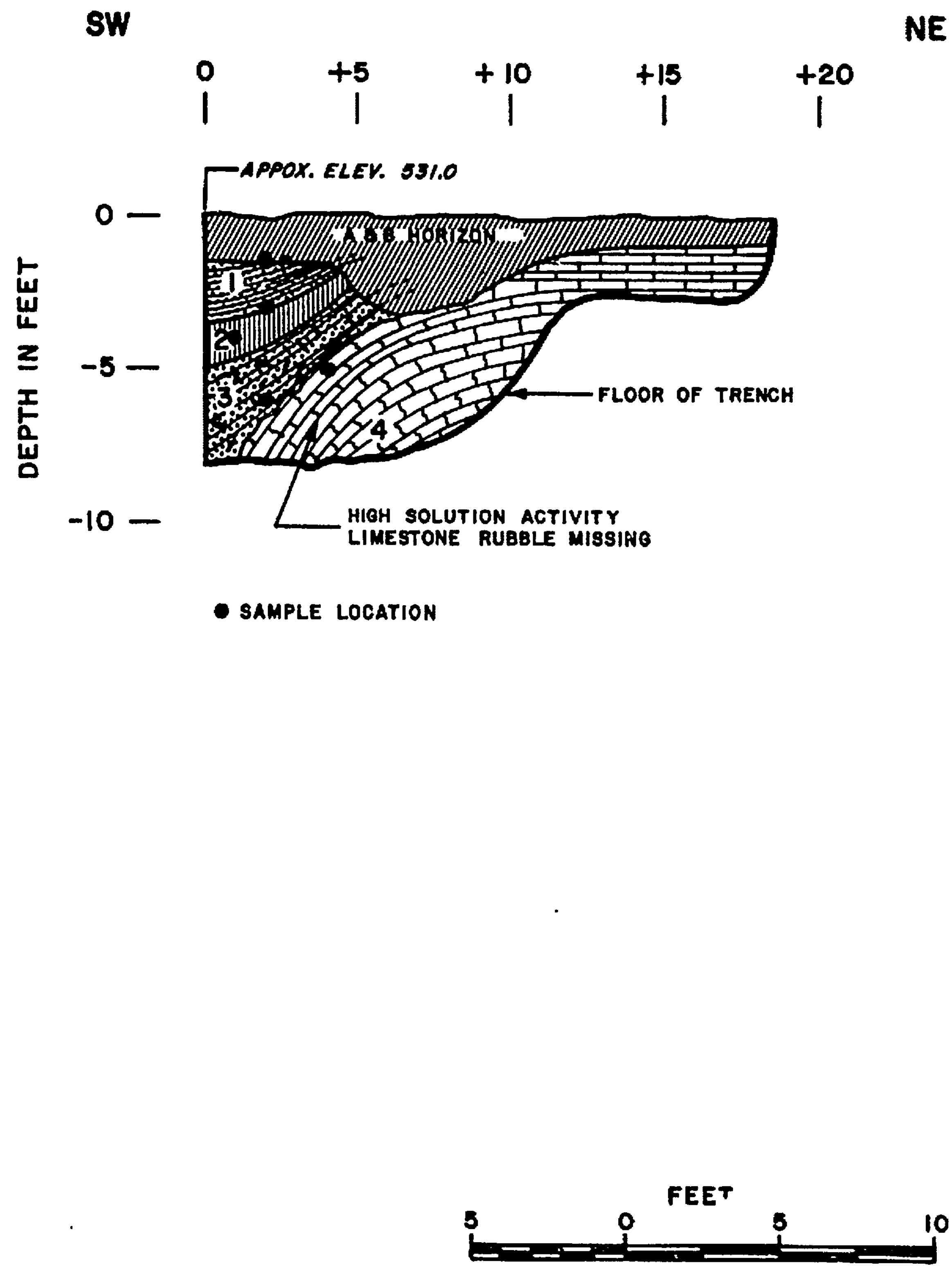
UNIT 3 - TILL: SAME AS UNIT 1; OCCASIONAL SMALL SANDSTONE SLAB; APPEARS TO INTRUDE BETWEEN SANDSTONE AN UNDERLYING LIMESTONE. CONTAINS OCCASIONAL SMALL PIECES OF WOOD; ONE 5" ELONGATED CARBONACEOUS DEPOS RESEMBLING A TREE BRANCH. TAPERS OUT NEAR JUNCTION OF SANDSTONE, OVERLYING TILL, SOIL AND LIMESTONE RUBBLE.

UNIT 4 - LIMESTONE-CLAY 'RUBBLE': CLAYEY GRAVEL: GRAY SILTY; ANGULAR LIMESTONE FRAGMENTS UP TO 3"; VERY CALCAREOUS; POORLY SORTED; POORLY GRADED; VARIES IRREGULAR TO LIGHT BROWN SILTY CLAY, FEW LIMESTONE FRAGMENTS; OCCASIONAL BRYOZOA FRAGMENTS; WITH CALCI CRYSTALLS NEAR FAULT.

UNIT 5 - LIMESTONE: LIGHT GRAY; COARSE CRYSTALLINE; T BEDDED TO MASSIVE; WEATHERS TO RED, COARSE CRYSTALL OR COARSE GRAINED TEXTURE. IRREGULAR BEDDING PLANE AND JOINTING COMPLICATED BY SOLUTION ACTIVITY. CON THIN LINING OF BROWN CLAY AND LIMONITE ALONG FAULT. CONTAINS AN IRREGULAR MASS OF GRAYISH-GREEN SILTY C AT +35' TO +40', PROBABLY SOLUTION CAVITY FILLING. FORT ATKINSON LIMESTONE (AS DESCRIBED IN BORINGS A- A-4 AND A-5).

TRENCH CROSS-SECT
T-3

FIGURE


SW
NE
0
+5
+ 10
+15
+20
APPOX. ELEV. 531.0
0
-5
-10
DEPTH IN FEET
1
2
3
4
FLOOR OF TRENCH
HIGH SOLUTION ACTIVITY
LIMESTONE RUBBLE MISSING
SAMPLE LOCATION
FEET
5
0
5
10

LEGEND

UNIT 1 - SANDSTONE: LIGHT GRAY WITH YELLOWISH-RED LAMINATIONS; FINE-MEDIUM GRAINED, MICACEOUS; THIN BEDDED; FRESH TO EXTREMELY WEATHERED AT UPPER SOIL CONTACT. OVERLAIN BY DARK BROWN SILT GRADING DOWNWARD TO YELLOWISH-BROWN MICACEOUS SILT. SANDSTONE DIPS GENTLY SW, 20°-30°. NEAR SOIL CONTACT, A 2" LAYER TAKES SHARP DROP-OFF. GRADES TO FINE BEDDED APPROACHING CLAY LAYER BELOW.

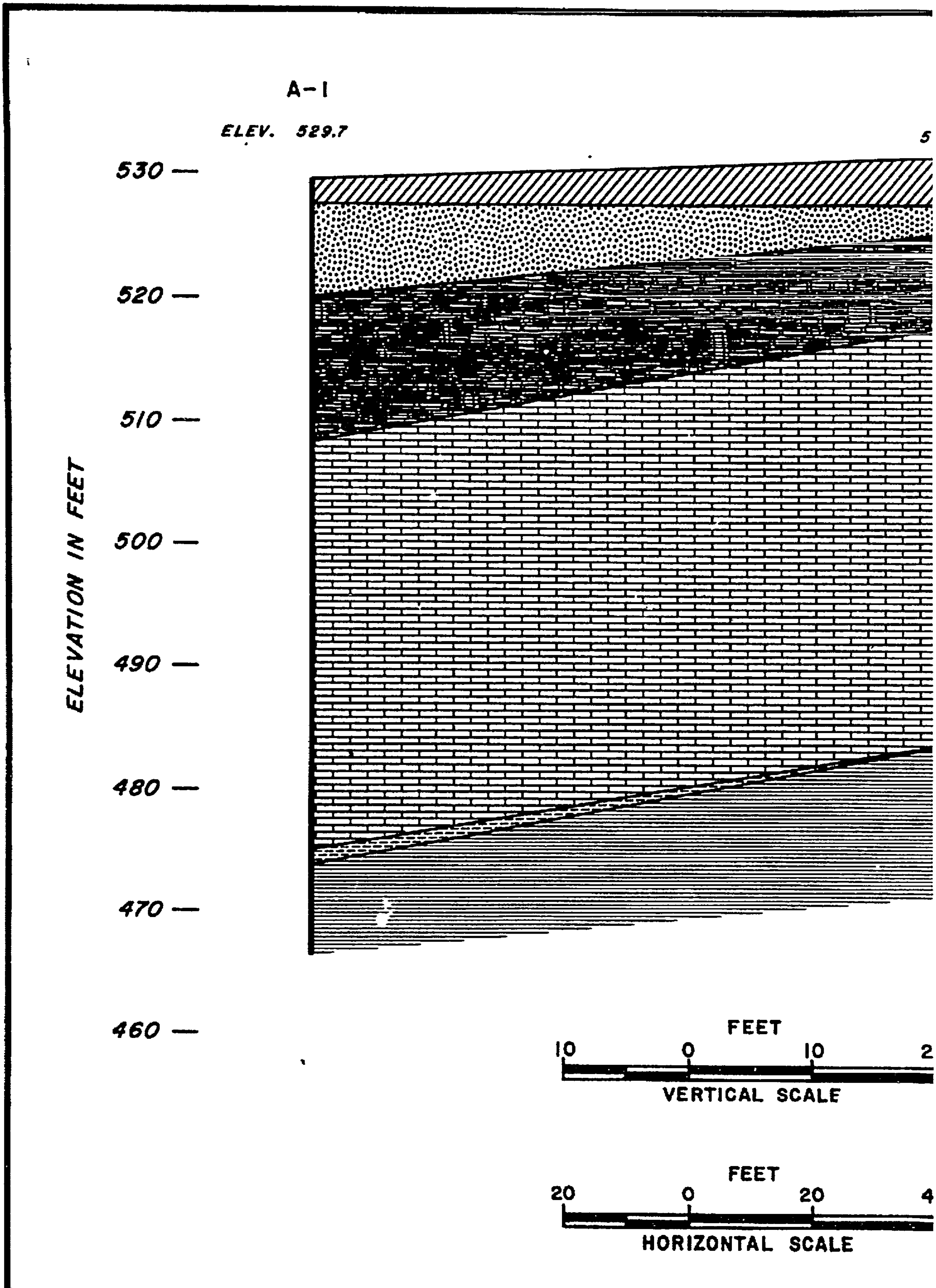
UNIT 2 - CLAY: BLUISH-GRAY, MOTTLED BROWNISH-YELLOW; SILTY; OCCASIONAL LOW PLASTICITY, VARIES TO DRIER WITH HIGHER SILT CONTENT. WEDGES OUT AT +3' INTO OVERLYING AND UNDERLYING SANDSTONE AND SOIL.

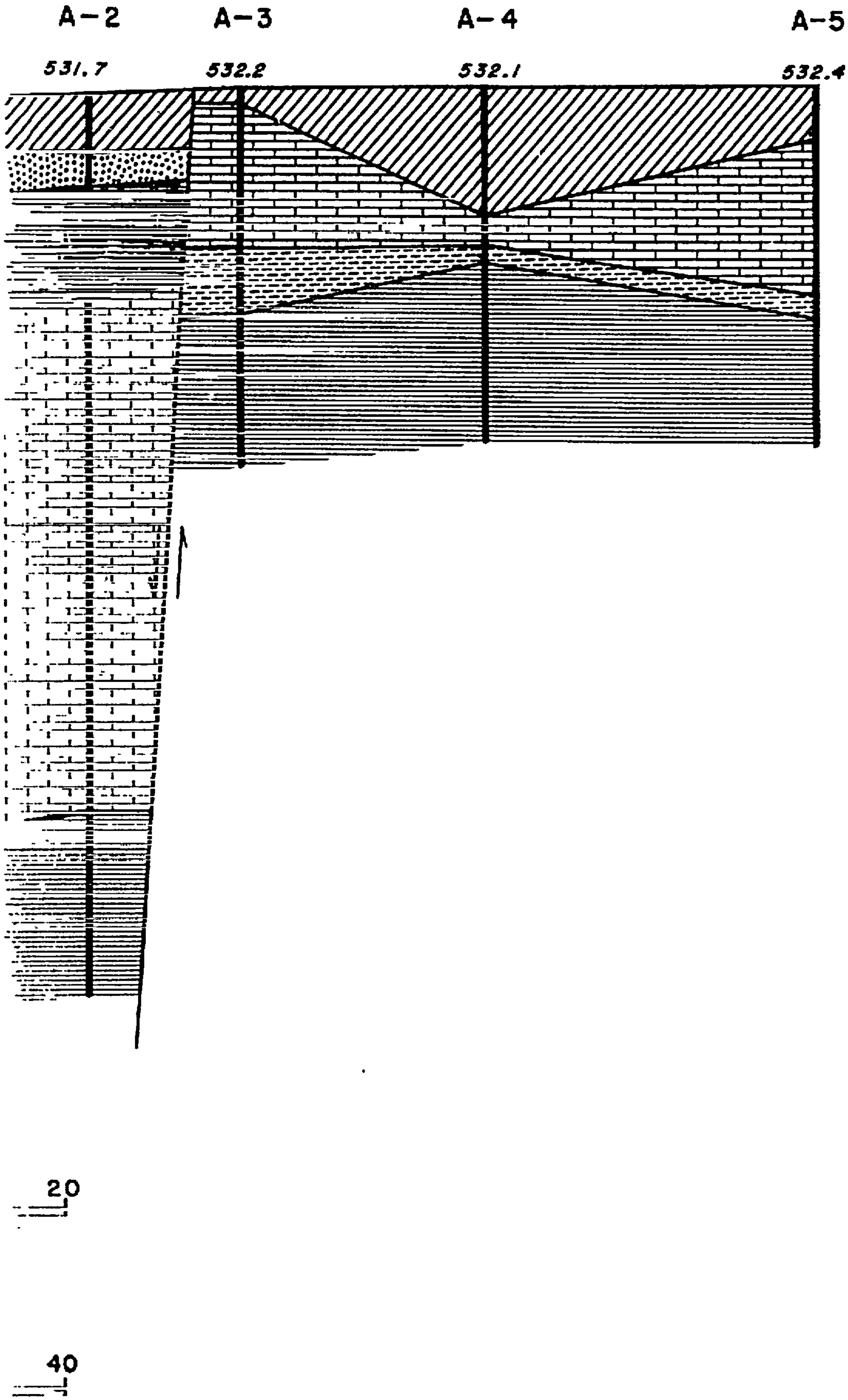
UNIT 3 - SANDSTONE: SAME AS ABOVE BUT MODERATE-HIGHLY WEATHERED; HIGH CARBON CONTENT IN MASSES ALONG IRREGULAR, BROKEN, BEDDING PLANES. MASS MAINTAINS SW DIP APPROXIMATELY 35°. COMPOSED OF LOOSE TO POORLY CEMENTED SAND, CLAY AND CARBONACEOUS MATERIALS.. CONTAINS DISORIENTED MASSES OF SLIGHT-MODERATELY WEATHERED SANDSTONE SLABS.

UNIT 4 - LIMESTONE: LIGHT GRAY; COARSE CRYSTALLINE, MEDIUM TO THICH BEDDED; OCCASIONALLY MASSIVE; WEATHERS TO RED, COARSE CRYSTALLINE OR COARSE GRAINED TEXTURE. JOINTS AND BEDDING PLANES EXHIBIT HIGH SOLUTION ACTIVITY. CALCAREOUS BROWN SILTY CLAY IN CONTACT WITH OVERLYING SANDSTONE. UPPER SURFACE DROPS OFF TO SW RAPIDLY APPROXIMATE +5'. GENERAL WARPING OF BEDDING WITH SOME TRANSVERSE CRACKS IN SOME OF THE THINNER BEDS IS VISIBLE; NO DEFINITE FAULT APPARENT.

TRENCH CROSS-SECTI

T-4


A-1
ELEV. 529.7
5
530
520
510
500
490
480
470
460
ELEVATION IN FEET
FEET
10
0
10
2
VERTICAL SCALE
FEET
20
0
20
4
HORIZONTAL SCALE



LEGEND

UNCONSOLI
MATERIAL

SANDSTONI

INTERBEDD
SHALE AN
LIMESTON

LIMESTONI

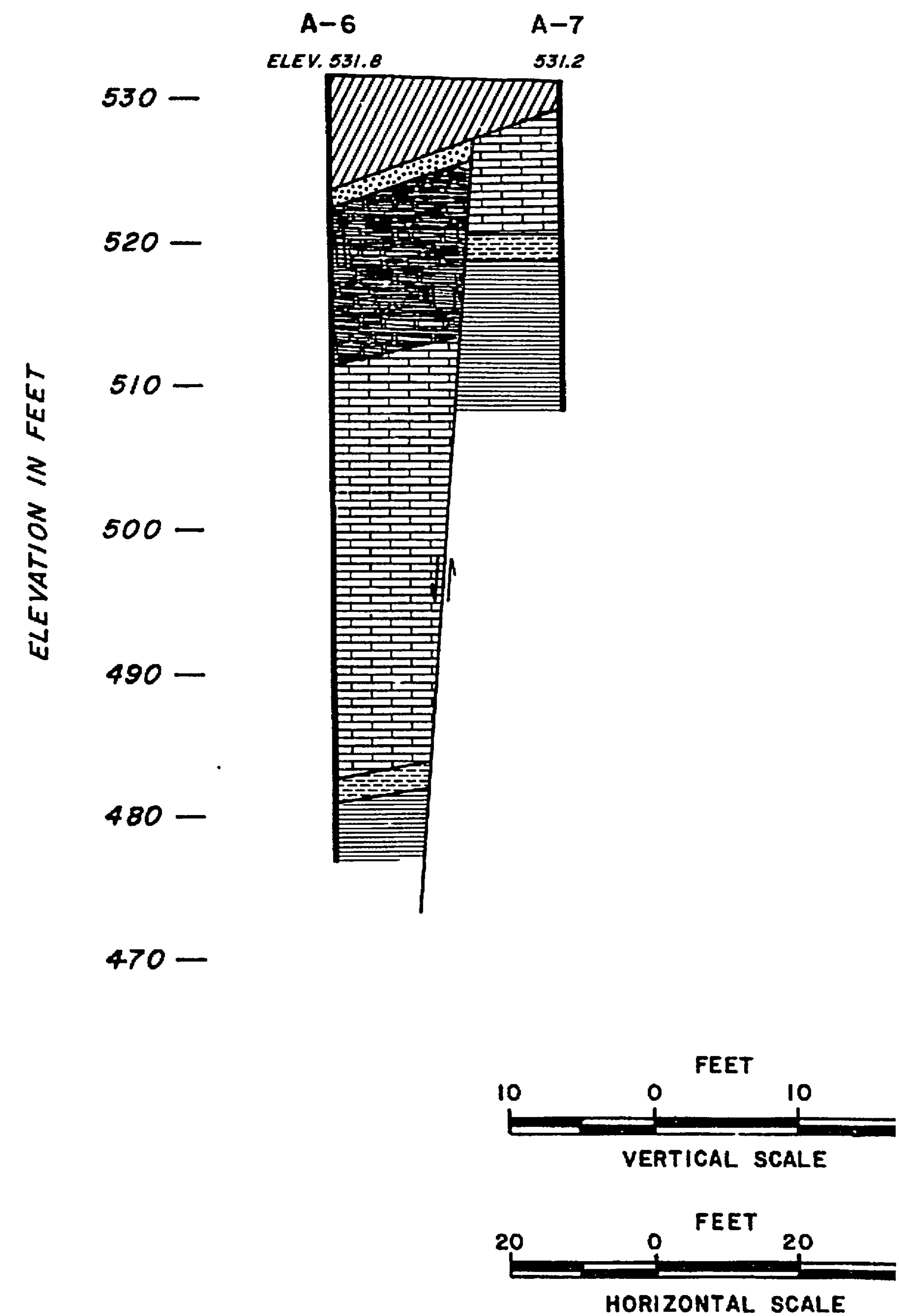
SILTSTONE

SHALE

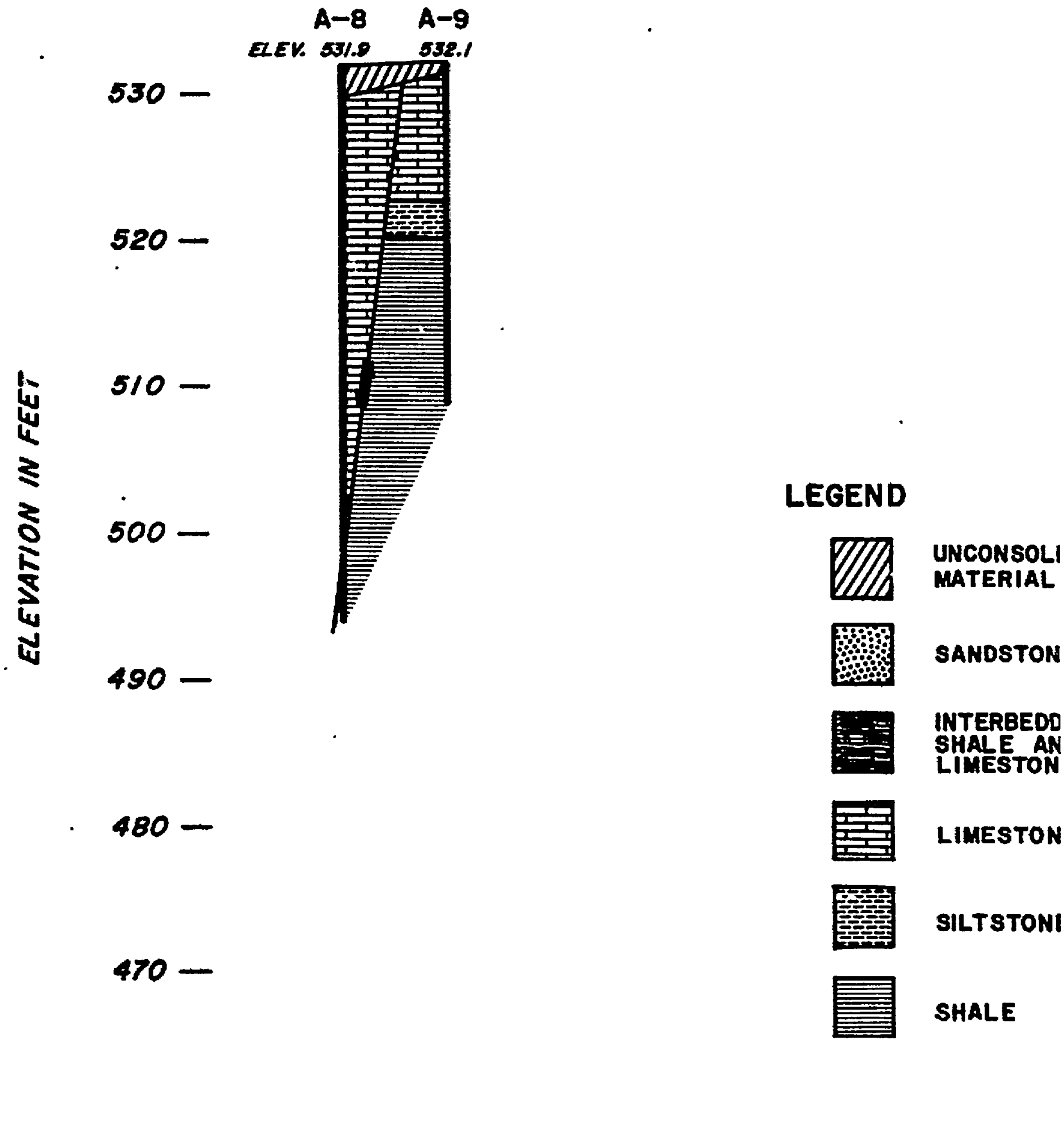
CROSS-SECTION
OF BORINGS

DANIEL & I

FIGURE



A-6
A-7
ELEV. 531.8
531.2
530
520
510
500
490
480
470
ELEVATION IN FEET
FEET
10
0
10
VERTICAL SCALE
FEET
20
0
20
HORIZONTAL SCALE

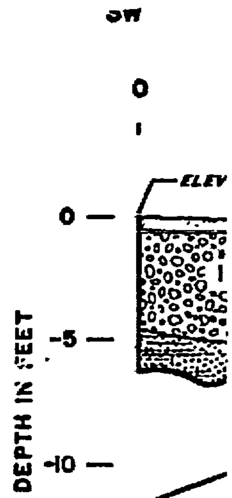


CROSS-SECTIONS OF BORINGS

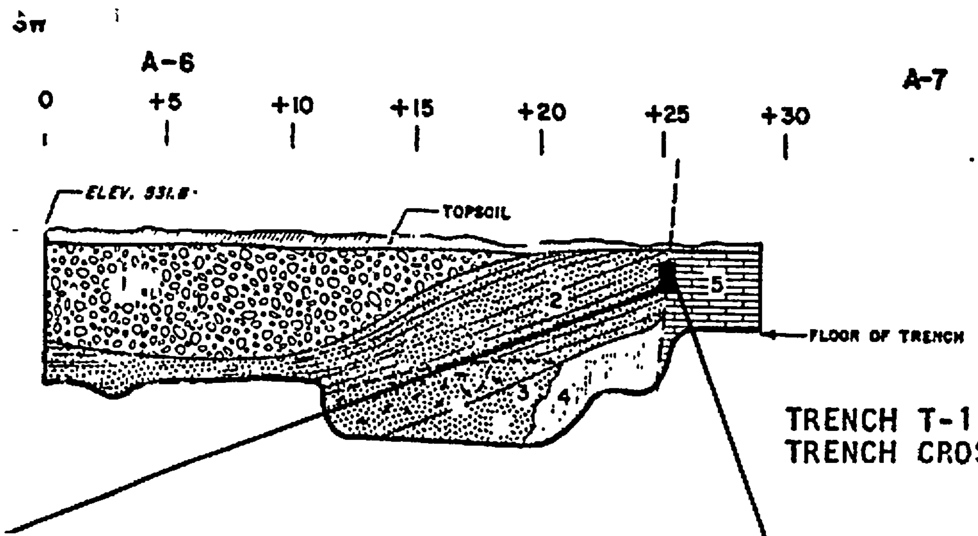
PHOTO 1-26

PHOTO 1-27

PHOTO 1-28



SANDSTONE - RUBBLE - LIMESTONE FAULT CONTACT. (TRENCH T-1 LOOKING NORTHWEST); SHOWING VEIN CALCITE AND SAND-CLAY MIXTURE AT THE LIMESTONE-SANDSTONE CONTACT.



TRENCH T-1: SEE FIGURE 2
TRENCH CROSS-SECTIONS, APPENDIX A

0 1-27

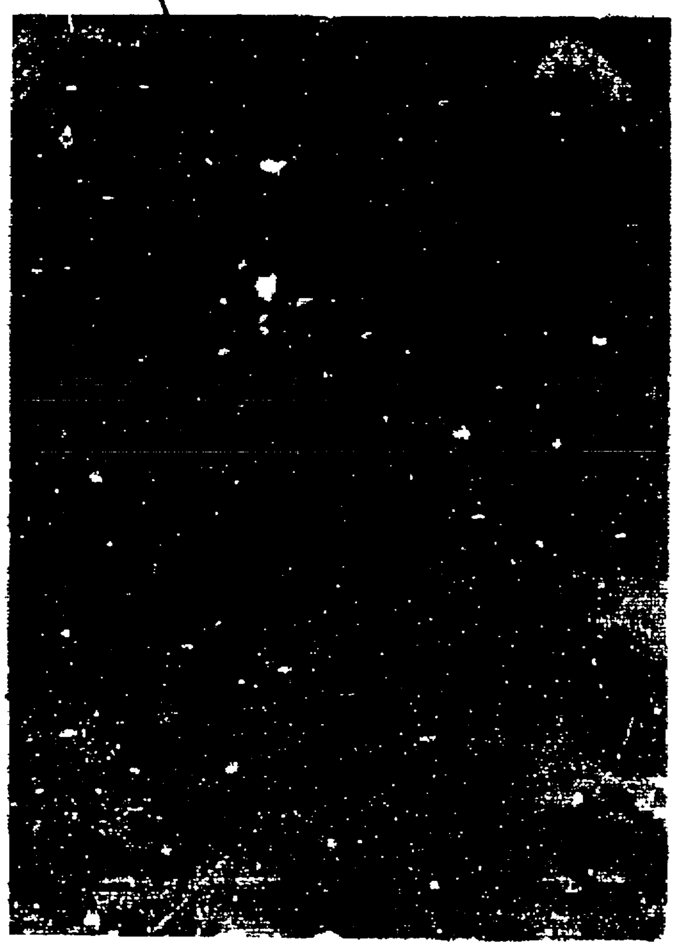
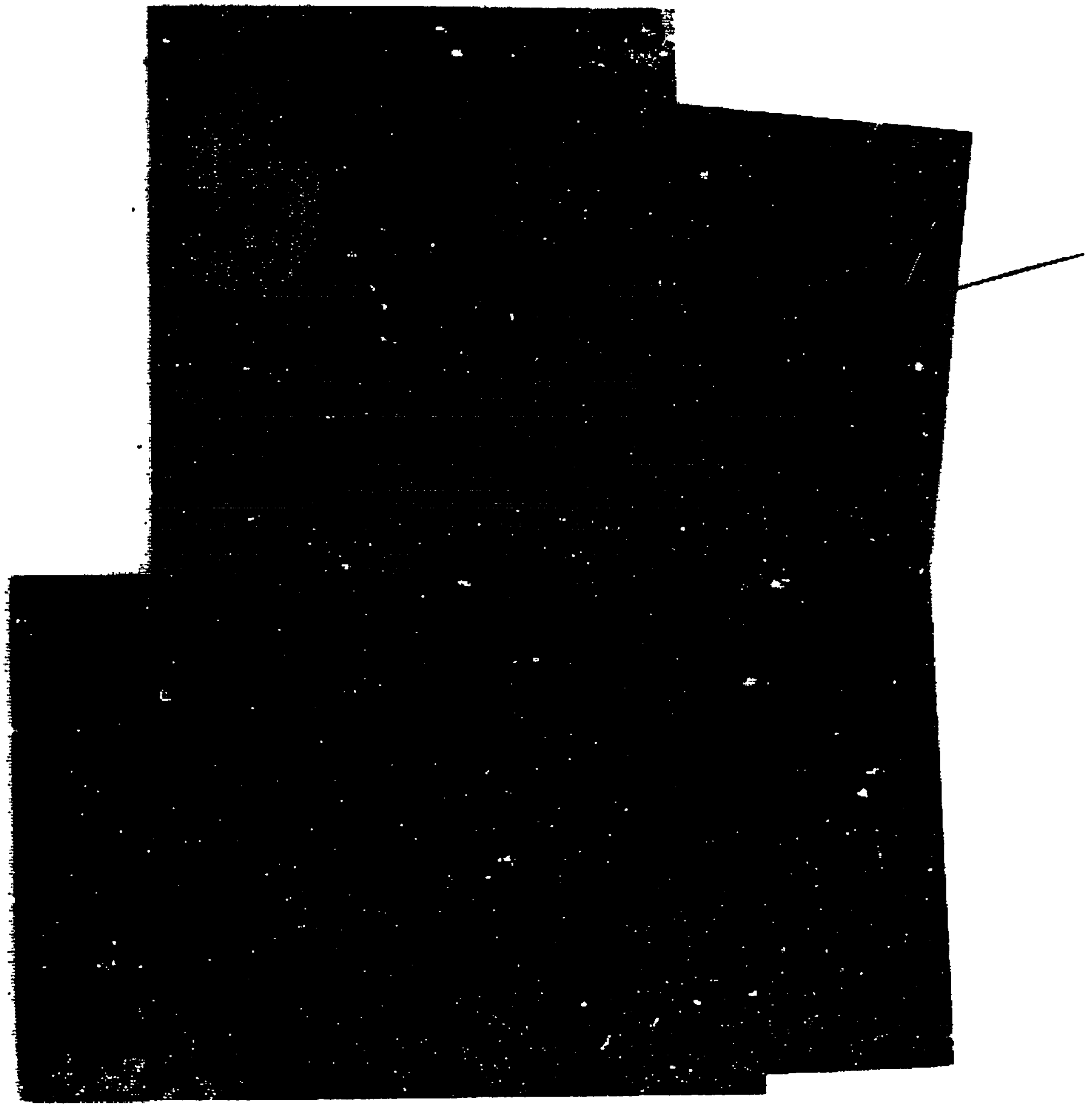
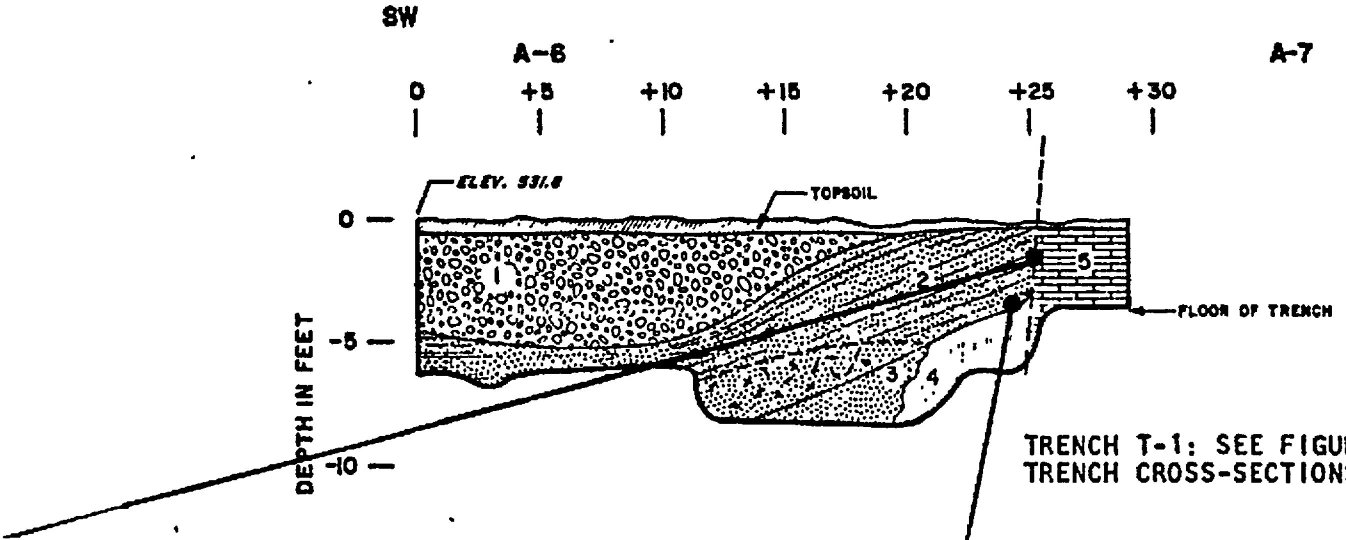


PHOTO 2-9: SANDSTONE - RUBBLE - LIMESTONE
FAULT CONTACT. (TRENCH T-1 LOOKING NORTH)



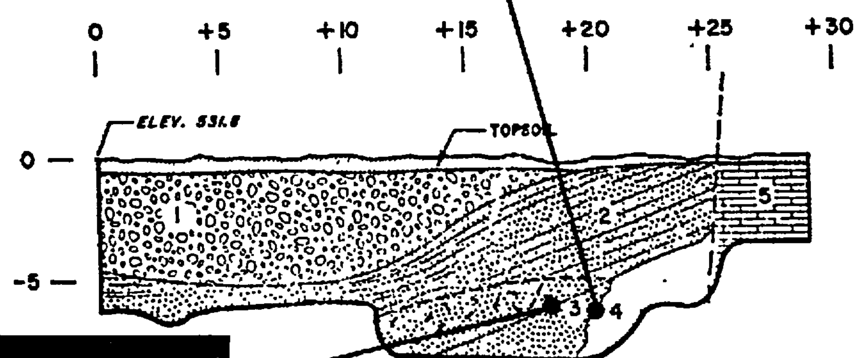
PHOTOS 2-14,15,16,17: FAULT CONTACT.
(TRENCH T-1 LOOKING SOUTHEAST)



TRENCH T-1: SEE FIGURE 2
TRENCH CROSS-SECTIONS, APPEND

PHOTO 2-13: SANDSTONE DEPOSITED ON SMOOTH LIMESTONE
BOULDER BELOW FAULT. (TRENCH T-1 LOOKING SOUTHEAST)

PHOTO 2-8: CONTACT WITHIN THE RUBBLE BETWEEN GRAY-GREEN SILTY CLAY AND BROWNISH-YELLOW SILTY CLAY. (TRENCH T-1 LOOKING NORTHWEST)



TRENCH T-1: SEE FIGURE 2
TRENCH CROSS-SECTIONS, APPENDIX A

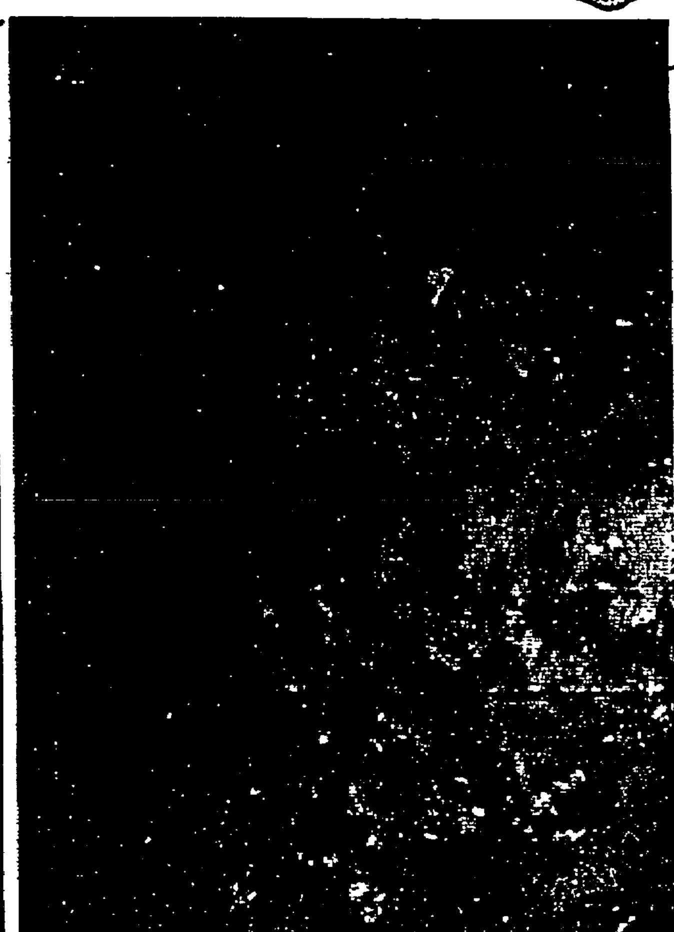


PHOTO 1-24: SANDSTONE-RUBBLE CONTACT. (TRENCH T-1 LOOKING NORTH)

DAMES & MOORE

FIGURE 10

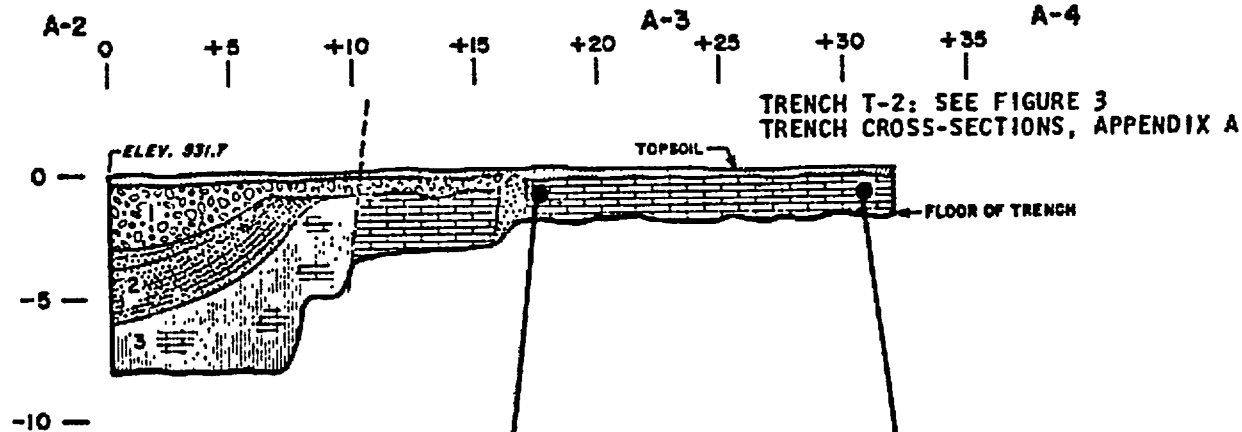


PHOTO 2-5:
LOOKING SOUTH.

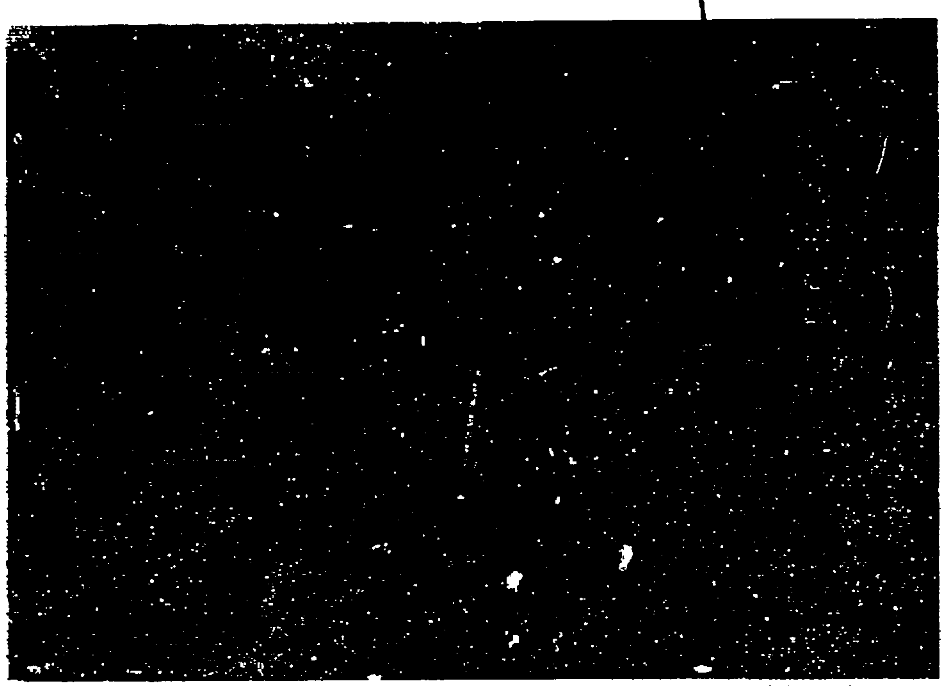


PHOTO 1-7:
LOOKING NORTHEAST

FORT ATKINSON FORMATION, SHOWING IRREGULAR FOLDED BEDDING AND SOLUTION ACTIVITY ON UPTHROWN SIDE OF FAULT.

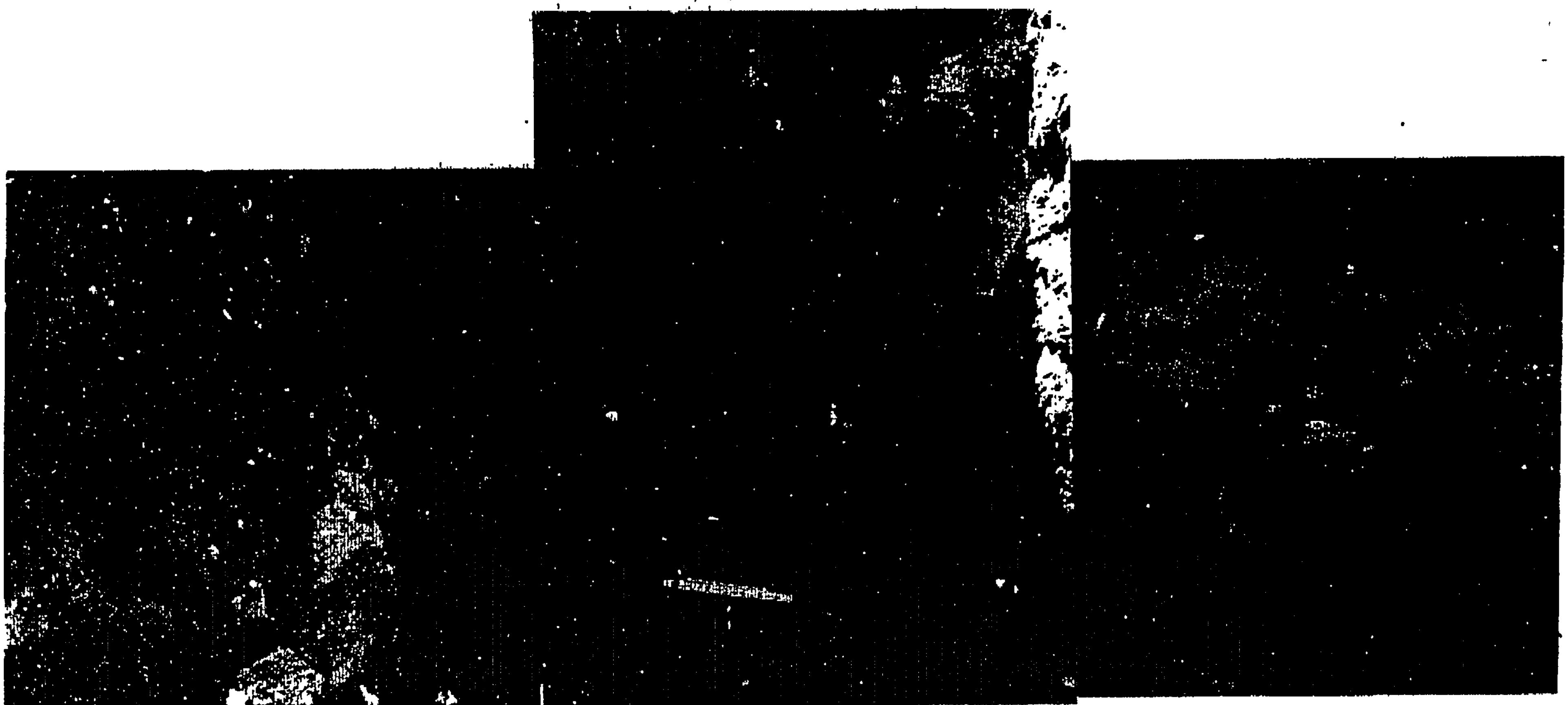
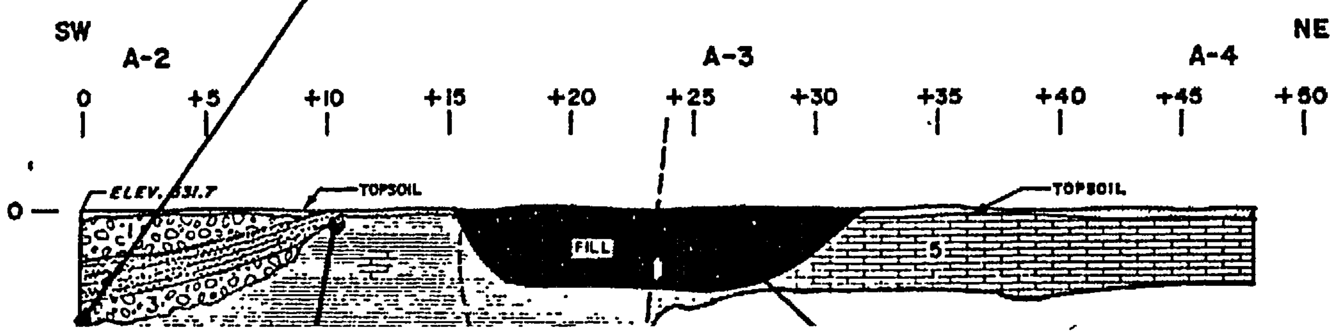
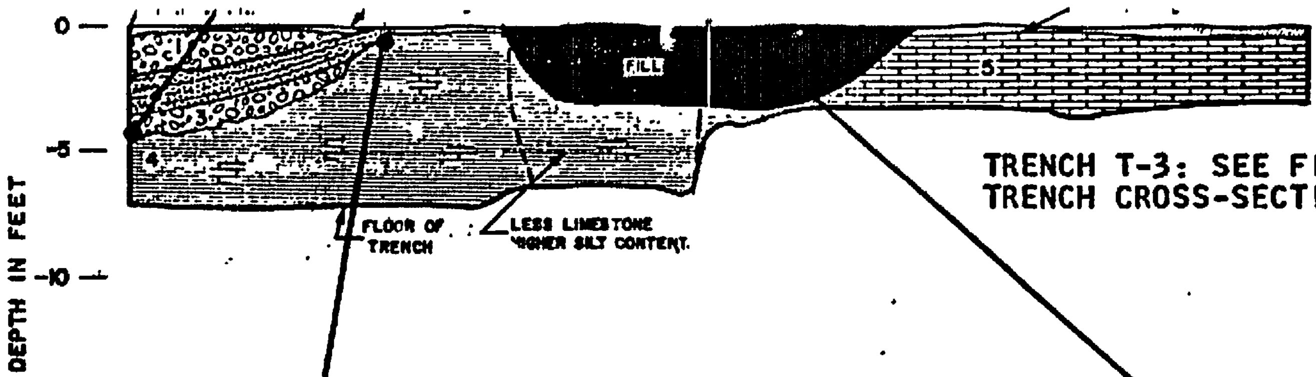


PHOTO 1-31 PHOTO 1-1 PHOTC 1-30

PANORAMA OF T-3 - LOOKING AT SOUTHWEST EDGE IN CENTER PHOTO.





TRENCH T-3: SEE FIGURE 4
TRENCH CROSS-SECTIONS, APPENDIX A

PHOTO 1-2: SANDSTONE-RUBBLE CONTACT.
(TRENCH T-3 LOOKING NORTHWEST)

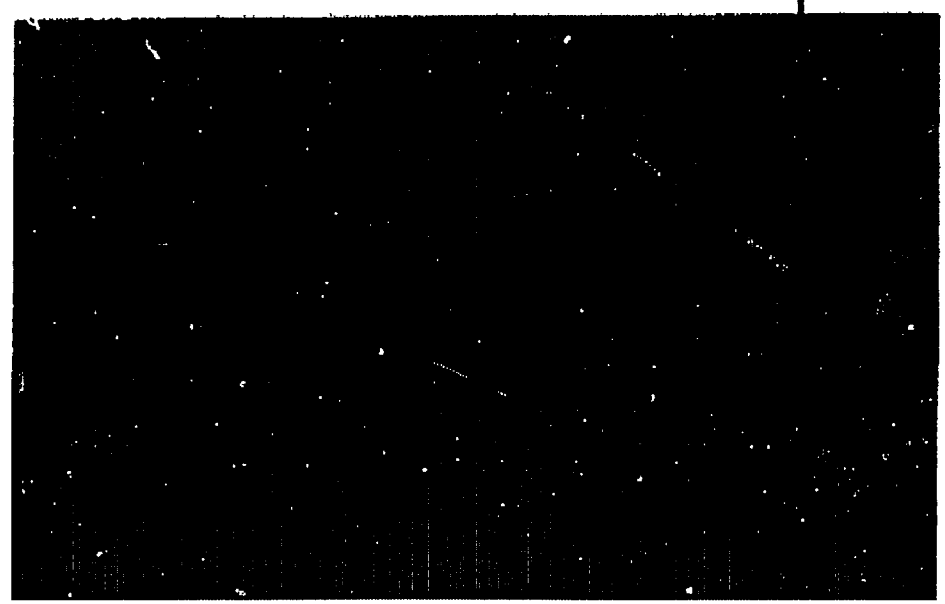


PHOTO 1-3: FILL MATERIALS COVERING
FAULT CONTACT. (TRENCH T-3 LOOKING
NORTH)

PH

PHOTO [illegible]

NORTHWEST WALL OF TRENCH T-4

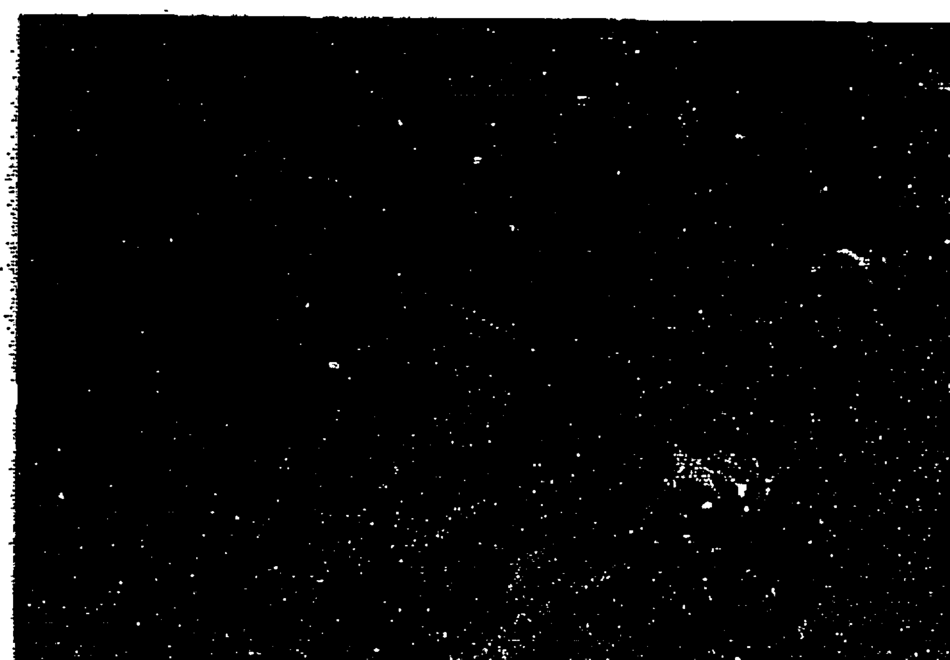
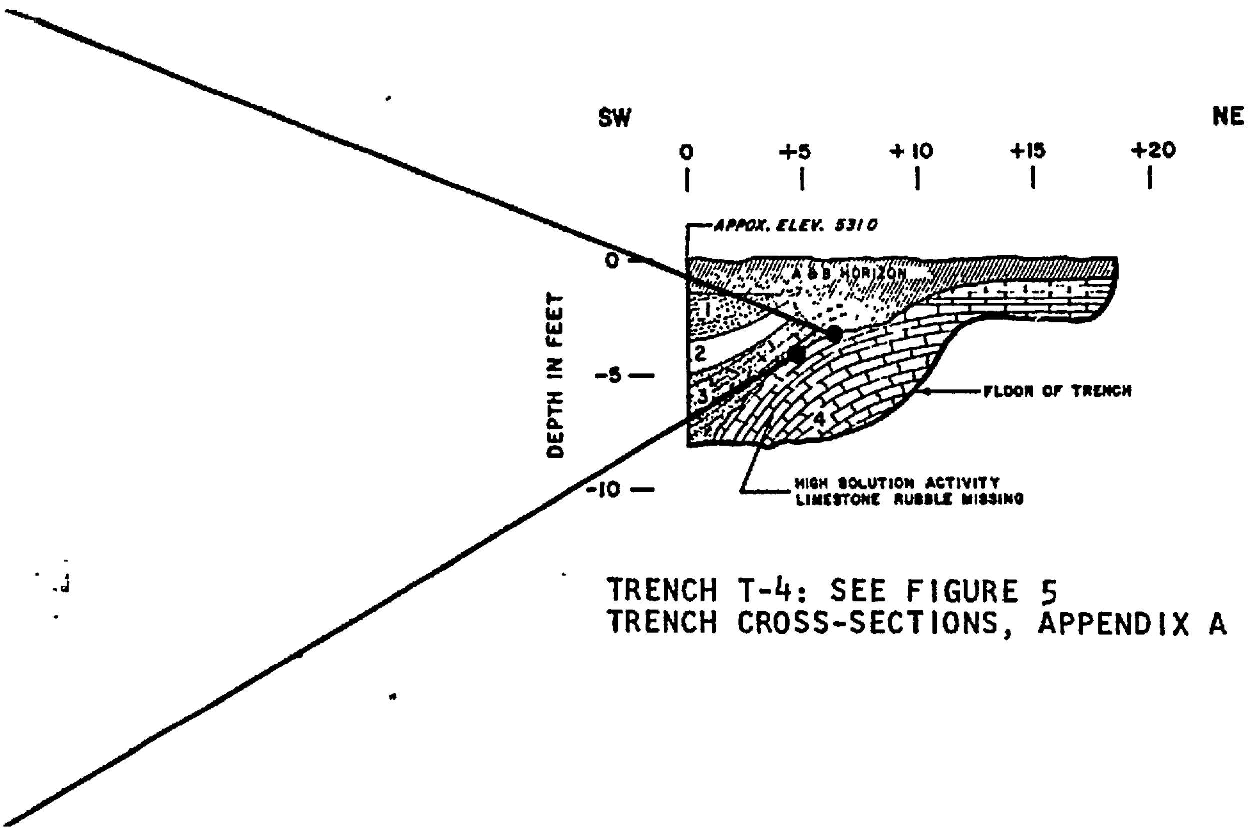
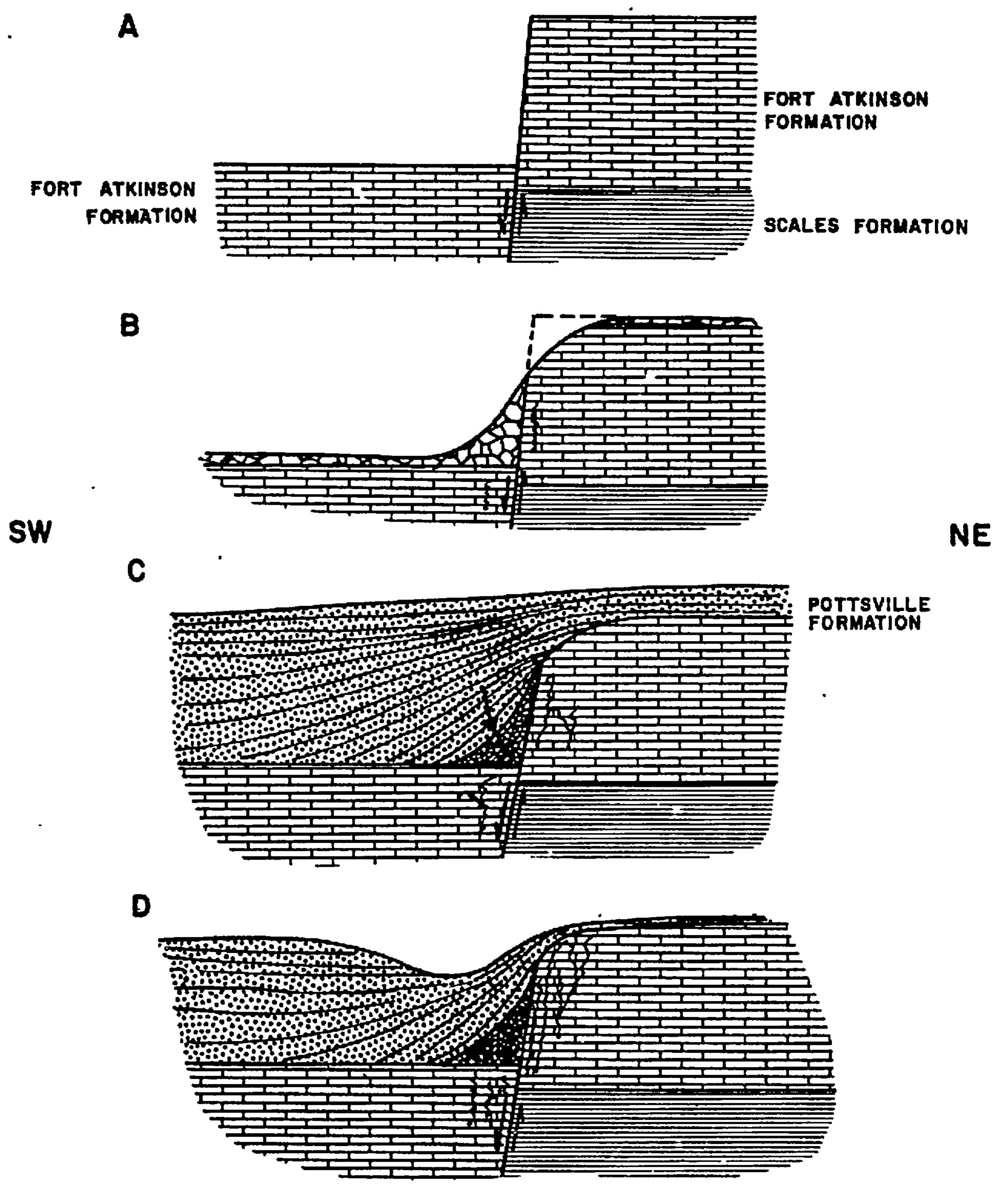


PHOTO 2-35: SANDSTONE - LIMESTONE CONTACT.
(TRENCH T-4 LOOKING SOUTH)

PHOTO 2-32

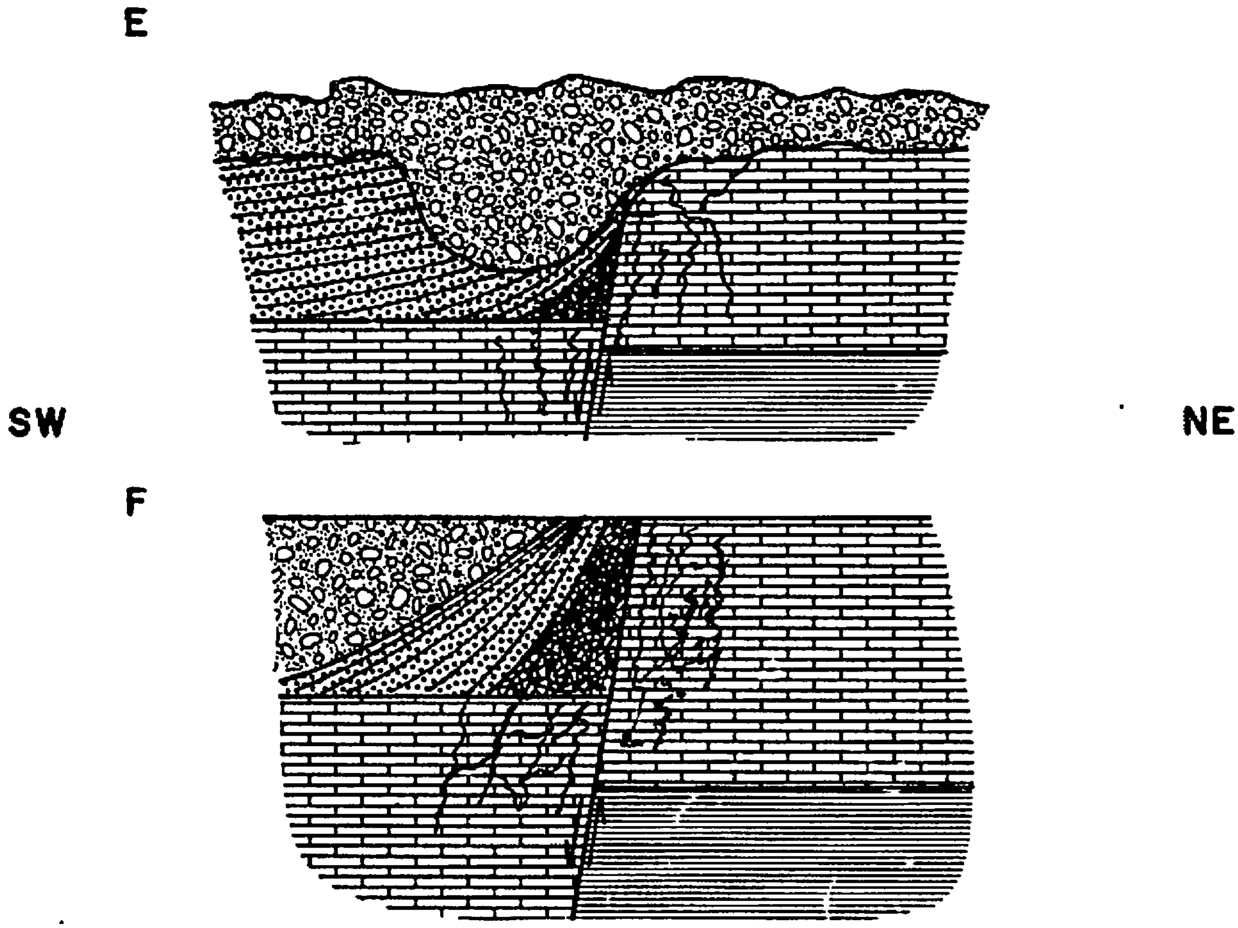


TRENCH T-4: SEE FIGURE 5
TRENCH CROSS-SECTIONS, APPENDIX A



GEOLOGICAL HISTORY

DAMES & MOORE

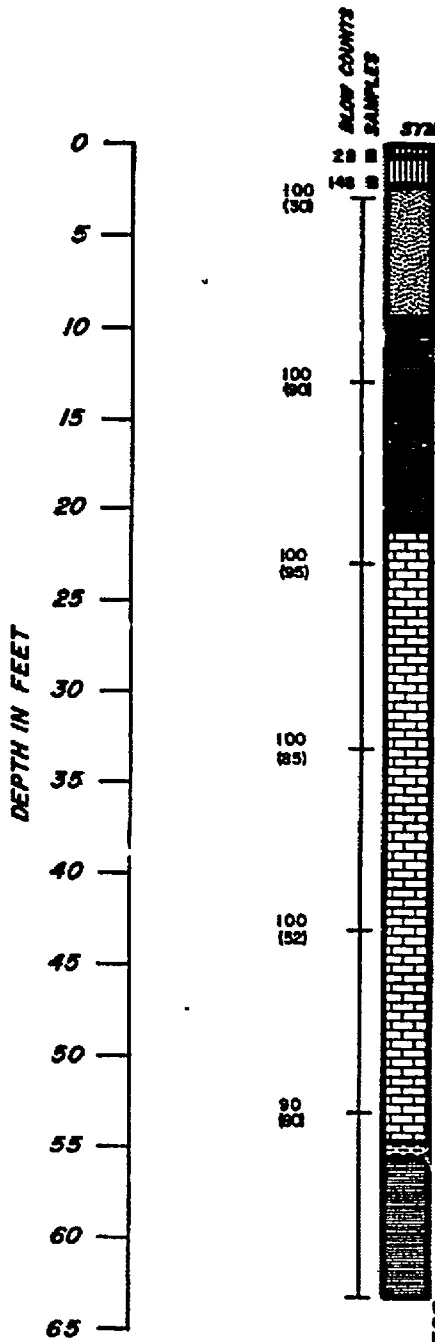


GEOLOGICAL HISTORY
(CONTINUED)

FIGURE. 14 CONT'D

BORING A-1

SURFACE ELEVATION 529.7



DESCRIPTIONS

BLACK SILT WITH TRACE ROOTS; CLAY; FINE SAND - TOPSOIL

GRAYISH-BROWN SILT WITH FINE SAND; TRACE ROOTS; FINE GRAVEL MICACEOUS; (HARD); WEATHERED SANDSTONE
1.5'; MICACEOUS GRAYISH-BROWN SILT; TRACE ROOTS; GRADING MORE DENSE BY 2.0', BUT EASILY BROKEN TO ROCK FLOUR

POTTSVILLE FORMATION
SANDSTONE; GRAY TO LIGHT GRAY; FINE TO MEDIUM GRAINED; THIN TO MEDIUM BEDDING; MODERATE TO WELL CEMENTED; UPPER FEW INCHES SLIGHTLY WEATHERED. OCCASIONAL BLACK SHALE OR CARBON-LAMINATIONS. FRACTURES ALONG SUB-HORIZONTAL BEDDING PLANES.

FORT ATKINSON FORMATION
INTERBEDDED SHALE AND LIMESTONE: SHALE; GRAY; SILTY; THIN TO THICK BEDDING; 3" ZONE YELLOWISH-BROWN CLAY AND GRAY LIMESTONE PIECES AT CONTACT; CRYSTALLINE; MODERATELY WEATHERED; CALCAREOUS, WITH 50% ELONGATE; ROUNDED SUB HORIZONTAL FOSSIL AND/OR LIMESTONE FRAGMENTS; LIMESTONE; GRAY IN IRREGULAR LAYERS UP TO 3", IRREGULAR BEDDING PLANE FRACTURES THROUGHOUT WITH OCCASIONAL GREEN CLAY FILL

LIMESTONE; GRAY TO LIGHT GRAY; FINE TO COARSE CRYSTALLINE; FOSSILIFEROUS; 2" GREEN CLAY AT CONTACT; THICK BEDDED TO MASSIVE; CALCAREOUS GREEN CLAY VEINLETS THROUGHOUT.
21.5'; 3" ZONE GREEN; SLIGHTLY CALCAREOUS SILT, WITH SMALL LIMESTONE FRAGMENTS
23.0'-27.0'; GRADES LIGHT GRAY TO PALE YELLOW
25.5'; 2" ZONE STYOLITES; OCCASIONAL CALCITE FILLED VUGS TO 1cm

27.0'-33.0'; GRADES TO LIGHT GRAYISH-WHITE

30.0'; IRREGULAR 2" ZONE OF GREEN CLAY AND PYRITE CRYSTALS IN AN IRREGULAR 1" VUG
31.0'; 4" 45° PYRITE FILLED FRACTURE AND GREEN CLAY IN VUGS 5-10mm DIAMETER
31.6'; GREEN CLAY FILLED ELONGATED VUG 1"X.5"
33.0'; .5" ZONE GREEN CLAY
GRADING TO LIGHT GRAY; 2" VERTICAL GREEN CLAY SEAM AT 33.0' OCCASIONAL PINHOLE VUGS
35.2'; IRREGULAR 45° FRACTURE, WITH PYRITE CRYSTALS; PARTIALLY OPEN TO CALCITE FILLED
37.0'; 4" HEALED, IRREGULAR FRACTURE
39.5'-40.5'; 10" VERTICAL OPEN FRACTURE WITH PYRITE, CALCOPYRITE AND GREEN CLAY; ROUNDED IRON OXIDE INCLUSIONS TO 1cm
39.5'-41.0'; BROKEN, HIGHLY WEATHERED ZONE
41.0'-43.0'; GREEN CLAY; 45° CONTACT WITH OVERLYING LIMESTONE; 45° FRACTURES THROUGHOUT; MINOR SLICKENSLIDING
GRADING TO GRAY; IRON OXIDE INCLUSIONS UPPER 3"; PINHOLE VUGS THROUGHOUT
46.5'-47.5'; 1' ZONE VERTICAL TO HORIZONTAL FRACTURES, WITH 10"-12" VERTICAL GREEN CLAY FILLED FRACTURE
48.5'-53.0'; GRADING MORE COARSE AND FOSSILIFEROUS; MORE PITTED; IRREGULAR BREAKS ALONG BEDDING PLANES, WITH GREEN CLAY FROM .1"-.5" THICK. PYRITE CONCENTRATIONS UP TO .5cm DIAMETER.

SCALES FORMATION
SILTSTONE; GREENISH-GRAY; SHALEY; THIN BEDDED; CONTACT MARKED BY 3" LAYER GREEN SILTY CLAY WITH ROUNDED PYRITIC LIMESTONE PEBBLES.
SHALE; GRAY TO DARK GRAY; VERY SILTY; THIN TO MEDIUM BEDDING; WITH FEW LIMESTONE AND/OR FOSSIL FRAGMENTS AND LENSES; VERY SLIGHTLY CALCAREOUS UPPER 1'. FOSSIL FRAGMENTS AND PYRITE TO 57.0'.

57.2'; 45° FRACTURES

61.5'; 45° FRACTURES; SLIGHT SLICKENSLIDES

BORING COMPLETED AT 63.0 FEET ON 8/24/74.
CASING USED TO A DEPTH OF 4.0 FEET.
HOLE DRY UPON COMPLETION.

KEY TO SAMPLES:

INDICATES THE NUMBER OF BLOWS REQUIRED TO DRIVE A DAMES & MOORE TYPE U SAMPLER 1 FOOT WITH A 340 POUND HAMMER FALLING 24 INCHES

28 INDICATES DEPTH OF UNDISTURBED SAMPLE OBTAINED WITH DAMES & MOORE TYPE U SAMPLER (3.25" O.D. 2.42" I.D. SPLIT SPOON SAMPLER)

INDICATES DEPTH OF DISTURBED SAMPLE OBTAINED WITH DAMES & MOORE TYPE U SAMPLER

INDICATES DEPTH AND LENGTH OF CORE RUN RECOVERED FOR NX DIAMOND ROCK CORING

100 INDICATES PERCENT OF CORE RUN RECOVERED

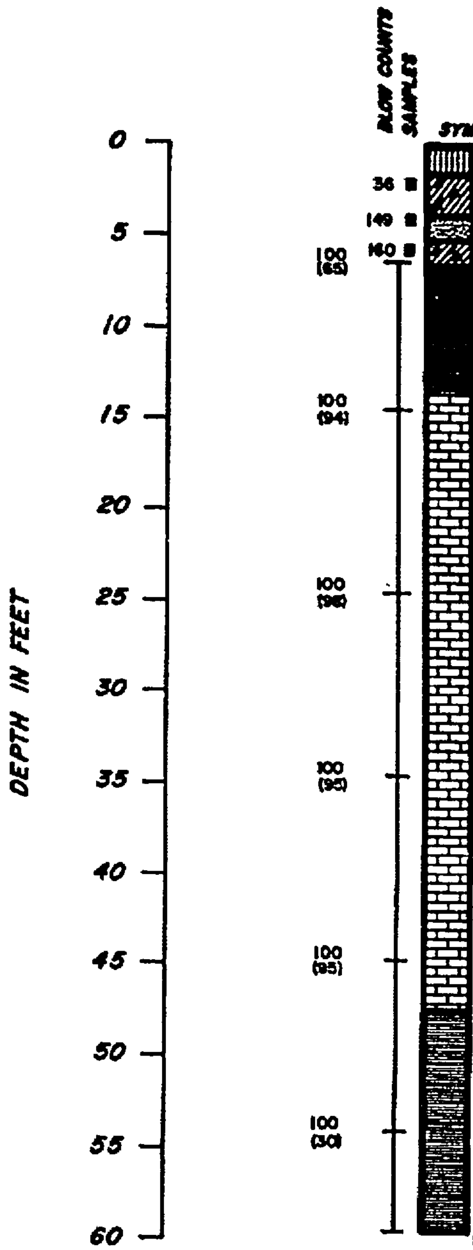
INDICATES PERCENT RQD FOR NX DIAMOND DRILL ROCK CORING

LOG OF BORINGS

DAMES & MOORE

BORING A-2

SURFACE ELEVATION 531.7



DESCRIPTIONS

BLACK SILT WITH TRACE ROOTS; CLAY; FINE SAND - MIXED TOPSOIL AND FILL

MOTTLED BROWN AND GRAY CLAYEY GRAVEL; TRACE SAND (DENSE; TILL

SANDSTONE; GRAY TO LIGHT GRAY; FINE-MEDIUM GRAINED; THIN BEDDED; MODERATE TO WELL CEMENTED; FRESH TO SLIGHTLY WEATHERED; OCCASIONAL BLACK SHALE OR CARBON LAMINATIONS.

MOTTLED BROWN AND GRAY CLAYEY GRAVEL· TRACE SAND (VERY DENSE) TILL

FORT ATKINSON FORMATION

INTERBEDDED SHALE AND LIMESTONE; SHALE: GRAY TO DARK GRAY; SILTY; DENSE; THIN BEDDING; LIMESTONE; FINE CRYSTALLINE; THIN TO MEDIUM BEDDING; SLIGHTLY TO MODERATELY WEATHERED; LIMESTONE IN 1"-4" LAYERS, LENSES AND STRINGERS. BREAKS ALONG VERY IRREGULAR SHALE BEDDING PLANES, AND CONTACTS WITH BROKEN FOSSIL FRAGMENTS; 50% BROKEN FOSSIL PIECES.

6.5'-11.5': MODERATE TO HIGHLY WEATHERED; INTERBEDDED BROWN SILTY CLAY AND REDDISH-GRAY LIMESTONE; SUB HORIZONTAL TO 45° BREAKS

10.5'-11.5': 45° FRACTURES, CLOSED AND BROWN CLAY FILLED

LIMESTONE: GRAY TO PALE YELLOW; FINE TO MEDIUM CRYSTALLINE; MASSIVE; FRESH TO SLIGHTLY WEATHERED; FOSSILIFEROUS; GREEN CLAY AND PYRITE VEIN, STYOLITE AND BEDDING PLANE FILLINGS.

13.7': YELLOWISH-GREEN CLAY LAYER WITH SMALL ROUNDED LIMESTONE PEBBLES

GRADING LIGHT GRAY TO WHITE; FINE TO COARSE CRYSTALLINE; MASSIVE; PYRITE INCLUSIONS AND VEINLETS; ROCK FRACTURES ALONG STYOLITES; OCCASIONAL DARK GRAY BANDING

15.0': 6" BROKEN ZONE BOUNDED BY 45° ANGLES WITH 2" GREEN CLAY LAYER

16.5': CLOSED, NEAR VERTICAL FRACTURE

26.3': IRREGULAR 45° FRACTURE WITH YELLOWISH-BROWN SILTY CLAY

28.0': 3" IRREGULAR 45° FRACTURED ZONE WITH GRAY CLAYEY SILT AND PYRITE; BROKEN ZONE

29.0': 6" HEALED FRACTURE AND STYOLITIC ZONE; INTERSECTING IRREGULAR FRACTURES AND STYOLITES

29.0'-30.8': VERTICAL AND HIGH ANGLE ZONE OF FRACTURES AND JOINTS, FILLED WITH GREEN CLAY AND SILT

31.6': 2" IRREGULAR SUB-HORIZONTAL FRACTURES WITH GREEN CLAY

32.5': GRADES TO PITTED, DARKER GRAYISH-BROWN LIMESTONE, WITH REDDISH-BROWN BANDING AND ELONGATED VUGS TO 5mm; GREEN CLAY CONCENTRATION IN VUGS

33.0': 45° FRACTURE HEALED WITH PYRITE

50% PINHOLE TO 10mm VUGS; 10-20% CLAY LAMINATIONS

37.1': IRREGULAR SUB HORIZONTAL FRACTURE WITH GREENISH-GRAY CLAY

38.0'-40.0': INTERSECTING VERTICAL TO SUB-HORIZONTAL FRACTURES, CLOSED TO GREEN CLAY FILLED

38.1': 1" BROKEN GREENISH-YELLOW CLAY LAYER

40.0', 41.5', 43.5': 45° FRACTURES

BOTTOM 1.0': 50-60% GREEN SHALE STRINGERS AND LENSES

SCALES FORMATION

SHALE; GRAY TO DARK GRAY; SILTY; THIN BEDDED TO DENSE; WITH LIMESTONE, FOSSIL FRAGMENTS AND PYRITE STRINGERS IN UPPER 2.0'; MODERATE TO HIGHLY WEATHERED

50.3'-53.5': 45° SLICKENSLIDE FRACTURES THROUGHOUT

55.3'-56.5': 45° SLICKENSLIDE FRACTURES THROUGHOUT

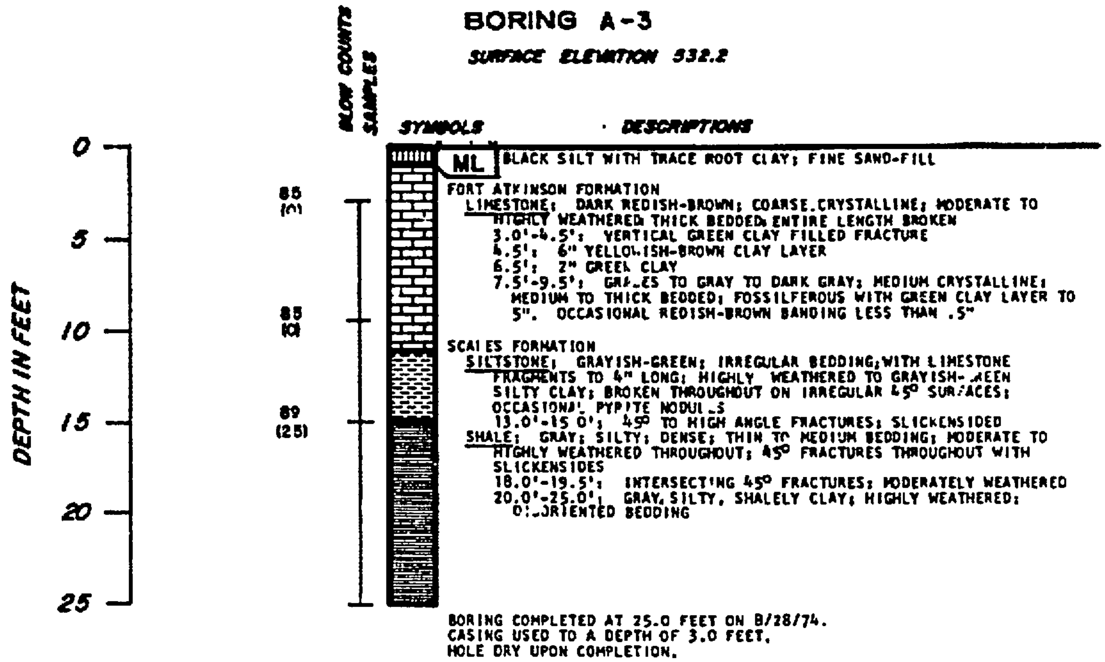
57.5'-58.5': 45° SLICKENSLIDE FRACTURES THROUGHOUT

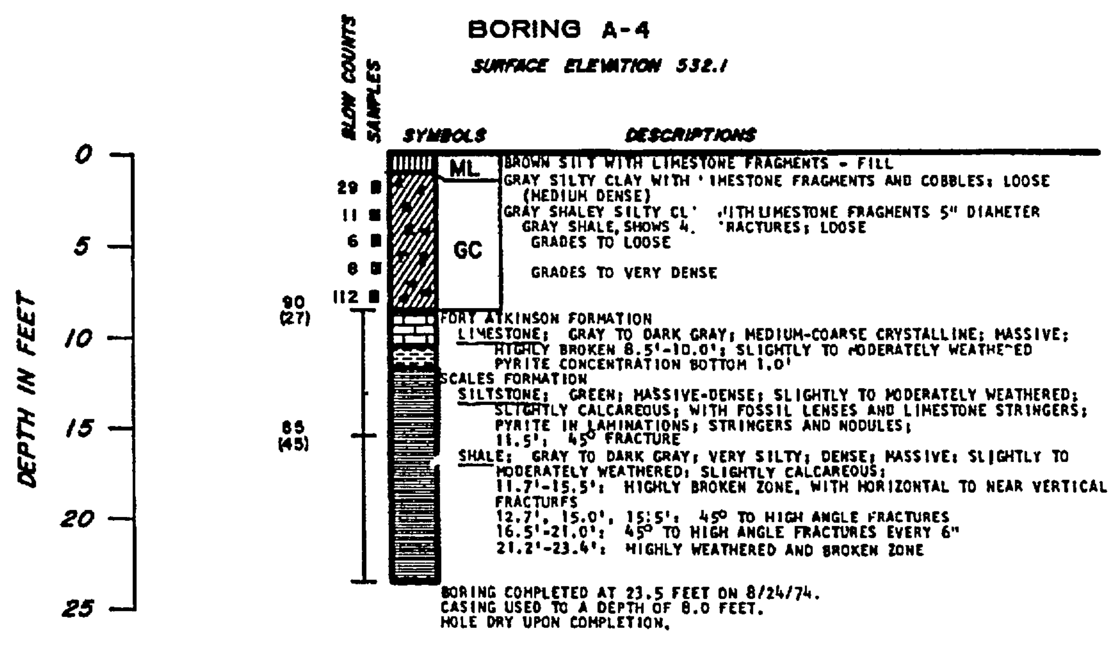
ENTIRE LOWER 5' MODERATED TO EXTREMELY WEATHERED

58.5'-59.5': SLICKENSLIDES

BORING COMPLETED AT 59.5 FEET ON 8/28/74.
CASING USED TO A DEPTH OF 6.5 FEET.
HOLE DRY UPON COMPLETION.

LOG OF BORINGS





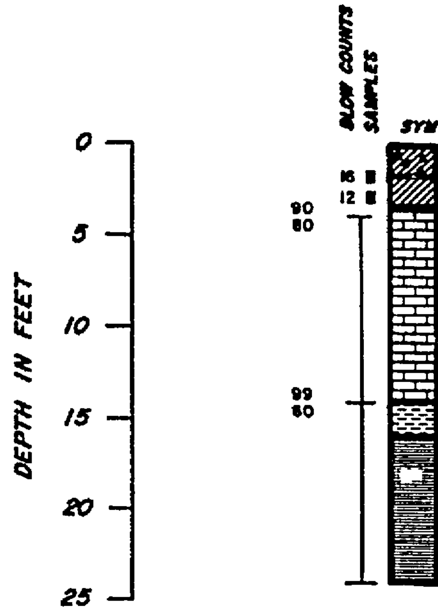
LOG OF BORINGS

DAMES & MOORE

FIGURE 3

BORING A-5

SURFACE ELEVATION 532.4



DESCRIPTIONS

GRAVEL FILL; GRAY TO BLACK CLAYEY GRAVEL WITH TRACE SAND, LIMESTONE PEBBLES, AND COBBLES; FILL

DARK BROWNISH-BLACK SILTY CLAY WITH TRACE ROOTS (VERY STIFF)
2.3'-3.4': GRADES TO MOTTLED BROWN, GRAYISH-GREEN CLAY; SILTY; VERY STIFF TO HARD; OCCASIONAL RED SAND PORTIONS AND TRACE SMALL PEBBLES.

FURT ATKINSON FORMATION

LIMESTONE; RED TO DARK RED; COARSE CRYSTALLINE; THICK BEDDED TO MASSIVE; MODERATELY WEATHERED; ROCK FRACTURES ON HORIZONTAL TO LOW ANGLE PLANES; PINHOLE VUGS THROUGHOUT, BROKEN FOSSIL PARTICLES; OCCASIONAL PYRITE NODULE; GREEN TO YELLOW SILTY CLAY SEAMS EVERY 4"-5" BROKEN ON SEAMS
4.3': 3" 45° FRACTURE
7.5': GRADES TO GRAY; SLIGHLTY WEATHERED LIMESTONE WITH GREEN CLAY ALONG BEDDING PLANES; 2" BANDS WEATHERED RED LIMESTONE WITH GREEN AND YELLOWISH-BROWN CLAY
11.0'-14.0': PYRITE VEINLETS AND NODULES

SCALES FORMATION

SILTSTONE; GREENISH-GRAY; THICK BEDDED; SLIGHTLY WEATHERED; 6" GREEN CLAY LAYER AT TOP; MODERATELY CALCAREOUS; OCCASIONAL PYRITE NODULE, AND LIMESTONE OR FOSSIL FRAGMENTS

SHALE; GRAY TO DARK GRAY; VERY SILTY; DENSE; THIN TO THICK BEDDING; SLIGHTLY TO MODERATELY WEATHERED; OCCASIONAL FOSSIL FRAGMENTS TOP 2'-3'; ROCK BREAKS ON HORIZONTAL TO LOW ANGLE PLANES;
16.0': 7" BROKEN ZONE WITH NEAR VERTICAL FRACTURE
17.5': 5" HIGH ANGLE FRACTURE
19.0'-22.0': 30°-45° FRACTURES

BORING COMPLETED AT 4.0 FEET ON 8/23/74.
CASING USED TO A DEPTH OF 4.0 FEET.
HOLE DRY UPON COMPLETION.

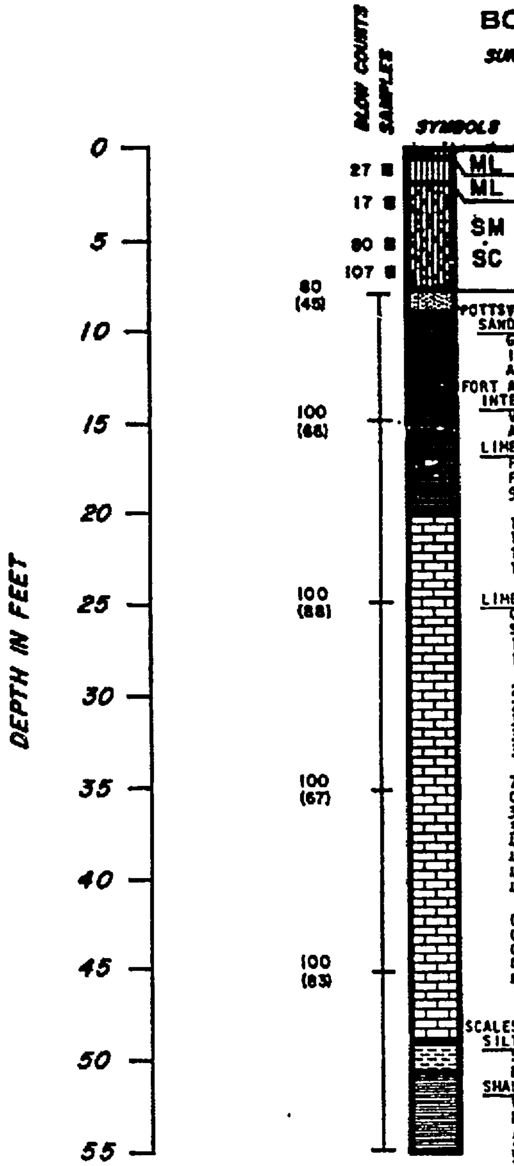
LOG OF BORINGS

DAMES & MOORE

FIGURE 4

BORING A-6

SURFACE ELEVATION 531.8



DESCRIPTIONS

BROWN SILT WITH TRACE SAND AND CLAY; ROOT-TOPSOIL FILL

BLACK SILT WITH ROOTS; TRACE SAND AND GRAVEL-OLD TOPSOIL

MOTTLED BROWNISH-YELLOW SILTY, CLAYEY, GRAY SAND; WEATHERED; MICACEOUS; (MEDIUM DENSE) BANDED; LOOSE SANDSTONE. IRON OXIDE STAINING TO 1cm. BECOMING MOIST; OCCASIONAL .5" ROUNDED PEBBLES; VERY MICACEOUS; ORGANIC MATERIAL ALONG BEDDING PLANES UP TO 1mm THICK. TILL

GRADES TO VERY DENSE; GRADING MORE YELLOW; INCREASED MANGANESE OXIDE STAINING

POTTSVILLE FORMATION

SANDSTONE; BANDED BROWNISH-YELLOW AND LIGHT GRAY; FINE TO MEDIUM GRAINED; THIN BEDDED; SLIGHTLY TO MODERATE WEATHERED; MICACEOUS; IRON STAINING AND CARBON LAMINATIONS; BREAKS ALONG HORIZONATAL AND SUB HORIZONTAL BEDDING PLANES

FORT ATKINSON FORMATION

INTERBEDDED SHALE AND LIMESTONE; SHALE; LIGHT TO DARK GRAY; SILTY; VARIES TO DARK GRAY, SILTY SHALE WITH SOME 75% LIMESTONE FRAGMENTS AND BLOCKS AND FOSSILS;

LIMESTONE; MEDIUM GRAY-DARK GRAY; MEDIUM TO COARSE CRYSTALLINE FOSSILIFEROUS; FRACTURES ALONG IRREGULAR PLANES AND BROKEN FOSSIL PIECES

9.0'-9.7': BROKEN ZONE WITH IRREGULAR, SUB-HORIZONTAL, GRAY CLAY FILLED FRACTURES
10.5'-12.0': 45° FRACTURES
12.2': 2" CLAY LAYER WITH LIMESTONE FRAGMENTS
14.5': 4"-5" GRAYISH-GREEN CLAY LAYER
15 0'-16.2': DARK GRAY LIMESTONE LAYER WITH VERTICAL CALCITE FILLED JOINT AND 45° BREAKS

LIMESTONE: WHITE TO LIGHT GRAY; FINE-COARSE CRYSTALLINE WITH GREEN CLAY SEAMS AND VEINLETS; OCCASIONAL GREEN CLAY AND PYRITE FILLED STYOLITES

15.6',17.3',18.3',19.0',22.8': 45° OR HIGHER ANGLE FRACTURE
19.9',20.3',21.0',23.1': GREEN SILTY CLAY LAYERS
GRADING MORE WHITE WITH IRREGULAR VERY LIGHT GREEN BANDING
28.0'- 45° OR HIGHER ANGLE FRACTURE
29.0': 8"-10" 45° OR HIGHER ANGLE FRACTURES
33.0': 1" BROKEN ZONE
33.7': GRADES TO GRAY SPECKLED; PITTED; VUGS TO 5mm
34.5': 8"-10" 45° OR HIGHER ANGLE FRACTURE

75% VUGS; PINHOLE TO .5" DIAMETER; GRADING DARK GRAY; PYRITE CONCENTRATIONS IN PITS AND VUGS
35.8': 7" NEAR VERTICAL FRACTURE
37.4': 30°-45° FRACTURES, HEALED WITH GREEN CLAY
40.0': 13" NEAR VERTICAL FRACTURE
42.5': .5" GREEN CLAY LAYER
42.8': 30°-45° FRACTURES
44.5': 30°-45° FRACTURES

GRAY WITH GREEN CLAY LAMINATIONS; LENSES; POCKETS CALCITE CRYSTALS, GREEN CLAY, PYRITE IN VUGS UP TO .5"; GREEN CLAY LAMINATIONS AND VEIN FILLING
45.5',46 0',46.2',46.9',48.5': 30°-45° FRACTURES
49.2': 4" GREEN CLAY ZONE

SCALES FORMATION

SILTSTONE; GREEN; THIN TO MEDIUM BEDDING WITH LIMESTONE AND FOSSIL STRINGERS AND FRAGMENTS; 2" GREEN CLAY AT TOP; SLIGHTLY CALCAREOUS BOTTOM 4" BROKEN; VERTICAL TO SUB HORIZONTAL

SHALE; GRAY TO DARK GRAY; SILTY; THIN TO THICK BEDDED; DENSE; VERY SLIGHTLY CALCAREOUS; UPPER 1.5' 10% LIMESTONE OR FOSSIL FRAGMENTS
50.1',50.5',51.0',51.6',51.9',52.3': 45° LOW ANGLE FRACTURES; 50.5'-51.0' BROKEN ZONE

BORING COMPLETED AT 54.8 FEET ON 8/26/74.
CASING USED TO A DEPTH OF 8.0 FEET.
HOLE DRY UPON COMPLETION.

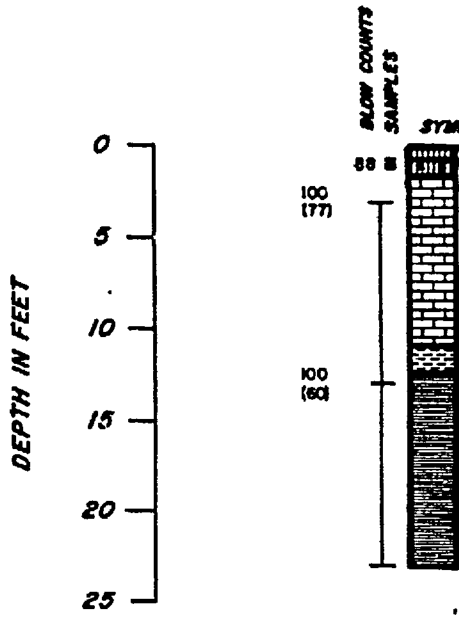
LOG OF BORINGS

DAMES & MOORE

FIGURE 5

BORING A-7

SURFACE ELEVATION 531.2



DESCRIPTIONS

6"-8" TOPSOIL; DARK BROWNISH-BLACK CLAYEY SILT WITH ROOTS

REDDISH-BROWN SILTY SANDY GRAVEL; WEATHERED LIMESTONE; LIMESTONE FRAGMENTS, (VERY DENSE, EASILY BROKEN TO ROCK FLOUR)

FORT ATKINSON FORMATION

LIMESTONE; RED TO DARK RED; COARSE CRYSTALLINE; MEDIUM TO THICK BEDDING; MODERATE TO HIGHLY WEATHERED LIMESTONE;
- 3.0'-8.0'; CALCITE AND GREEN CLAY FILLED VERTICAL VEINS; SILTY GREENISH-YELLOW CLAY IN LAMINATIONS AND UP TO 1" LAYERS; 50%-75% BROKEN FOSSIL PIECES; BREAKS ON SUB-HORIZONTAL PLANES
- 8.0': GRADES TO GRAY, FOSSILIFEROUS LIMESTONE WITH GREEN CLAY SEAMS AND JOINT FILLING.

SCALES FORMATION

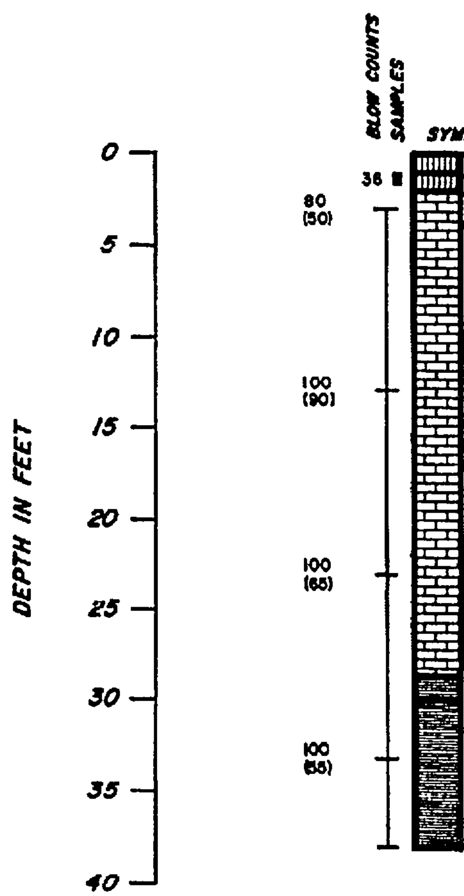
SILTSTONE; GRAYISH-GREEN; THIN BEDDED; MODERATELY WEATHERED .5" GRAYISH-GREEN CLAY LAYERS; OCCASIONAL CONCENTRATION OF FOSSIL FRAGMENTS AND PYRITE; VERY SLIGHTLY CALCAREOUS; 6" GREEN CLAY LAYER AT CONTACT

SHALE; GRAY TO DARK GRAY; SILTY; THIN TO MEDIUM BEDDING; FRESH; BROKEN ON HORIZONTAL BEDDING PLANES AND VERTICAL FRACTURES
- 15.2': 45° FRACTURE
- 17.5': 8" VERTICAL FRACTURE
- 19.0'-23.0'; GRADING MORE FISSILE; HIGHLY BROKEN ; BREAKS IN SUB-HORIZONTAL TO SUB-VERTICAL PLANES.
- 19.5': 6" NEAR VERTICAL FRACTURE
- 20.0': 3" CLAY LAYER; SHOWING MINOR SLICKENSIDES
- 22.0': 3" CLAY LAYER; SHOWING MINOR SLICKENSIDES; WITH SHALE

BORING COMPLETED AT 23.0 FEET ON 8/27/74.
CASING USED TO A DEPTH OF 3.0 FEET.
HOLE DRY UPON COMPLETION.

BORING A-8

SURFACE ELEVATION 531.9



DESCRIPTIONS

8"-1.0' TOPSOIL; DARK BROWNISH-BLACK SILT WITH TRACE ROOTS

LIGHT YELLOW-BROWN SILT WITH TRACE ROOTS; OCCASIONAL LIMESTONE AND SILTSTONE FRAGMENTS; SLIGHTLY TO MODERATELY CEMENTED; EASILY BROKEN TO ROCK FLOUR

FORT ATKINSON FORMATION

LIMESTONE; GRAY TO DARK GRAY; FINE TO COARSE CRYSTALLINE; MASSIVE, TO THICK BEDDED; MODERATE TO HIGHLY WEATHERED. BANDED RED ALONG WEATHERED BEDDING PLANE FRACTURES; FOSSILIFEROUS; STYOLITIC; GRAY AND GREEN CLAY IN STYOLITES AND SUB-HORIZONTAL BEDDING PLANES OR FRACTURES
- 3.0'-6.0'; MODERATE TO HIGHLY WEATHERED AND BROKEN; BROWNISH-YELLOW CLAY AND LIMESTONE FRAGMENTS. APPROXIMATELY 3.5"-4.0" MISSING FROM CORE
- 3.1', 5.8', 6.8', 7 3', 9 0', 9.5'-10.0', 11.0', 12.6'; IRREGULAR 45° FRACTURES
- 6.0'-7.0'; BROKEN ZONE, HIGHLY WEATHERED RED LIMESTONE AND YELLOWISH-BROWN SILTY CLAY
- 11.0'-12.0'; BROKEN ZONE, HIGHLY WEATHERED RED LIMESTONE AND YELLOWISH-BROWN SILTY CLAY
- 12.0'; 3" GREEN AND BROWN CLAY LAYER
  GRADING LIGHT GRAY; FRESH TO SLIGHTLY WEATHERED
- 13.0'-14.5'; INTERSECTING VERTICAL TO HORIZONTAL FRACTURES, FILLED WITH GREEN AND GRAY CLAY; REDDISH-BROWN BANDING ALONG FRACTURES
- 13.0'-15.0'; PITTED AND CHARACTERIZED BY 6" LONG HIGH ANGLE FRACTURES, WITH GREEN CLAY AND PYRITE FILLING IN VUGS AND FRACTURES
- 14.5', 15 0', 15 7'-16.0', 17.1', 20.3', 22.4'; IRREGULAR 45° FRACTURES, GREEN CLAY AND IRON OXIDE LINED.
- 25.5'; GRADING MORE FRACTURED; INTERSECTING HIGH ANGLE TO HORIZONTAL FRACTURES, FILLED WITH GREEN CLAY, CALCITE AND PYRITE
- 26 7'-27.7'; CLEAR-WHITE, VERY COARSE CRYSTALLINE LAYER IN CONTACT WITH MATRIX AT HIGH ANGLE; INTERSECTING HIGH ANGLE, AND PYRITE HEALED FRACTURES. (FAULT?)
- 27.6'-28.6'; HIGH CONCENTRATION OF PYRITE
- 28.6'; 3" LAYER GREEN CLAY IN CONTACT WITH SILTY SHALE BELOW

SCALES FORMATION

SHALE; GREENISH-GRAY; VERY SILTY; THIN BEDDED; SLIGHTLY WEATHERED.
- 29.0'-30.0'; CALCITE AND/OR FOSSIL FRAGMENTS AND PYRITE ALONG BEDDING PLANES

SHALE; GRAY TO DARK GRAY; SILTY; THIN TO MEDIUM BEDDED
- 30.8'-31.7'; 45° FRACTURES WITH SLICKENSLIDES
- 33.0'-34.0'; HIGHLY BROKEN WITH 45° SLICKENSLIDES
- 34.0'-38.0'; FISSILE, SLIGHTLY WEATHERED; MODERATELY CEMENTED; CHARACTERIZED BY 45° BREAKS EVERY 3"-8". OCCASIONAL GREEN CLAY SEAMS.

BORING COMPLETED AT 38 0 FEET ON 8/29/74.
CASING USED TO A DEPTH OF 3.0 FEET.
HOLE DRY UPON COMPLETION.

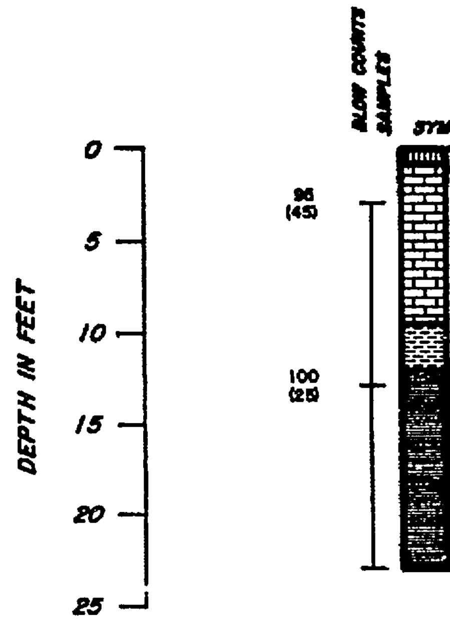
LOG OF BORINGS

DAMES & MOORE

FIGURE 6

BORING A-9

SURFACE ELEVATION 532.1



DESCRIPTIONS

RED SILT WITH FRAGMENTS, TRACE OF ROOTS. (CLAY LOOSE)

FORT ATKINSON FORMATION

LIMESTONE: REDDISH-BROWN; COARSE CRYSTALLINE; THICK-MEDIUM BEDDING; MODERATE TO HIGHLY WEATHERED. GRADES AT 6.0' TO GRAY; FOSSILIFEROUS; MODERATELY WEATHERED; BANDED WITH 1½-3" LAYERS OF RED LIMESTONE AND PALE YELLOW SILTY CLAY. VERTICAL CALCITE FILLED VEINS.

4'; 9" HIGH ANGLE VERTICAL FRACTURE AND BROKEN ZONE

6.5'-7.3': INTERSECTING VERTICAL-HORIZONTAL CALCITE FILLED FRACTURES; BROWN AND GREEN CLAY FILLED ALONG IRREGULAR BEDDING PLANES

8.6': 8" VERTICAL GREEN CLAY FILLED FRACTURE.

SCALES FORMATION

SILTSTONE: GRAYISH-GREEN; DENSE; MODERATELY-HIGHLY WEATHERED TO GREEN SILTY CLAY; VERY SLIGHTLY CALCAREOUS. OCCASIONAL 1" LIMESTONE FRAGMENT LAYER WITH PYRITE

SHALE: DARK GRAY-GRAY; SILTY; THIN-MEDIUM BEDDING; FRESH TO HIGHLY WEATHERED

12.0': CONTACT DARK GRAY-BLACK SHALE; SLIGHTLY WEATHERED; INTERSECTING VERTICAL-HORIZONTAL FRACTURES THROUGHOUT; NO SLICKENSIDES.

13.0'-23.0': MODERATE-HIGHLY WEATHERED (TO GREEN CLAY); BREAKS ALONG THIN BEDDING PLANES; AND 30°-45° ANGLES

14.0'-15.0': HIGHLY WEATHERED BROKEN ZONE, GRAY SILTY CLAY

19.0'; GRADING MORE DENSE;

21.7'; 3" PYRITE CONCENTRATION

BORING COMPLETED AT 23.0 FEET ON 8/29/74.
CASING USED TO A DEPTH OF 3.0 FEET.
HOLE DRY UPON COMPLETION.

LOG OF BORINGS

DAMES & MOORE

FIGURE 7

END