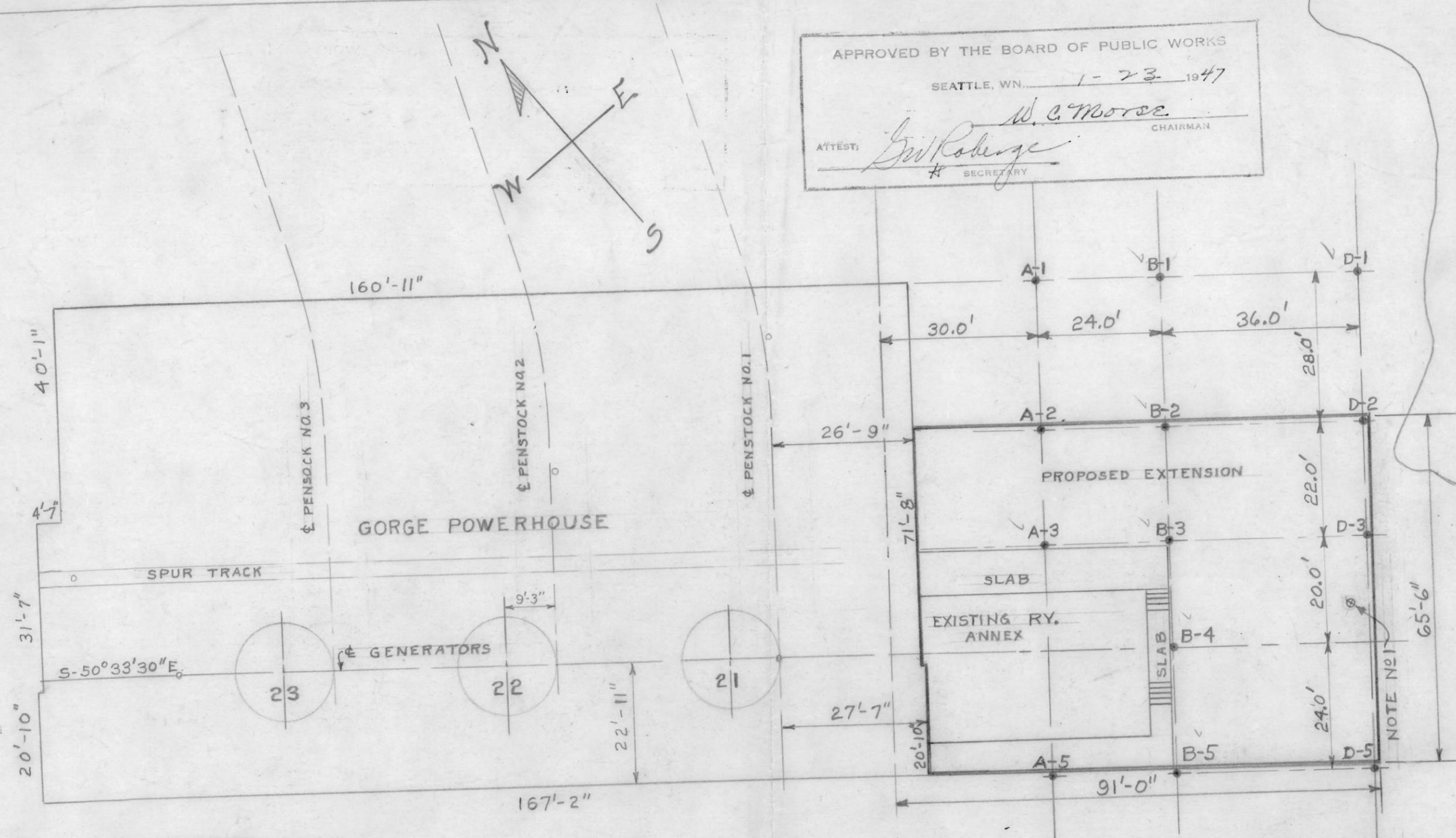


APPROVED BY THE BOARD OF PUBLIC WORKS
 SEATTLE, WN. 1-23-1947
 W. C. MORSE
 CHAIRMAN
 ATTEST: G. W. ROSENBERG
 SECRETARY



LADDER CREEK

NOTES:

1. APPROX. LOCATION OF HOLE NO 208 DRILLED IN AUG. AND SEPT. 1920
2. THE ORDER OF DRILLING HOLES IN THE FIELD WILL BE DETERMINED BY THE SUPERINTENDENT OF LIGHTING
3. THUS: A-2, A-3, B-1, ETC.

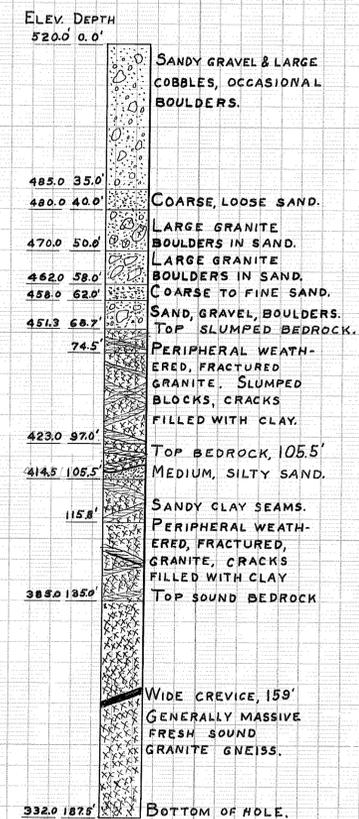
SCALE 1"=20'

GORGE PLANT EXTENSION		
DIAMOND DRILLING		
CITY OF SEATTLE LIGHTING DEPARTMENT E. R. HOFFMAN, SUPERINTENDENT		
ORD.	SUB. <i>W.S. - 2118</i>	DATE 11-21-46
DW. BY R.V.R.	REC.	B-2386
CH. BY C.M.L.	APP. <i>E.R. Hoffman</i>	

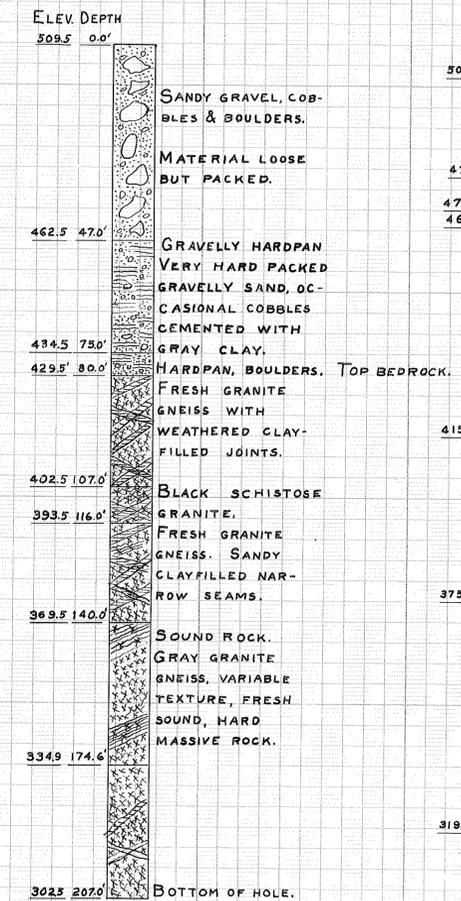
SERIAL NO. 11117

REVISIONS			
SUB. MARK	DESCRIPTION	DATE	APPROV.

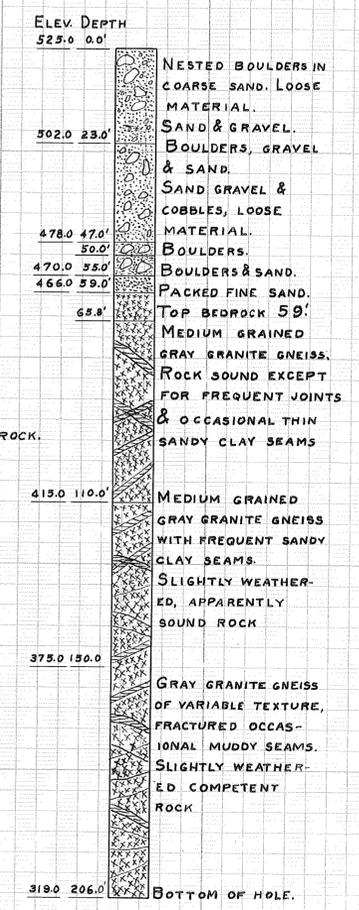
HOLE B-4



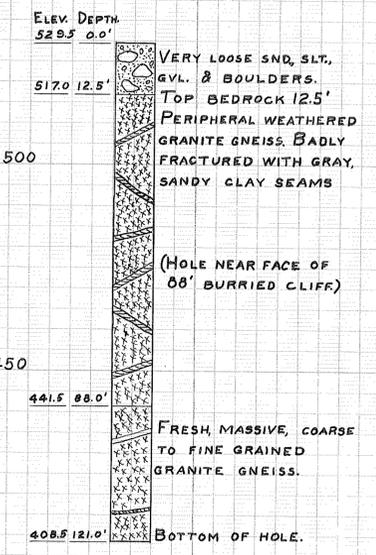
HOLE D-1



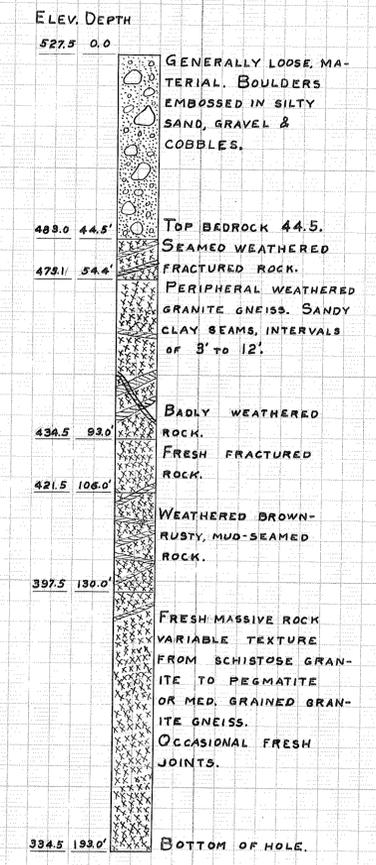
HOLE B-3



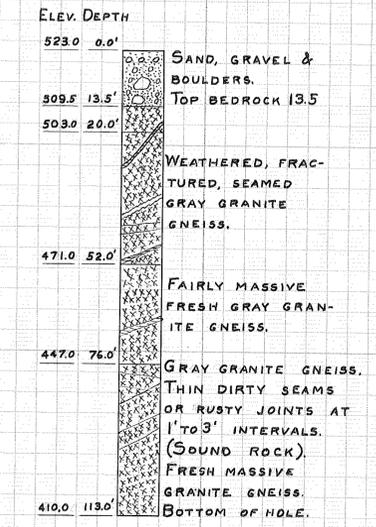
HOLE B-1



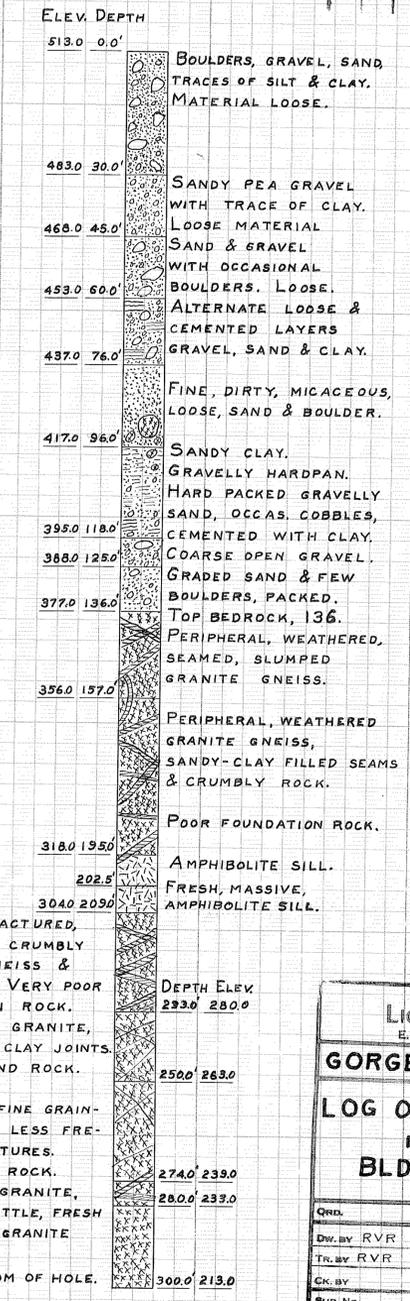
HOLE B-2



HOLE A-3



HOLE B-5



SEE PAGE 21-35
21-36
21-37
21-38
21-39
21-40
21-41
21-42
21-43
21-44
21-45
21-46
21-47
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21-95
21-96
21-97
21-98
21-99
21-100

DRAWING CONVERTED BY:
Vicki PIM, CIT, SARA
DATE: 4/13

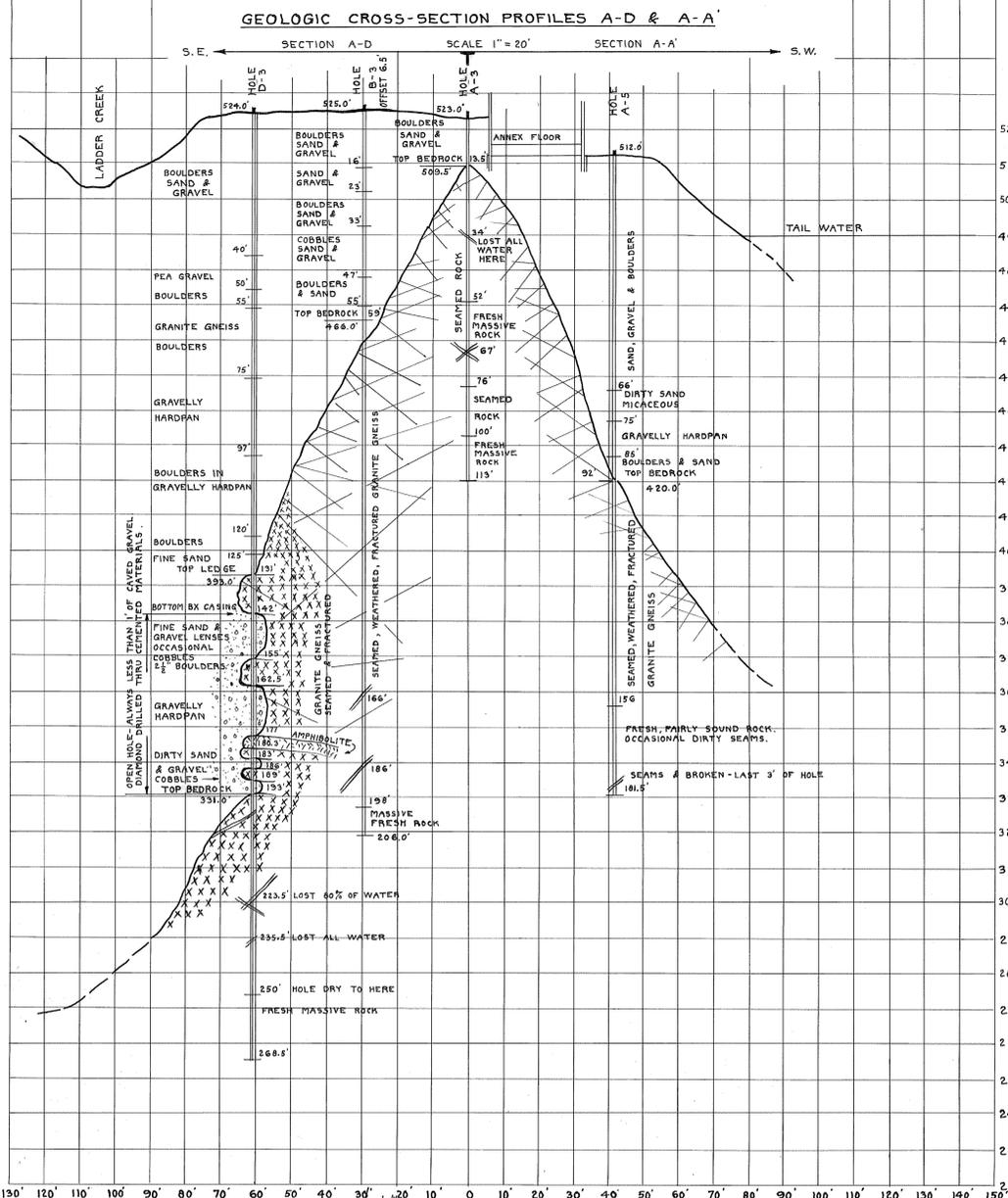
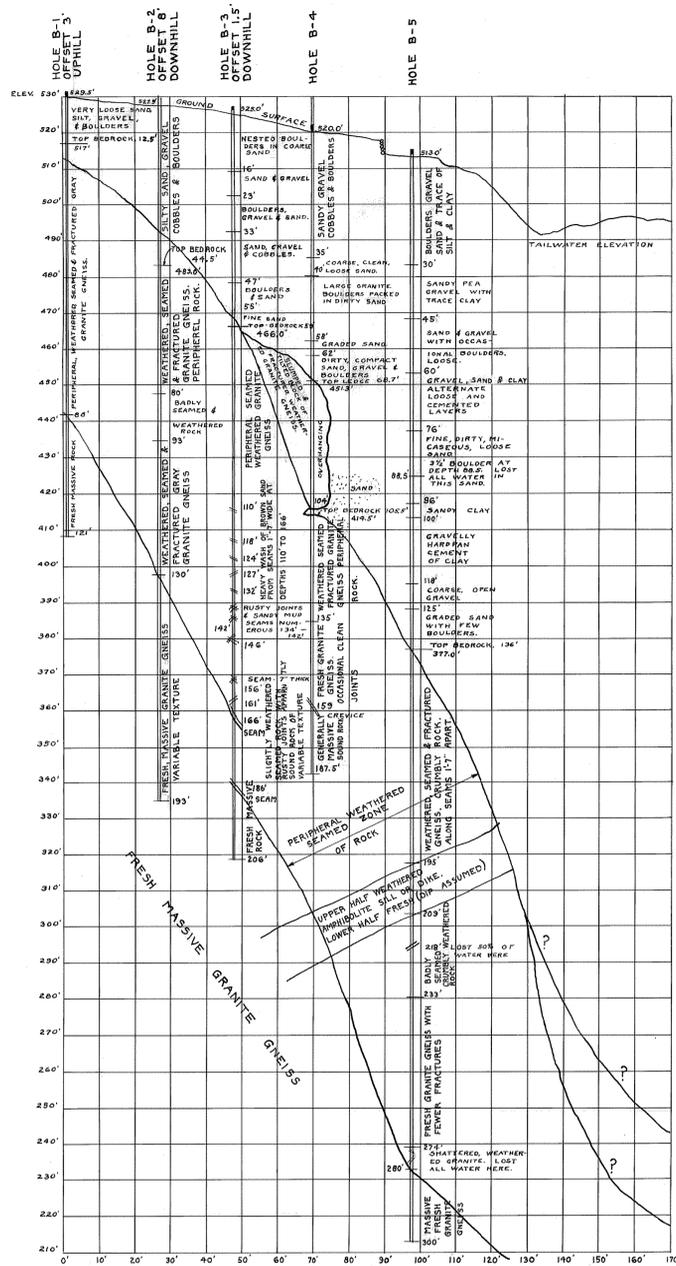
CITY OF SEATTLE
LIGHTING DEPARTMENT
E. R. HOFFMAN, SUPERINTENDENT

GORGE P.H. EXTENSION

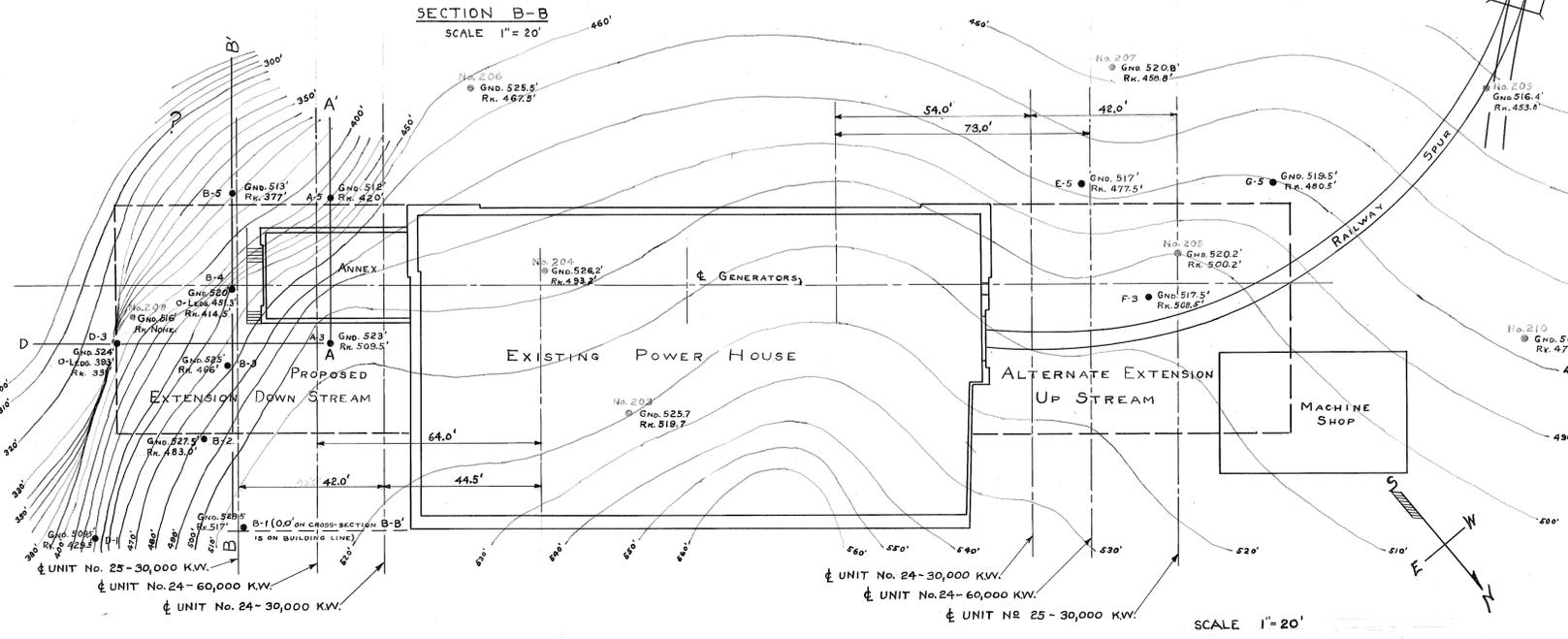
LOG OF DIAMOND DRILL HOLES FOR BLDG. EXTENSION

DRG.	WORK ORDER 11970-1	DATE 3-21-47
DW. BY RVR	SUBMITTED	
TR. BY RVR	RECOMMENDED	
CK. BY	APPROVED	SUPT.
SUB. NO.	DRAWING NO.	

D-14013-1



REVISIONS				
SUB	MARK	DESCRIPTION	DATE	AP'D



- NOTES-**
- SEE DRG. D-14017 FOR BED ROCK PROFILES AND POWERHOUSE CROSS SECTIONS FOR 30,000 AND 60,000 KW. UNITS.
 - SEE FIELD BOOK 71-D

DRAWING CONVERTED BY:
Vendor: PIM, CIT, SARA.
other: _____
Date: 3/97

SCALE 1" = 20 FT.

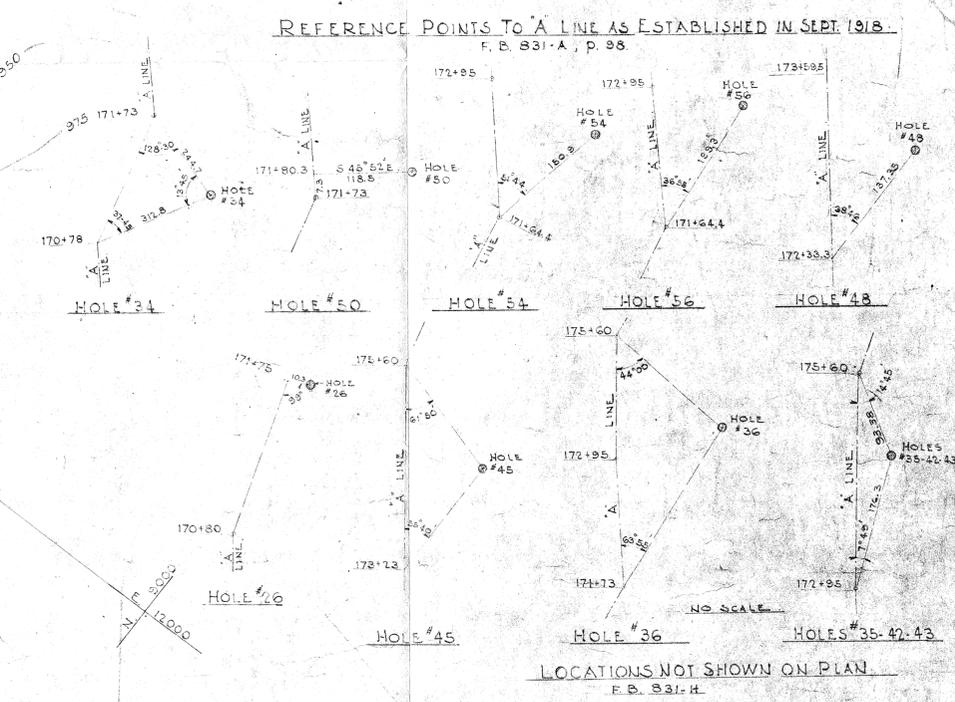
CITY OF SEATTLE
LIGHTING DEPARTMENT
E. R. HOFFMAN, SUPERINTENDENT

GORGE POWERHOUSE EXTENSION

DIAMOND DRILL HOLES - ROCK
CONTOUR MAP & CROSS
SECTIONS OF PROPOSED
BUILDING SITES

DRG.	WORK ORDER 11970-1	DATE 8-22-47
DW. BY A.W. SCHMIDT	SUBMITTED	<i>[Signature]</i>
TR. BY RVA - HCB	RECOMMENDED	<i>[Signature]</i>
CK. BY C.M.D.	APPROVED	<i>[Signature]</i>
SUB. NO.	DRAWING NO.	D-14016

SER. NO. 11344 MF



NOTE: ELEVATIONS FOR CONTOURS SHOWN TAKEN IN 1918.

INDEX FOR FIELD BOOK LOCATION

HOLE NUMBER	FIELD BOOK	PAGE	LOCATION
1	B-7	10	CO-ORD ONLY
2	B-7	10	B-7 A
3	B-7	10	B-7 B
4	B-7	10	B-7 C
5	B-7	10	B-7 D
6	B-7	10	B-7 E
7	B-7	10	B-7 F
8	B-7	10	B-7 G
9	B-7	10	B-7 H
10	B-7	10	B-7 I
11	B-7	10	B-7 J
12	B-7	10	B-7 K
13	B-7	10	B-7 L
14	B-7	10	B-7 M
15	B-7	10	B-7 N
16	B-7	10	B-7 O
17	B-7	10	B-7 P
18	B-7	10	B-7 Q
19	B-7	10	B-7 R
20	B-7	10	B-7 S
21	B-7	10	B-7 T
22	B-7	10	B-7 U
23	B-7	10	B-7 V
24	B-7	10	B-7 W
25	B-7	10	B-7 X
26	B-7	10	B-7 Y
27	B-7	10	B-7 Z
28	B-7	10	B-7 AA
29	B-7	10	B-7 AB
30	B-7	10	B-7 AC
31	B-7	10	B-7 AD
32	B-7	10	B-7 AE
33	B-7	10	B-7 AF
34	B-7	10	B-7 AG
35	B-7	10	B-7 AH
36	B-7	10	B-7 AI
37	B-7	10	B-7 AJ
38	B-7	10	B-7 AK
39	B-7	10	B-7 AL
40	B-7	10	B-7 AM
41	B-7	10	B-7 AN
42	B-7	10	B-7 AO
43	B-7	10	B-7 AP
44	B-7	10	B-7 AQ
45	B-7	10	B-7 AR
46	B-7	10	B-7 AS
47	B-7	10	B-7 AT
48	B-7	10	B-7 AU
49	B-7	10	B-7 AV
50	B-7	10	B-7 AW
51	B-7	10	B-7 AX
52	B-7	10	B-7 AY
53	B-7	10	B-7 AZ
54	B-7	10	B-7 BA
55	B-7	10	B-7 BB
56	B-7	10	B-7 BC

LOCATIONS NOT SHOWN ON PLAN
F. B. 831-K

HOLE NO.	CO-ORDINATE NORTH	CO-ORDINATE EAST
1	9784.3	11805.4
2	9786.5	11805.6
47	9698.1	11676.2
43	9663.4	11681.0
53	9568.0	11675.4
46	9400.5	11491.3

NOTE: EXISTING DRILL HOLES SHOWN THUS: PROPOSED DRILL HOLES SHOWN THUS:

REFERENCES

PLAN AND CONTOURS TRACED FROM ENLARGED ENG. DEPT. DWG. E-5, SHEET NS 3 FOR LOG OF EXISTING HOLES SEE ENG. DEPT. DWG. B-1 FOR CO-ORDINATE LOCATION, ELEV., ETC. SEE DWG. B-7 FOR LOCATION AND LOG OF 'X' HOLES. SEE WERNICKE FILE.

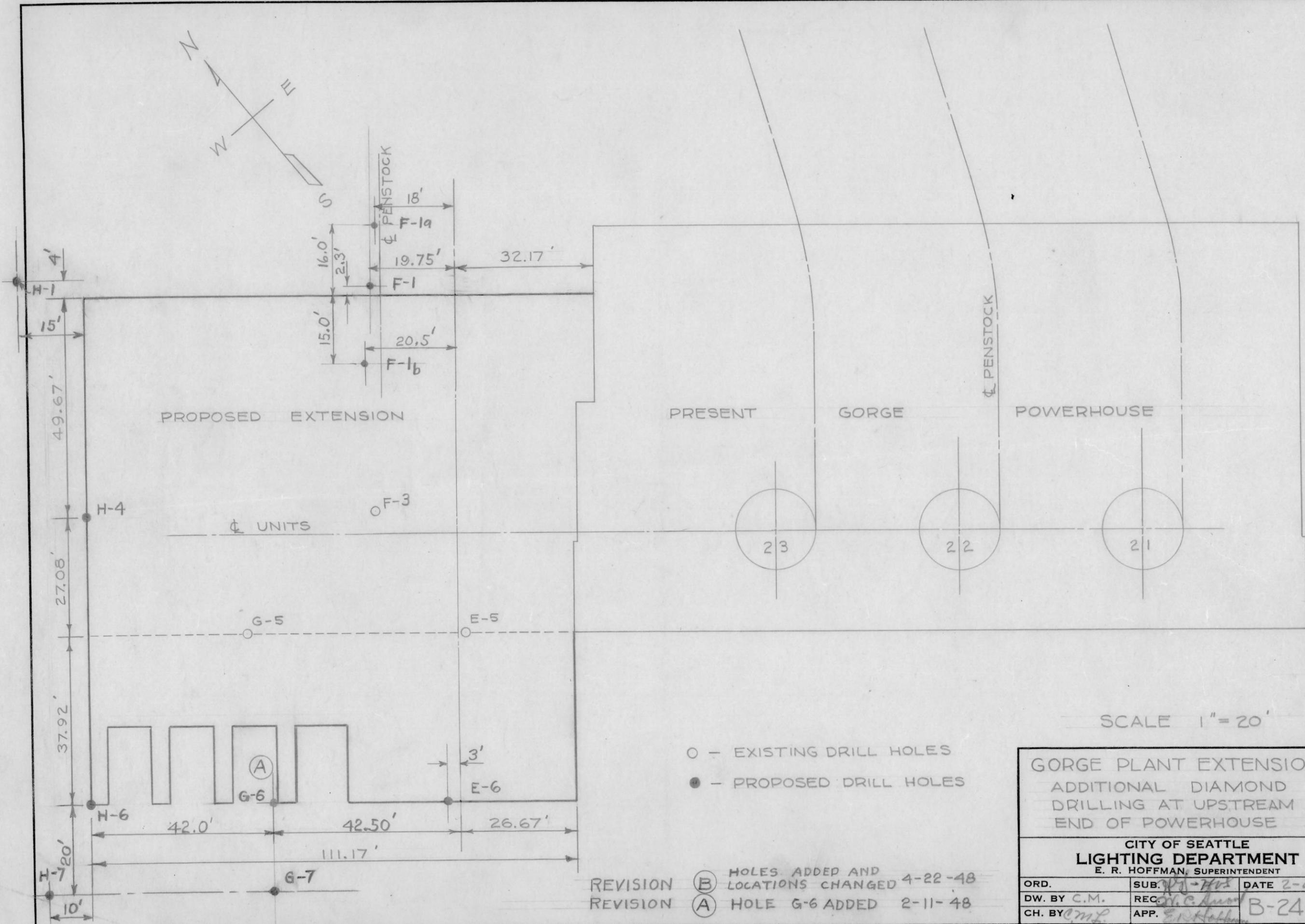
CITY OF SEATTLE—LIGHTING DEPARTMENT		
SKAGIT PROJECT—GORGE DEVELOPMENT		
GORGE DAMSITE		
LOCATION OF DIAMOND DRILL HOLES		
DATE: FEB. 11, 1918	DESIGNED BY: G. R. Schumacher	SCALE: 1" = 50'
BY: G. R. Schumacher	CHECKED BY: G. R. Schumacher	DATE: FEB. 11, 1918

NOTE: Bearings on 'A' Line are magnetic bearings

SCALE 1" = 50'-0"

No. 4844-1

D-11615



SCALE 1" = 20'

- - EXISTING DRILL HOLES
- - PROPOSED DRILL HOLES

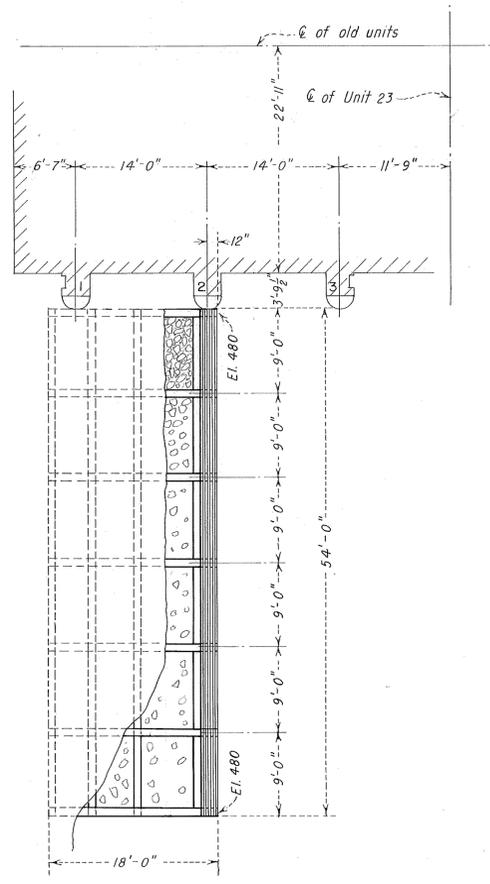
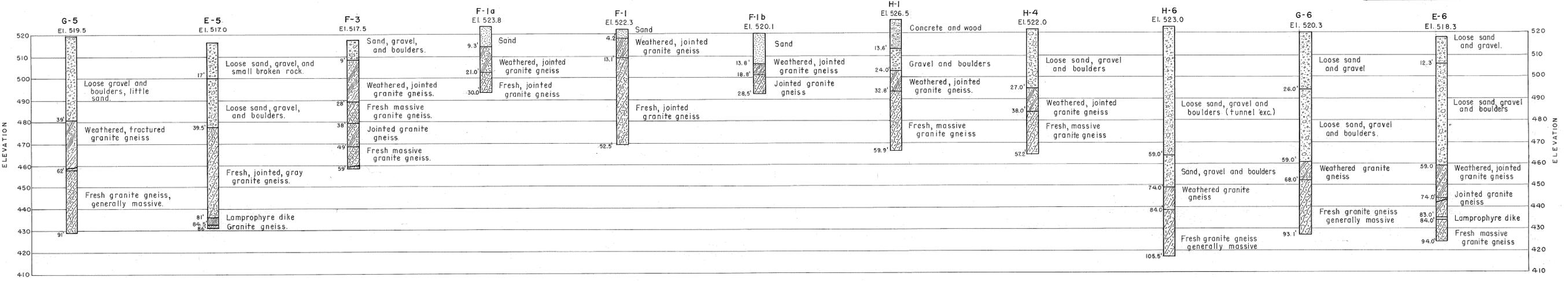
GORGE PLANT EXTENSION
 ADDITIONAL DIAMOND
 DRILLING AT UPSTREAM
 END OF POWERHOUSE

CITY OF SEATTLE
 LIGHTING DEPARTMENT
 E. R. HOFFMAN, SUPERINTENDENT

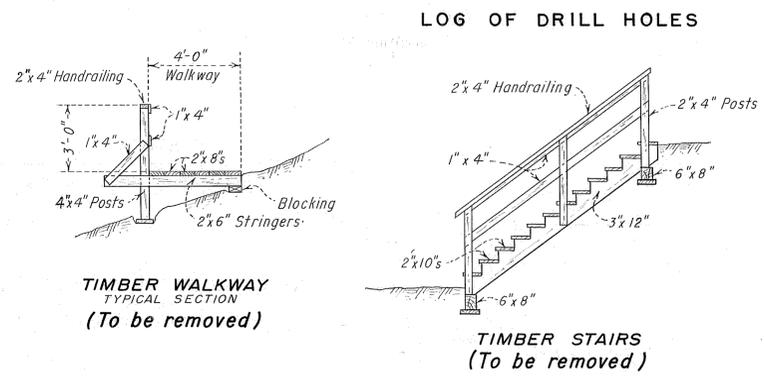
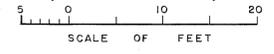
REVISION (B) HOLES ADDED AND LOCATIONS CHANGED 4-22-48
 REVISION (A) HOLE G-6 ADDED 2-11-48

ORD.	SUB. <i>10-11-48</i>	DATE 2-4-48
DW. BY C.M.	REC. <i>[Signature]</i>	B-2449
CH. BY <i>[Signature]</i>	APP. <i>[Signature]</i>	

REVISIONS					
MARK	MADE BY	CHK BY	DESCRIPTION	DATE	APP'D.
1	G.V.B.	W.H.W.	Rev. tunnel dia. - plate liner sect. and added penstock anchor excav.	8-21-48	<i>W.H.W.</i>
2	W.H.W.		Notes for final excavation.	9-2-48	<i>W.H.W.</i>

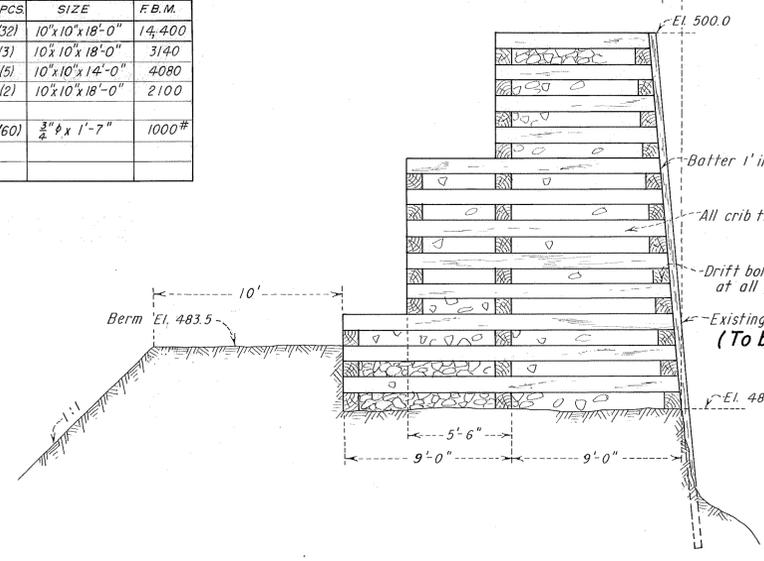


PLAN OF TIMBER CRIB AT NORTH END OF POWERHOUSE (1922 CONSTRUCTION) (To be removed)

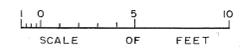


EXISTING TIMBER CRIB BILL OF MATERIAL

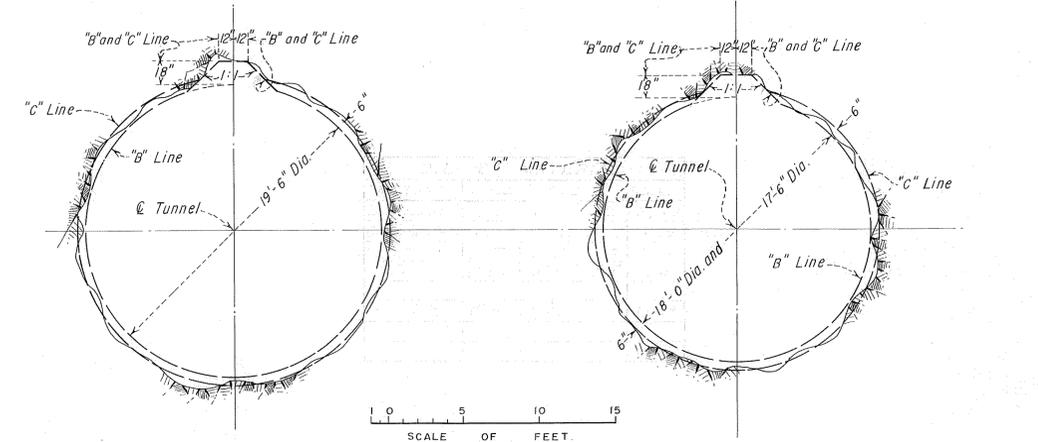
MATERIAL	NO. PCS.	SIZE	F.B.M.
Longitudinals	(3) (32)	10"x10"x18'-0"	14,400
Cross-members	(7) (3)	10"x10"x18'-0"	3140
Cross-members	(7) (5)	10"x10"x14'-0"	4080
Cross-members	(7) (2)	10"x10"x18'-0"	2100
Drift bolts	(7) (60)	3/4" φ x 1'-7"	1000#



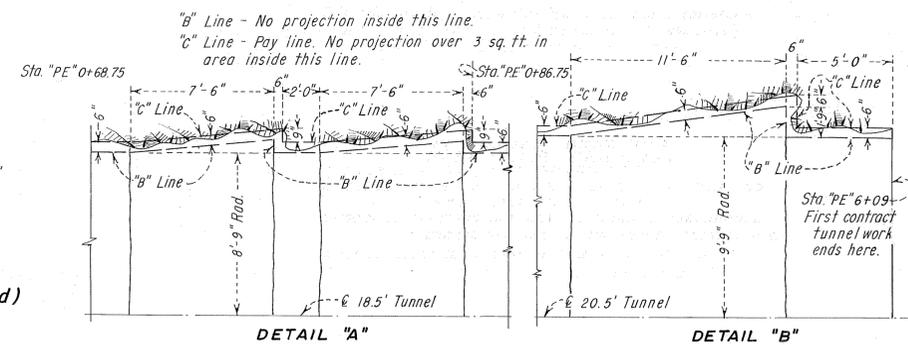
TYPICAL SECTION - CONSTANT THRUOUT
All cribs filled to El. 500.0



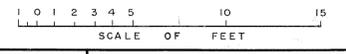
NOTE
This crib dam is to serve as a cofferdam during construction of Unit 24.



20'-6" DIA. PENSTOCK TUNNEL (REINFORCED SECTION)
19'-0" DIA. AND 18'-6" DIA. PENSTOCK TUNNELS (PLATE LINER SECTION)



DETAIL "A" DETAIL "B"
PLAN OF DETAILS FOR PENSTOCK ANCHOR EXCAVATION (Continuous about center of circular portion of tunnel)



- REFERENCE DRAWINGS**
- D-15003.....GENERAL PLAN AND PROFILE GORGE TUNNEL
 - D-15005.....PLAN SHOWING POWERHOUSE EXCAVATION AND APPURTENANT CONSTRUCTION.
 - D-15006.....SECTIONS AND DETAILS SHOWING POWERHOUSE EXCAVATION AND APPURTENANT CONSTRUCTION.

SCALE OF FEET AS NOTED

CITY OF SEATTLE - LIGHTING DEPARTMENT
E.R. HOFFMAN - SUPERINTENDENT

SKAGIT PROJECT - GORGE P.H. EXTENSION

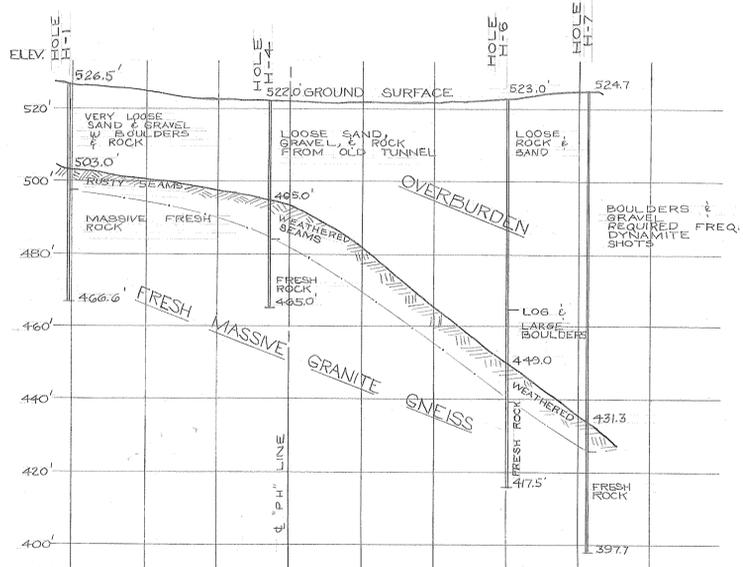
LOG OF DRILL HOLES AND DETAILS OF TIMBER CRIB

DW. BY C.G.B.	SUBMITTED <i>H. Shandling</i>	ORIG.	SCALE AS NOTED
TR. BY W.M.S.	RECOMMENDED	DATE	5-8-48
CK. BY <i>W.H.W.</i>	APPROVED <i>E.R. Hoffman</i>		

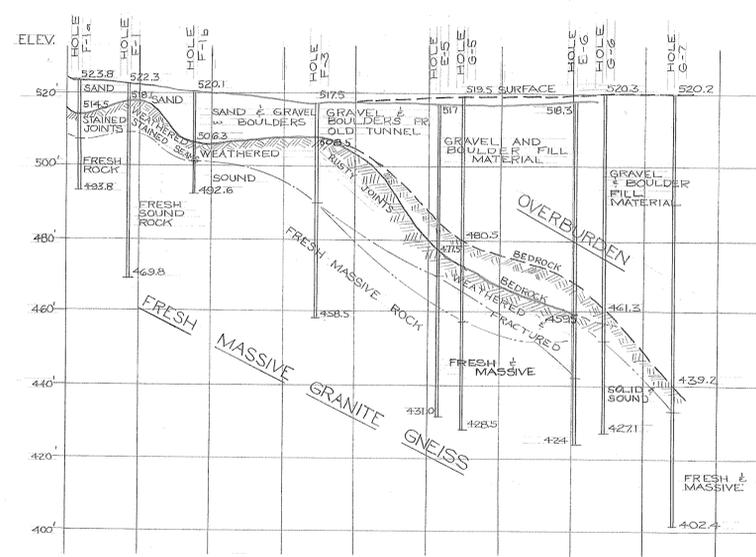
DRAWING CONVERTED BY:
Vendor: PIM, CT, SARA
other:
Date: *3/77*

Approved
J.L. Shrage
CONSULTING ENGINEER

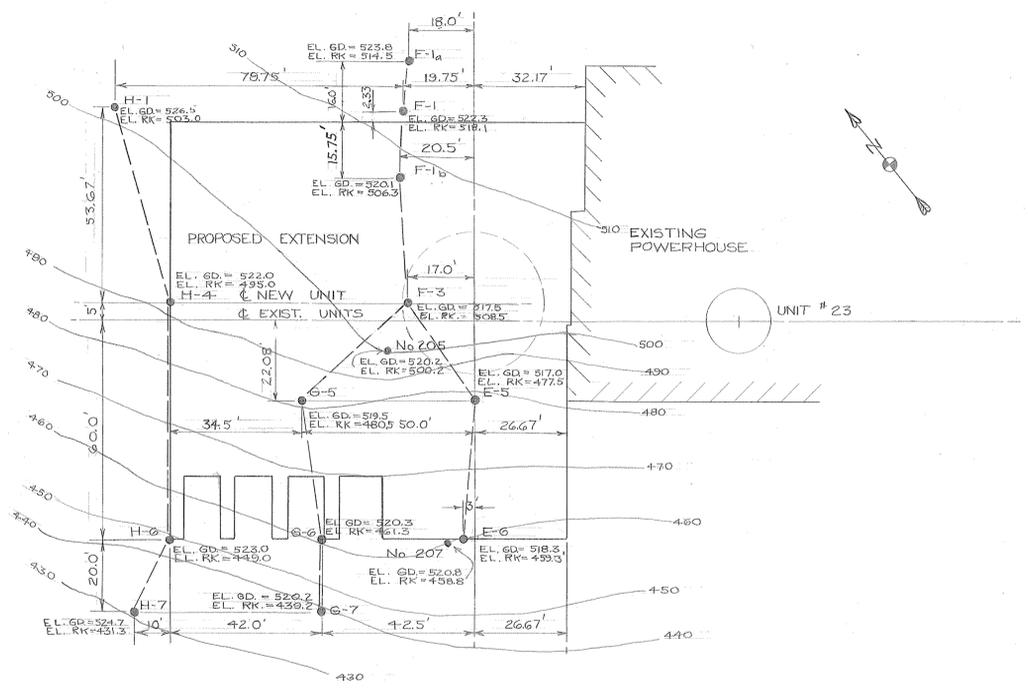
REVISIONS				
Sub	Mark	DESCRIPTION	DATE	APPR'D



SECTION H-1, H-4, H-6, H-7
SCALE: 1"=20' BOTH WAYS



SECTION F-1a, F-1, F-1b, F-3, E-5, E-6
AND F-3, G-5, G-6, G-7
SCALE: 1"=20' BOTH WAYS



PLAN OF DRILLING AREA
SCALE 1"=20'

NOTES

REF. FLD. BKS 71D & 71L
SEE PHOTOS # L-1031

DRAWING CONVERTED BY:
Vendor: PIM, CIT, SARA,
other: _____
Date: 2/97

EST. 600-D

APPROVED BY THE BOARD OF PUBLIC WORKS
SEATTLE, WA _____ 19____

ATTEND: _____ CHAIRMAN
SECRETARY

**CITY OF SEATTLE
LIGHTING DEPARTMENT**
E. R. HOFFMAN, SUPERINTENDENT

GORGE POWERHOUSE EXTENSION

DIAMOND CORE DRILLING
CROSS SECTION FOR
PROPOSED EXTENSION

ORD.	WORK ORDER 12849-20	DATE 5-15-48
DW. BY: H.C. HANSON	SUBMITTED	
TR. BY: C.F.B.	RECOMMENDED	
CK. BY: C.M.L.	APPROVED	SUPT.
Sub. No.	Drawing No.	D-14031

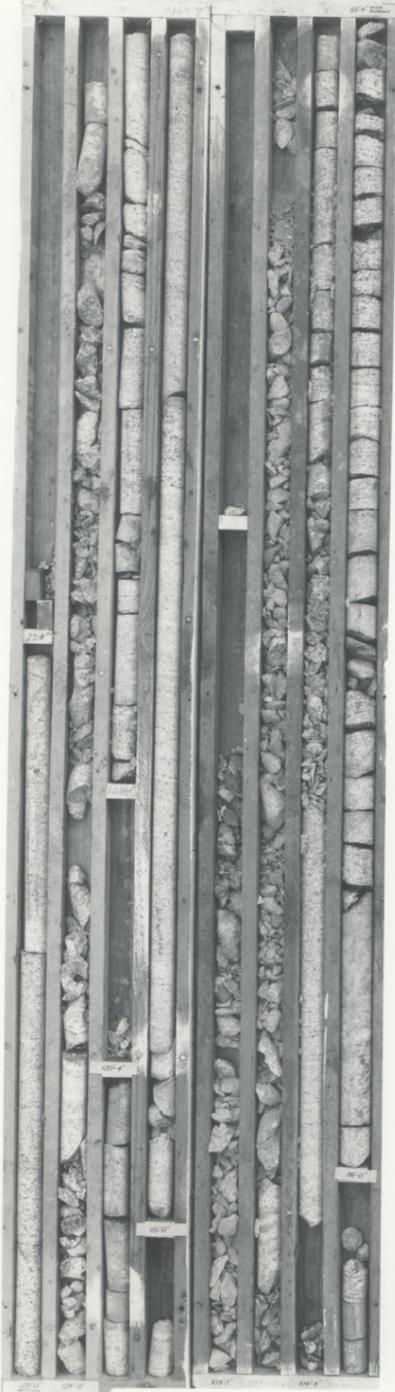
HOLE # H-4



HOLE # G-6

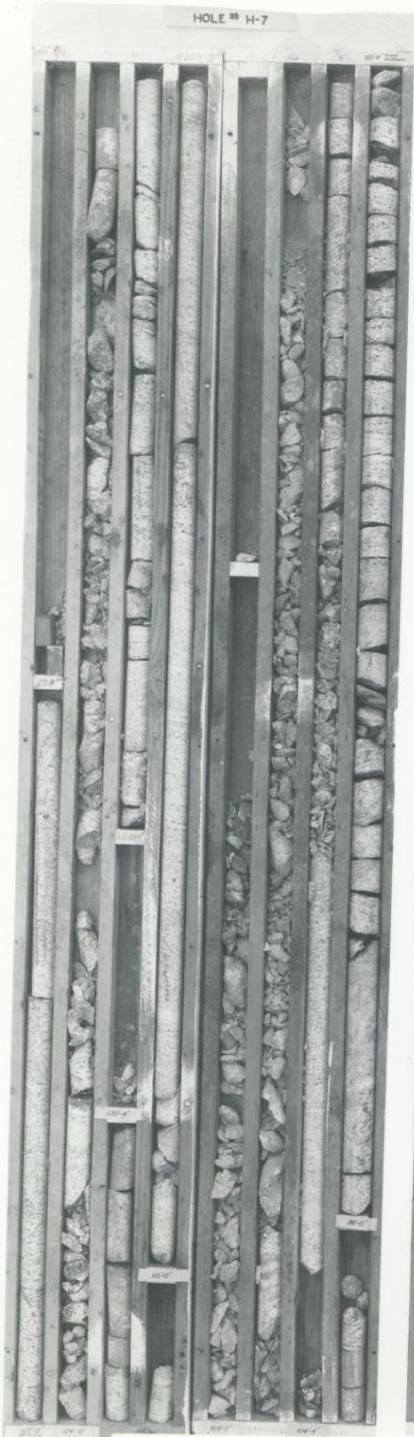


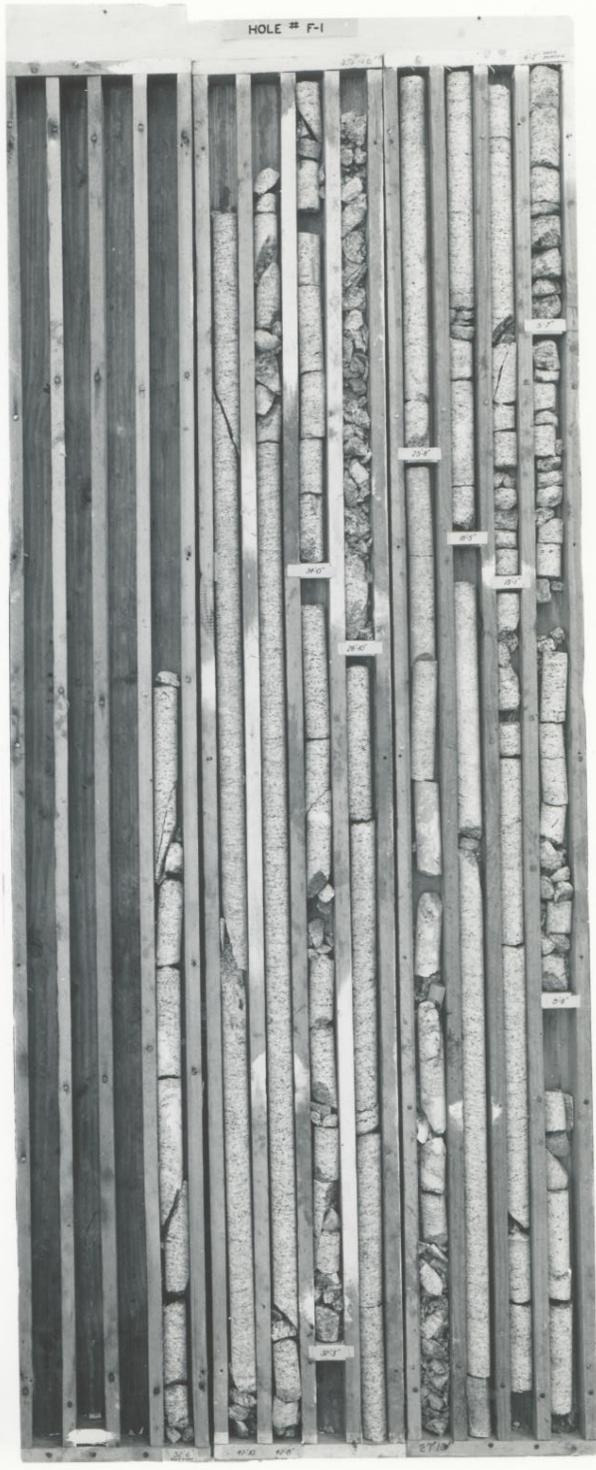
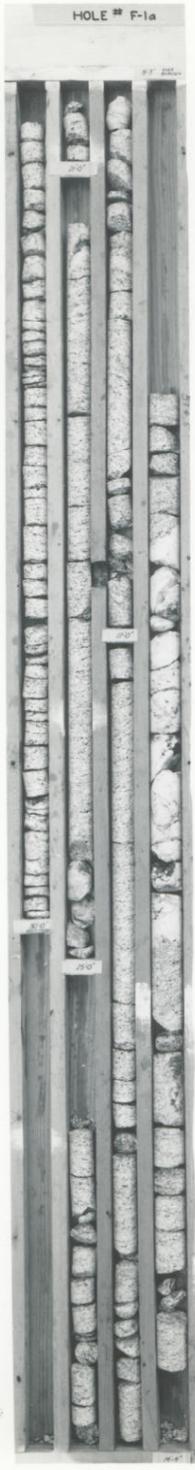
HOLE # H-7



HOLE # G-7



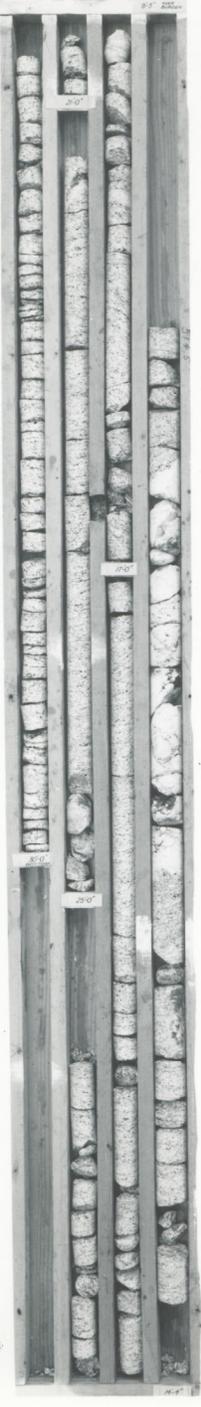




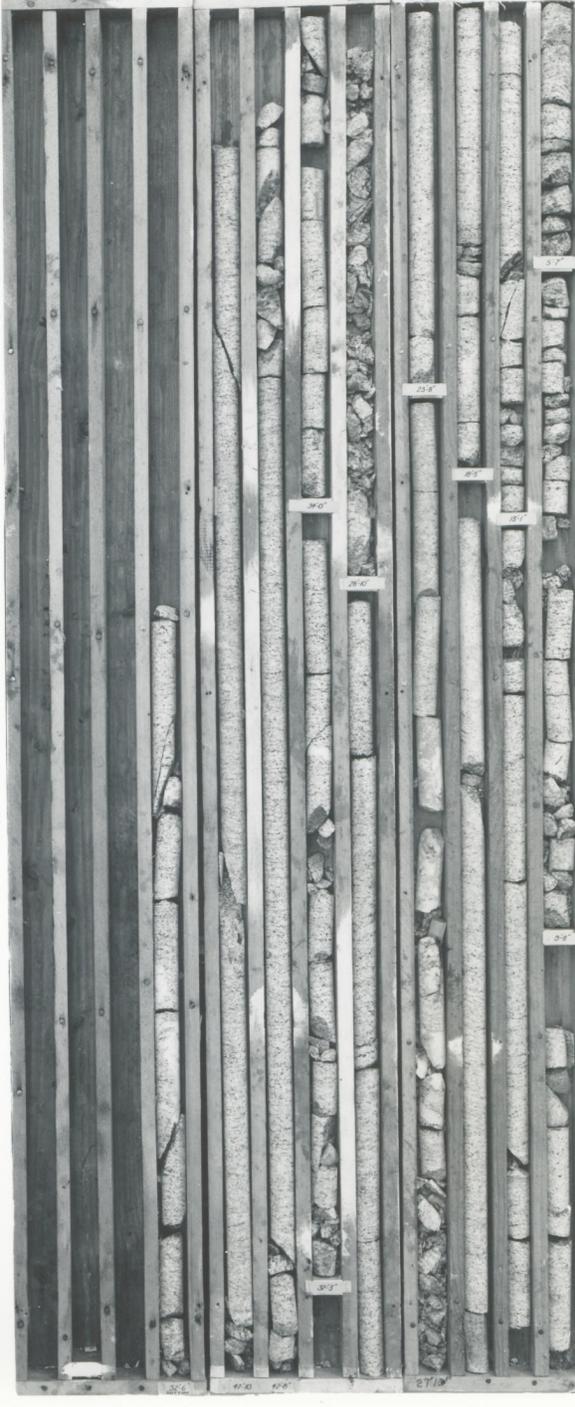
HOLE # F-1b



HOLE # F-1a



HOLE # F-1





HOLE # E-6



HOLE # H-6



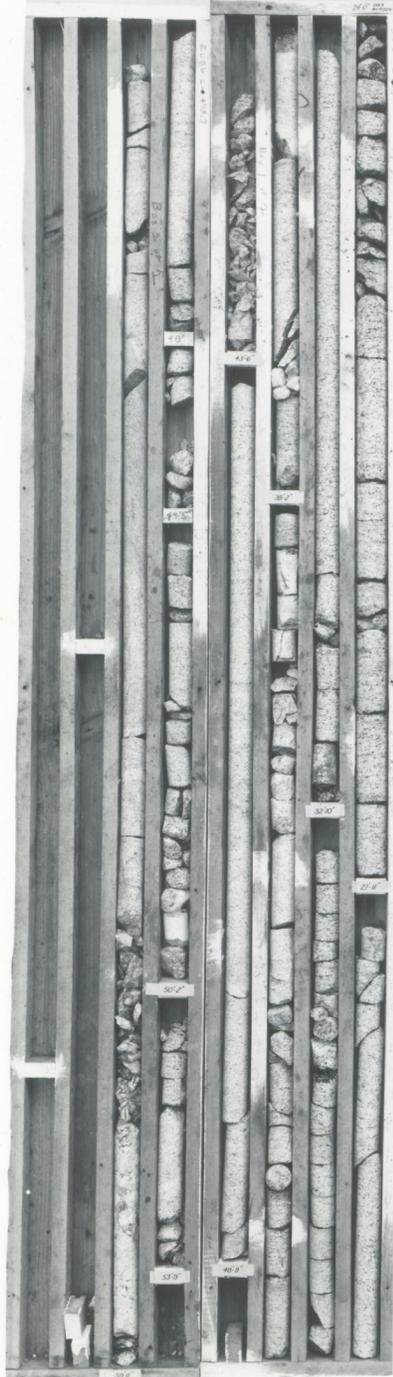
HOLE # E-6



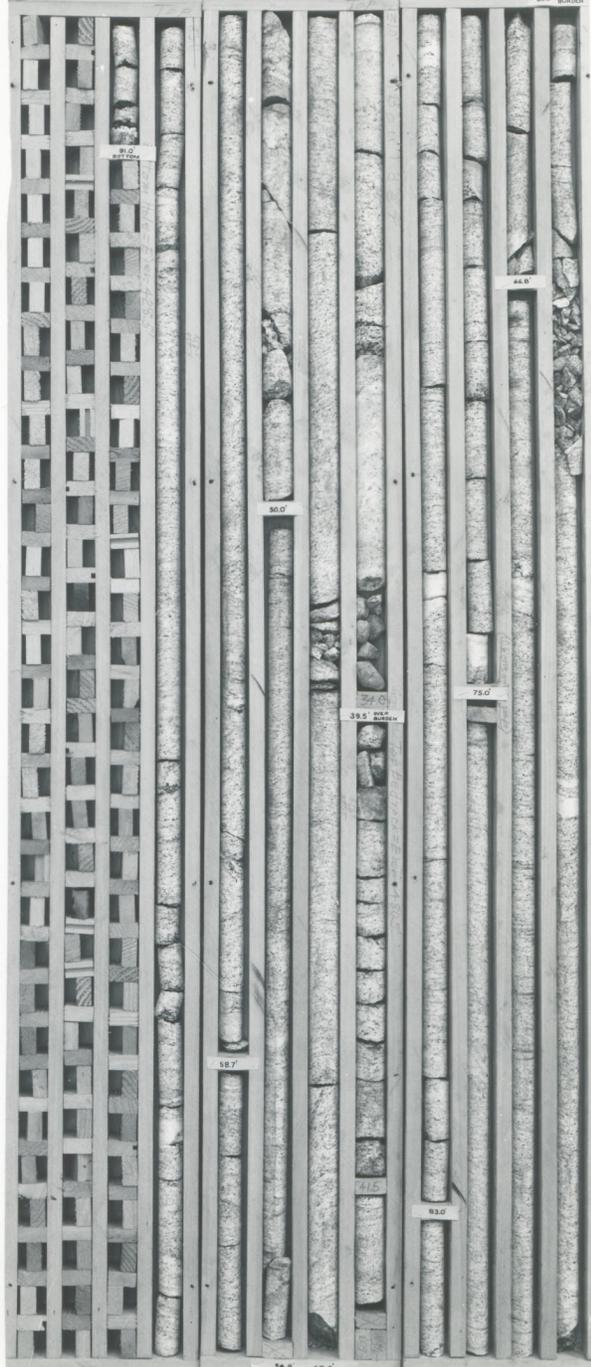
HOLE # H-6



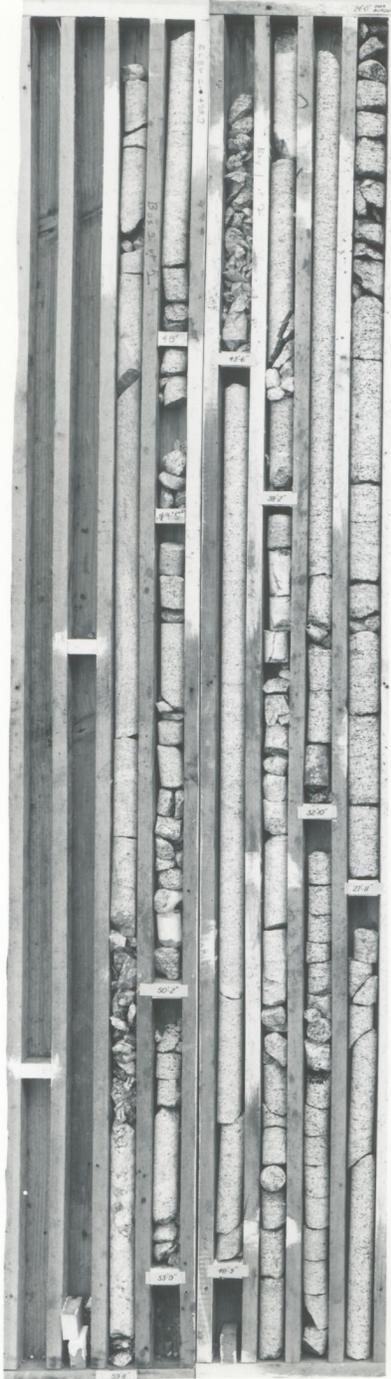
HOLE # H-1



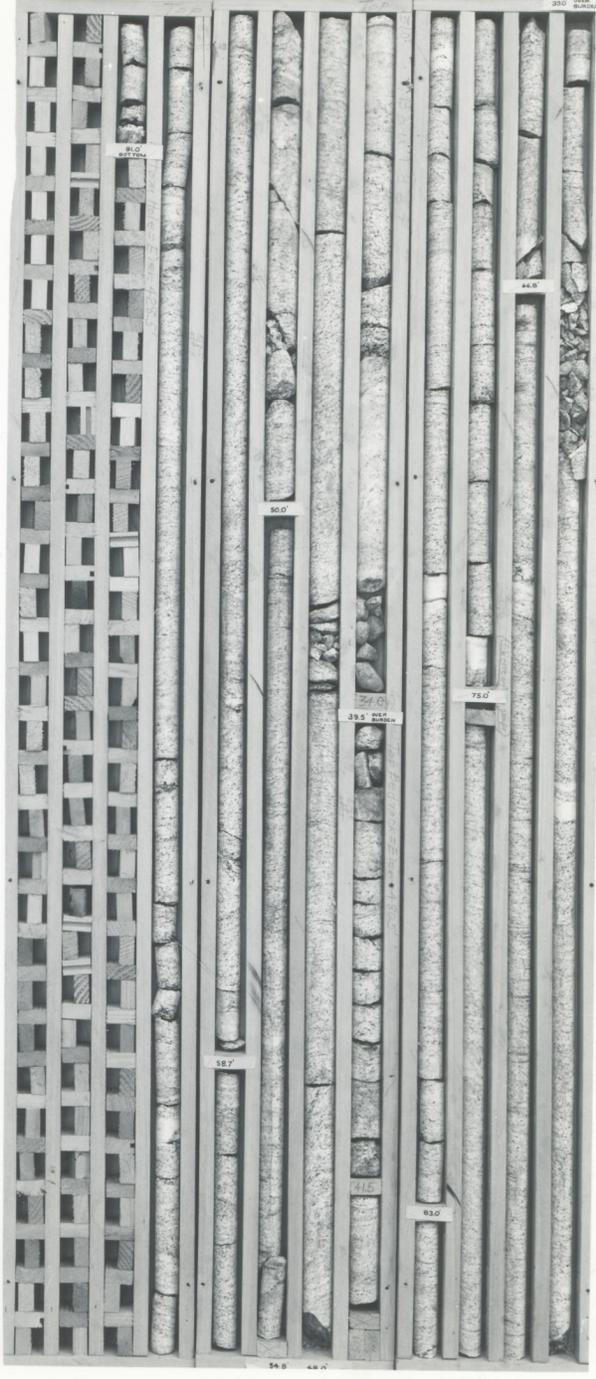
HOLE # G-5



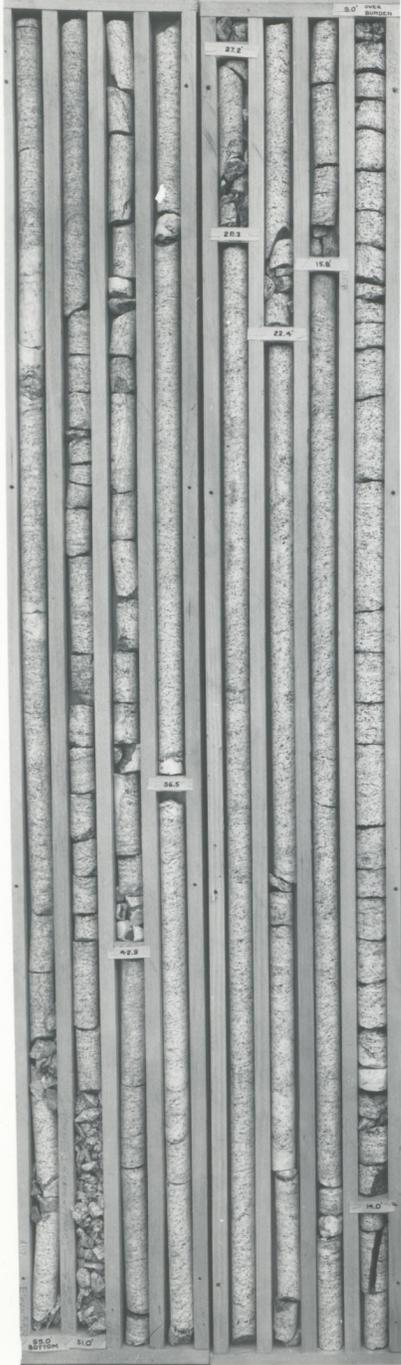
HOLE # H-1



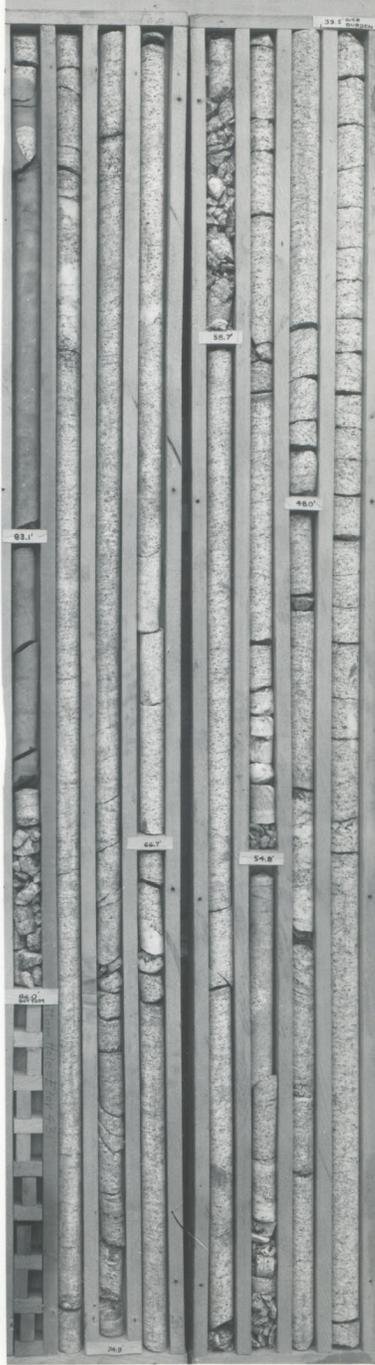
HOLE # G-5



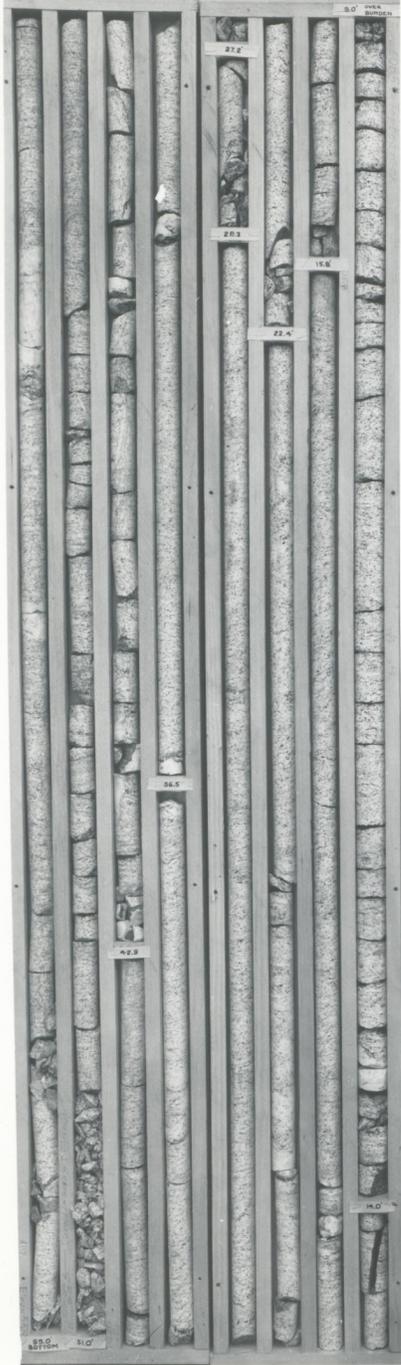
HOLE # F-3



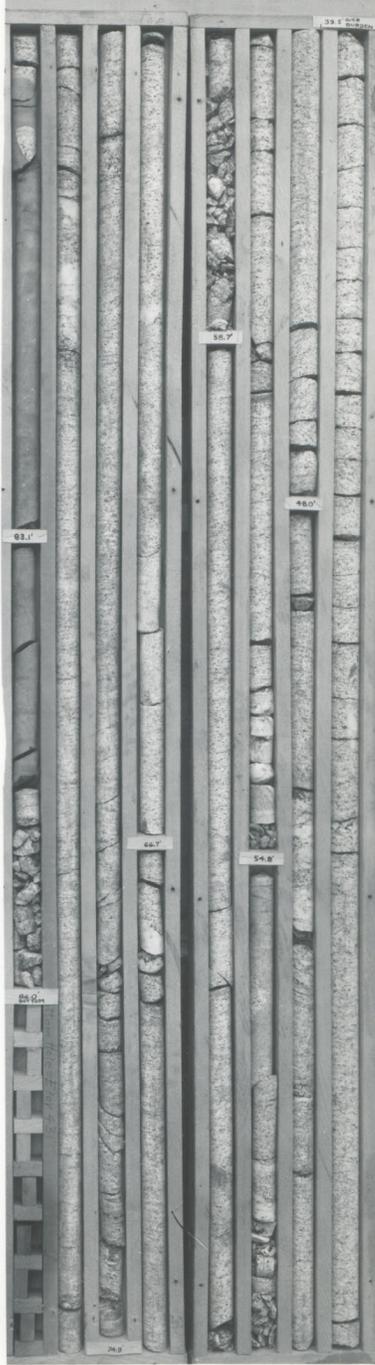
HOLE # E-5



HOLE # F-3



HOLE # E-5





HOLE # H-4



HOLE # G-6



EST. 600 D

No. _____

Name _____

Order _____

Remarks _____

Retouched _____

Order Finished _____

Reorder _____

Reorder _____

DIAMOND DRILL
CORES

GORGE P.H.
EXTENSION

DATE DRILLED
MAR - MAY 1948

Handwritten signature

Reorder _____

Reorder _____

Order Finished _____

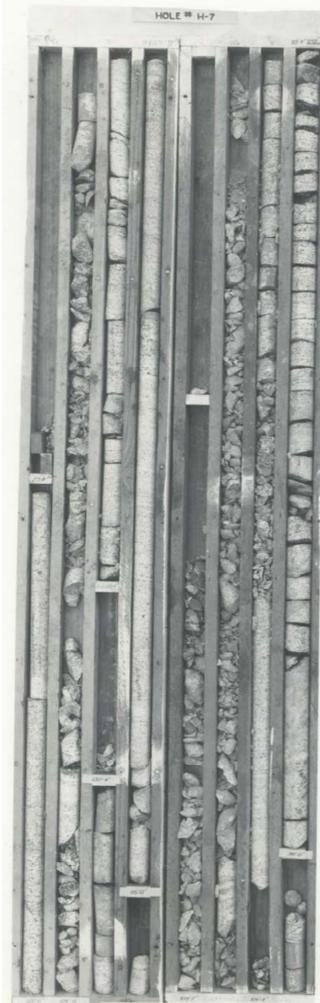
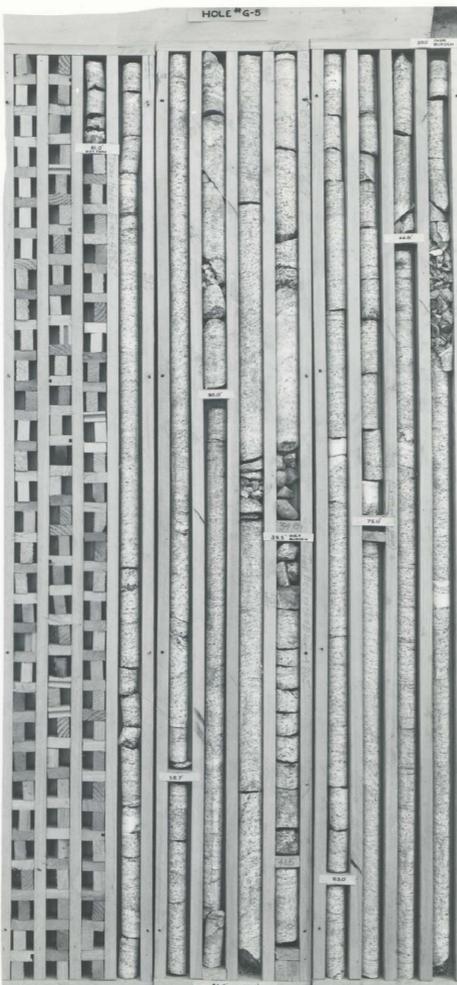
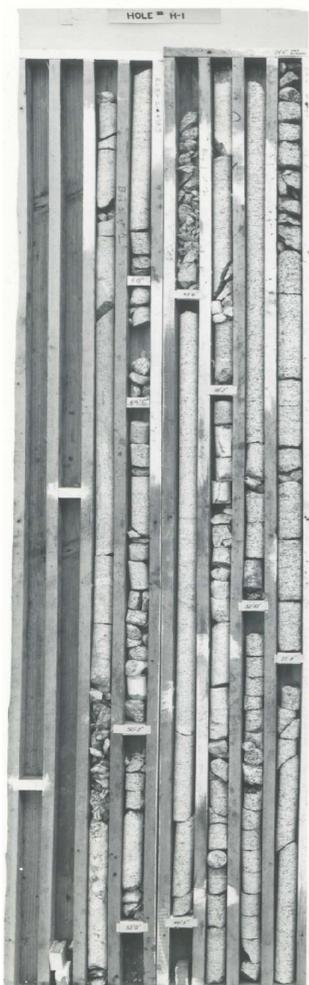
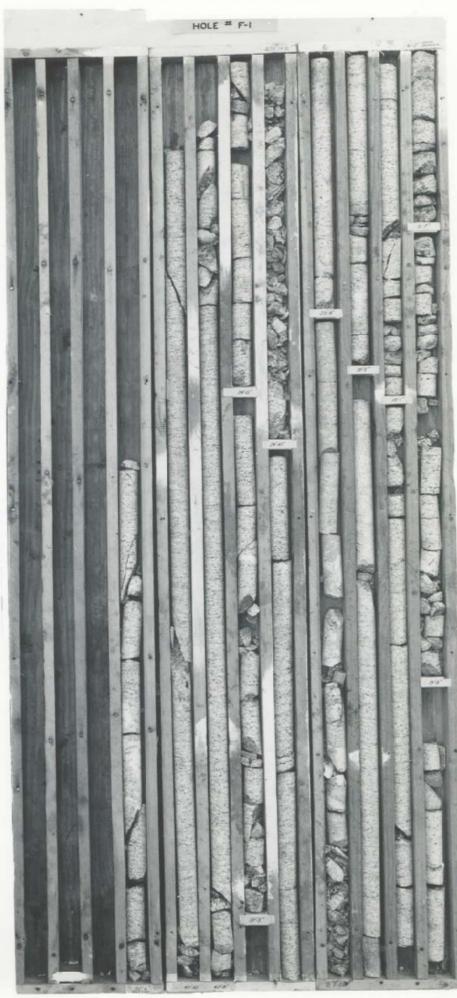
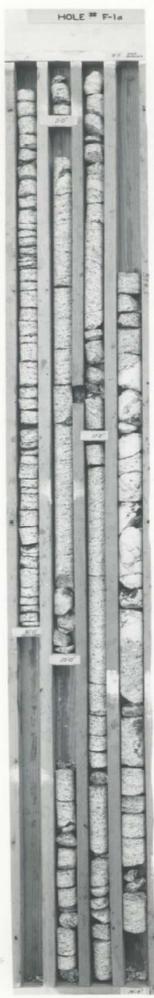
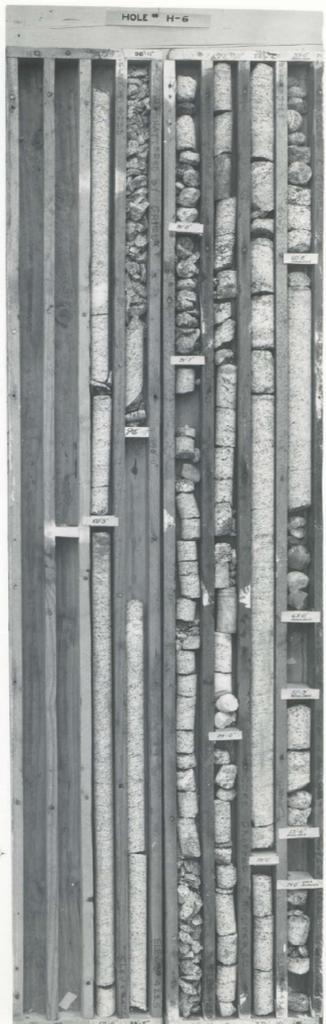
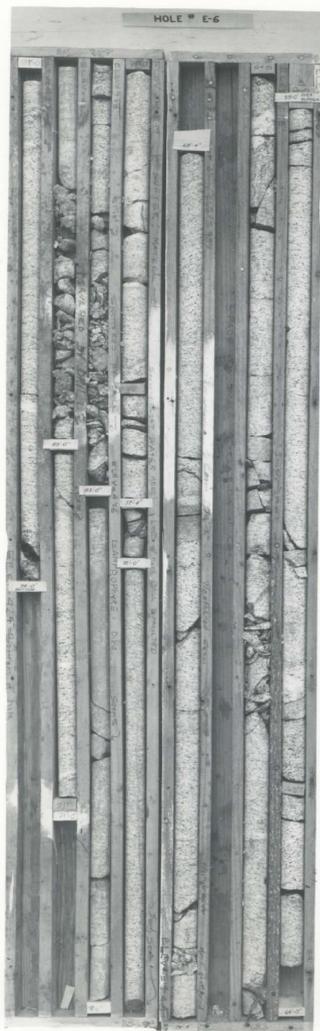
Retouched _____

Remarks _____

Order _____

Name _____

No. _____



GORGE POWERHOUSE EXTENSION

RECORD OF CONSTRUCTION

JULY 29, 1948 THROUGH JUNE 23, 1951

I N T R O D U C T I O N

Seattle City Light's long-range power development of the Skagit River in northwestern Washington received added impetus in 1948, when efforts were concentrated on expanding the plant, facilities, and generating capacity of the Gorge Powerhouse.

The expansion was designed to accomodate the increased potential which would be created by the new Gorge Diversion Dam. Ultimately, when all extensions and improvements are completed, the Gorge Plant will develop 153,000 kilowatts at 385 feet gross head, compared with the pre-expansion capacity of 60,000 kilowatts at a gross head of 278 feet.

The Gorge Powerhouse is the oldest development in Seattle City Light's huge Skagit River Power Project. The powerhouse site was selected in the mid-summer of 1919.

Located across the Skagit River from the town of Newhalem, the Gorge Powerhouse is 130 miles north of the metropolitan center of Seattle. It is the southernmost of three power plants situated in Whatcom County, Washington. The Diablo Dam and powerhouse lie a few miles to the north. And beyond Diablo is located the Ross Dam and powerhouse.

Combined, these three plants will have a total estimated power of 645,000 kilowatts, and a total estimated output of 2,690,000,000 kilowatt hours per year.

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The Seattle Board of Public Works opened bids for the first portion of the Gorge Powerhouse Extension Project on July 29, 1948. Original bids were for "Excavation for Powerhouse and Penstock Tunnel, Unit 24".

These excavations were primary steps in the preparations for future construction of an addition to the Powerhouse building. Construction of this addition was scheduled to begin under separate contracts in 1949, involving installation of a new generator (Unit 24) in the Powerhouse addition. The contract called for excavation beyond the limits actually occupied by the Powerhouse proper, in order to provide for an earth cofferdam.

Excavation of the penstock tunnel was to be carried to the extent where completion could be readily accomplished by firms working on later contracts. Thus, the new penstock tunnel leading from the Powerhouse would not be joined with the main tunnel until a later stage of construction had been reached.

Also included in the contract was excavation to enlarge the construction adit which was already on the site, a hold-over from earlier construction activity at Gorge. New timber sets were to be erected in this tunnel, if they were found to be necessary.

Three Seattle construction firms submitted bids for the new contract. On August 5, 1948, the contract was awarded to The General Construction Company for its bid of \$373,096.90.

The award was made after consideration of bids submitted by Paul Jarvis, Inc., (for \$379,802.20) and Rumsey & Company (for \$407,911.57).

Work on the project was authorized under Ordinance 76472 and

City Light Specification 824, approved April 28, 1948.

E. R. Hoffman, Superintendent of Lighting, issued notice to begin work on August 17, 1948. The contract called for completion of this portion of the extension project within a period of 150 days. According to the contract, the General Construction Company was to complete all excavation for the Powerhouse and penstock tunnel by January 14, 1949.

Plans and specifications for the project were prepared by the office of Dr. J. L. Savage, Consulting Engineer, of Denver, Colorado. G. W. Cutler, Skagit Project Engineer, was in charge of the work for City Light. Resident Engineer at the job site was R. P. Sonntag.

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On August 17, 1948, the contractor started clearing and construction work at his camp site area. The General Construction Company had been associated with the Shea Company and the Morrison--Knudsen Company during construction of Ross Dam. During that time, they were known as General-Shea-Morrison, Contractors. However, work on the Powerhouse extension was done by General Construction Company alone.

During the early days at the camp site, temporary sleeping quarters were established in an old City Light electrical repair shop at the north end of the Powerhouse.

Erection of Camp Buildings Begun

Within the first week, a two-room cottage for use by the contractor's superintendent, and a workshop, had been erected in the camp area northwest of Newhalem. Construction of a two-story bunkhouse and a small contractor's office was underway and making good progress. And the contractor had begun construction of three houses for the use of City Light engineers, located at the west end of

Newhalem. By September 1, the roofing, siding, interior framework, and plumbing for these houses had been completed. Early in September, work was started on a messhall for the contractor's crew. A three-phase transformer was installed behind the Powerhouse, to provide power for the contractor's camp.

Near the excavation site, the old electrical shop was torn down during the first week of September, as soon as quarters were furnished the contractor's men. Removal of this old building was completed September 20.

Erection of the bunkhouse and messhall continued through September and, with the exception of plumbing, were practically complete as the month drew to a close.

Construction was started immediately on an addition to the office of the City Light Engineer. Concrete footings were poured and some of the flooring was laid. Most of the work on this structure, however, was delayed pending arrival of necessary lumber. In the meantime, efforts were devoted to getting the engineers' houses ready for occupancy.

Road and Bridge Work Launched

Excavation was begun on September 16 for the road leading to the contractor's spoil dump. A power shovel was working on this road, near the parking area across the Skagit from the Powerhouse. The road was to extend to the dump area (between the river and the schoolhouse) into the center of Newhalem. Except for a small section adjacent to Railroad Avenue in Newhalem, the contractor was to build the entire road. In conjunction with this road construction, the contractor laid planking on the railroad bridge leading to the Powerhouse, and across railroad tracks which intersected the spoil dump road. The road had been entirely excavated by the end of September, and work

commenced on the grading of the road.

By the end of August, the contractor had begun work on a suspension bridge across the Skagit, about 375 feet downstream from the railroad bridge near the Powerhouse. Concrete footings for the east and west bridge towers were poured by September 16, and the placing of rock fill around the footings had begun. When erection of steel for the west tower was completed on September 24, similar construction was started at the east side. While this work was progressing, the four "deadmen" for the suspension bridge were poured between September 7 and October 6.

At this point, work on the suspension bridge was halted, pending arrival of cables, trusses, and decking. Nevertheless, the placing of fill around the tower on the Powerhouse end of the bridge continued through to the middle of October. By this time, the abutment had been raised to its approximate final outlines. The contractor's bulldozer worked overtime on this operation, in an effort to complete the work while they had easy access to the location.

Powerhouse Excavation Started

Before actually starting excavation at the site of the Powerhouse addition, the contractor removed two water lines which extended across the area. By the middle of September, the railroad tracks running into the area had been removed.

Finally, on September 25, the contractor's power shovel was moved into the excavation site and began operations on the contract work. This was the same shovel which had been excavating the spoil dump road.

The contractor first built a truck access road to the penstock portal, and it was surfaced with gravel removed from the excavation for the Powerhouse addition. Trucks began using the spoil

dump road as soon as grading was completed on October 4. Before this time, the road to the contractor's camp had been used for hauler coils. This procedure was stopped, however, when the three trucks that were hauling the spoils became the road. When more excavated material became available, the contractor was able to backfill and grade the road, and it was once again put to use.

Early in October, work was started on removal of the six-inch water supply line from Sudder Street to the Miller. It was necessary to remove the water line so it could be re-routed and re-connected across the new suspension deck bridge. During the changeover, more than 100 feet of new pipe were ordered to supplement the available supply. Removal of the water line was completed on October 11. Meanwhile, work on the suspension bridge had been further delayed by failure of the cables to arrive.

Contractor's Camp Completed

At the contractor's camp, work had progressed to the point where, by early October, the messhall and bunkhouse were finished. Plumbing in both buildings, including septic tank and cesspool, was almost complete. The messhall was put into operation October 5, less than a week after the bunkhouse was declared ready for occupancy. Grading of the area around these two buildings was completed by October 11.

Work on the extension of the City Light Engineer's office, which had been delayed by slow-arriving millwork, was resumed on October 20, when this material finally arrived. Office construction was accelerated into haste, and the new part of the building, which housed the drafting room, was essentially complete by November 3. Only minor floor and electrical work remained to be done on the unit. The engineers' houses, meanwhile, had been finished by the middle of

October, with a single exception. Minor work continued on the second until the middle of November. Work was started during October on three identical houses, located side-by-side. When completed, these houses were occupied by officials of City Light.

Strain-Gauging Program Begun

On October 6, E. R. Hoffman and C. W. Cutler conferred with two physicists from the United States Bureau of Reclamation and made arrangements for the installation of strain gauges, pressure meters, and accelerometers inside the Gorge power tunnel for the measurement of vibration and the control of blasting. The instruments, shipped to Newhalem by City Light truck, arrived October 7. Shortly before midnight on Saturday, October 9, the Powerhouse was shut down and the tunnel was unwatered. The tunnel was clear of water early the next morning (October 10) and crews from the U. S. Bureau of Reclamation immediately entered the tunnel to set up the strain meters. They had some difficulty drilling holes in the concrete tunnel liner for installation of the meter mounts, but by noon, all the necessary holes had been drilled.

Four strain meters were mounted in the afternoon, three in the tunnel liner nearest the blasting area, and one between penstock #23 and the Johnson valve. (The latter was lost during operations a week later). Messenger cables were laid between the meters and their gauges simultaneously. And inside the Powerhouse additional instruments were placed in the scroll case and on the bearings of the turbines, and on the top arm bracket of one generator, to measure water pressure, acceleration, and deflection, respectively. Work was completed Sunday night, October 10, and the tunnel was subsequently refilled.

Installation of these sensitive instruments was for the purpose of controlling the blasting which would be done in the excavation work, and to determine whether stresses of any magnitude were otherwise

present in the tunnel or Powerhouse. Calculations made on the basis of these instrument readings would decide the maximum blasts which could be employed at any one time, in order not to exceed the safe stresses in the Powerhouse structure, the machinery, or the Power Tunnel liner. The two men from the Bureau of Reclamation remained at the construction site to observe the operation of the meters.

Excavation Blasting Begins

As excavation for the Powerhouse addition resumed on October 11, the contractor made several blasts during the day near the portal of the old construction adit. The strain instruments registered no noticeable vibration or other effects; no vibration was felt in the Powerhouse. Maximum loading to this date was nine sticks, six holes. The next day (October 12) some blasting was done west of the adit portal (24-stick maximum) with no disturbance being recorded. Three cable-type blasting mats for protection of the Powerhouse arrived on October 14, and windows on the north side of the building were boarded up as added protections against blasts.

Excavation continued in the area adjoining the north wall of the Powerhouse and at the construction adit, with particular emphasis on excavation of common. On October 18, excavation of rock began on a large scale, with the contractor starting a swing shift composed of several jackhammers and a foreman.

An estimated 12,000 cubic yards of common excavation (of the 27,000 cubic yard approximate total) had been removed by October 22. Rock excavation had reached a total of 500 cubic yards of the estimated 8,000 cubic yard total.

Operations were proceeding very slowly. This was due in large part to the fact that prior to October 19th the contractor had employed only a single shift. It became obvious that at his present rate of

progress, the contractor could not complete the excavations in time to meet the January 14, 1949, deadline. Since progress was generally unsatisfactory, the Skagit Project Engineer, C. W. Cutler, attempted to remedy the situation by suggesting to the contractor that a graveyard shift be started at once. It was also recommended that the crew on swing shift be increased, since it consisted mainly of jack-hammers. It was suggested that the contractor obtain heavier construction equipment, after his shovel and trucks proved too light for the work demanded of them.

Considerable headway was recorded during the ensuing days, as excavation proceeded north of the Powerhouse. Surface blasting was especially effective. Late in October, one of the strain gauges detected some vibration in the north wall of the Powerhouse after several large blasts. As a result, the holding rods on the 18" x 26" wooden beam across the wall were tightened. This appeared to be sufficient bracing for the wall, when no further vibrations were detected by the strain gauges.

Removal of Spoils Lags

Near the end of October, blasting in the excavation reached a point where the spoils could not be mucked out fast enough to keep up with the blasting. Various equipment breakdowns slowed up the removal of spoils. The frame of one of the contractor's three trucks broke squarely in half under the weight of a load of rock. It was out of service for a considerable time while repairs were made. A new truck, having an 11-cubic-yard capacity, arrived and began work on October 27. This made a total of four trucks on the job. The three older trucks each had an 8-cubic-yard capacity. When the shovel proved inadequate, the contractor said a new one would be sent to replace it. But by the beginning of November, the new shovel had not arrived.

At the end of October, the contractor was employing 25 men on excavation work during the day, and ten men (all jackhammers) on the swing shift. Approximately 14,000 cubic yards of common had been removed, and more than 800 cubic yards of rock had been hauled away. At the west side of the excavation, the berm adjacent to the river had been lowered to elevation 500. The contractor's shovel was working toward the portal of the new penstock tunnel, preparatory to starting tunnel drilling.

Three-Shift Operations Requested

To re-affirm his previous request for a three-shift operation, the Skagit Project Engineer sent a letter to General Construction Company's Project Manager, emphasizing the urgency of an immediate start of full-scale operations. It was pointed out that an average of eleven feet of tunnel would have to be drilled every day starting October 29, if the work was to be completed within the time allotted by the contract. Inasmuch as the safe limit was considered to be four feet of tunnel for every 8-hour shift, three-shift operation was absolutely essential to the fulfillment of contract.

A conference was held with the contractor's Project Manager in his Seattle office on October 27. His attention was called to the fact that blasting and jackhammer work had progressed on a two-shift basis to the point where the shovel was swamped. Consequently, blasting could not proceed, and the shovel was unable to keep up with the trucks in removing the spoils.

At this meeting, City Light officials emphasized their point that the primary concern was to get the contractor to "hole in" and begin drilling the new penstock tunnel, because a delay in this work would be extremely costly to the City. It was pointed out to the contractor that an extension of his contract would not be allowed.

In response to the points brought out at the meeting, the contractor promised that a number of measures would soon be instituted to speed up the work. He said he would begin working his crews on ten-hour shifts. He said the shovel would be worked long enough each day to keep abreast of mucking operations, until a new shovel could be moved in. The contractor also disclosed that he was considering a new method of drilling the tunnel, and would have a conference later in the week with two mining experts to determine the amount of speed-up which could be obtained by using the new method. The Project Manager said he planned to personally visit the excavation site, possibly with the two mining consultants, to see what he could do about accelerating the operations.

~~Work Continues at Snail's Pace~~

As operations continued into November, the contractor's work showed no noticeable improvement, until the new shovel arrived on November 8. Two days earlier, considerable delay had been caused by the breakdown of the contractor's old shovel. When this happened, the new 11-cubic-yard truck had to be laid off because blasting had been halted to allow mucking operations to catch up, and there was no longer enough rock to keep the truck busy.

On November 9, shooting was resumed -- this time on a larger scale than before, using loads about 25% above the old schedule.

On November 10, a blast at elevation 490, about 30 feet from the Powerhouse in foundation rock, caused the main switch to fall off Generator No. 22. After this happened, the blasting loads were reduced to their former schedule. The register bank of Generator No. 23 was put out of order on November 14, by another blast in the foundation. This occurred when only one stick beyond the normal schedule was applied. Repairs to this generator were effected when the Powerhouse was shut down

for tunnel inspection on November 21st. The two physicists from the Bureau of Reclamation left the site on November 8, after acquainting the Chief Inspector, J. U. Mattila, with the operation of the strain gauge and other instruments. They left a controlled-shooting chart for use on about half of the remaining open-cut excavation. It was noted that no dangerous effects had yet resulted from the blasting.

Progress By Mid-November

By the second week in November, common excavation had reached 16,600 cubic yards and rock excavation was tabulated at about 2,700 cubic yards, of estimated totals of 27,000 and 8,000, respectively. Approximately 45 linear feet of line-drilled holes incidental to the excavation had been completed, from a total of 3,800 linear feet. The berm next to the river (completed to elevation 500) served as a cofferdam to keep the river from flowing into the excavation which was being done directly north of the Powerhouse. With only mucking operations left to be done in the adit tunnel, excavation at that point and in the penstock portals was almost complete. The pit was down to elevation 490 at the penstock portal about 25 feet east of the Powerhouse line.

During November 3, some leakage began to seep through at the southwest corner of the excavation where the berm adjacent to the river connected with the old berm and cribbing next to the Powerhouse tailrace. This occurred at a time when the contractor had just completed planking the face of the old timber crib with three-inch planks. The contractor set up a City-owned 100-horsepower pump on the cofferdam northwest of the Powerhouse. However, the fittings necessary to complete this installation and put the pump in operation did not arrive until the second week of November. And by the time it arrived, the leakage had decreased. The pump was used very seldom, because no further excavation was being done close to the river. Besides, because of the fact that

there was not enough seepage water to keep the pump primed, the pump failed to work satisfactorily in handling the small amount of water which continued to enter the excavation. A small 10-horsepower pump was brought in to take care of what pumping operations were required.

While this was going on, work apart from the excavation was progressing. While waiting for the arrival of the suspension bridge cables and other equipment, the bridge-erection crew assisted in the filling and grading work around the bridge abutment, on the Lowerhouse side of the river. The crew which had been working on removal of the Ladder Creek water supply line was laid off October 25, after the piping had been completely removed. More than half of these men were re-hired by the Strait Headworks Superintendent in charge of installing the new water line.

Final backfilling of the gravel dust road, and the road leading to the contractor's camp, was completed during the final days of October. A low spot in the road opposite the Newhalem schoolhouse was filled, and similar work was done on the road between the engineers' houses and the railroad.

Bridge Erection Completed

The cables, trusses, and timber decking which had been holding up the completion of the bridge (by delayed arrival) were received on the site during the first few days of November. Laying of the cable between the two steel towers was begun November 8th. This work had barely begun when it was discovered that the cable sockets did not fit the bolts cast in the "deadmen". However, shaptons were obtained and cable work proceeded. The cable was in place by November 18, and work on the trusses and decking was started the next day. During the cable installation, the City crew had extended the new water line to both ends of the suspension bridge.

Connection of the bridge trusses and installation of the timber

decking were completed during the first week of December, except for final bolting. When the crews had connected the six-inch water line across the completed wooden deck of the bridge, it was discovered that the weight of the piping threw the cable tensions out of balance. It was decided to offset this difficulty with counterweights.

Aside from the above-mentioned developments, the suspension bridge was complete. Only the riprapping of the abutments and the installation of permanent "deadmen" remained to be done. Early in December, plans were made for a reinforced concrete mat around the west abutment, but no immediate work was started to execute the plans.

Increased Blasting Program

With work moving at a comparatively slow pace, the contractor made an exhaustive study of blasting methods, in an effort to boost his blasting schedule to the maximum safe limit. The contractor's two blasting and powder consultants arrived the middle of November and, after looking over the situation, recommended the use of a new type of fast blasting cap for delayed-action shooting. Trial blasts using these new caps were made on November 15, and results were considered excellent. The new-style caps made possible four times the ordinary straight shot in zone shooting. In addition, a negligible effect was recorded on the instruments and in the Powerhouse. First shootings with the new caps was done under the adit portal on November 17th. Again, results were excellent.

Also on the 17th of November, the contractor gave his assurance that his work would be completed on time, inasmuch as the blasting schedule could now be increased without danger to the power units or tunnel. This information was stated in a letter from the president of General Construction Company to the Superintendent of Lighting, in reply to letters expressing concern about the lack of progress in the contractor's

excavation work.

Little increase in efficiency was noted even on November 17, when the contractor installed an air winch and tugger to drag muck from the adit tunnel invert. Old cribbing and shoring had been pulled from the adit by the winch on November 20. Blasting was continuing in the adit, and line drilling was started. The roof arch held up well, and the rock conditions appeared good, although a soft diagonal seam and some blocky rock had become evident. On November 24, the air tugger was replaced by a caterpillar tractor in the mucking operation, with far better results.

In general, excavation in the adit was making better progress than was apparent anywhere else on the job.

Penstock Tunnel Drilling Begun

The contractor began drilling into the upper face of the new penstock tunnel with jackhammers, on November 21. No blasting was done. The bottom of the excavation outside the penstock portal was not yet down to invert grade, and excavation work outside the portal continued. First blasting at the penstock portal (jackhammer holes only) was done on the 25th of November.

Gorge Powerhouse was shut down for tunnel inspection on the 21st of November. It was discovered that the lead wires of the strain meters had been broken, probably by debris which floated through the tunnel during Powerhouse operation. These were the wires which had been installed on October 10. The messenger cable was also broken in one place.

Two new strain meters were installed and a new cable was laid in the tunnel invert, replacing the one which had previously been suspended from the ceiling. (Less than a week later one of the newly-- installed strain gauges came partially open and was therefore no longer

reliable). The tunnel was refilled in the evening of the same day.

Excavation, except in the adit tunnel, was lagging badly by the end of November. Muck was piling up and was not being removed. In fact, for all practical purposes the mucking operation was at a complete standstill. Considerable delay was still being caused by equipment failures and breakdowns. Two of the contractor's trucks were entirely undependable, being in the shop for repairs as often as they were available at the job site. A third truck had been out of service for several days while a new engine was being put in it. And on November 22, a dump hoist on one of the trucks collapsed while the truck was being loaded, thus necessitating extensive repairs.

The contractor worked on Thanksgiving Day, and then took the weekend off. Muck that had been shot out on Wednesday and Thursday (November 24-25) remained untouched until the following Monday. Two trucks were then in operation, and muck removal proceeded.

Graveyard Shift Started

Technically speaking, the contractor started a graveyard shift on November 30. However, the only workers he employed during this shift were drillers, and little immediate benefit was apparent. Because of the large amounts of unremoved muck which hindered drilling, the drillers were at a standstill for several days.

The timber frame and mechanical parts for the contractor's jumbo, which would be used for drilling in the new penstock tunnel, had arrived at the site and were being assembled by the end of November. Rails upon which the jumbo would operate were installed to the face of the rock, preparatory to "holing in". Assembly of the jumbo was planned to include the mounting of a winch on the frame, so the machine could be used for mucking as well as drilling.

A conference between the General Construction Company's Project

Manager, the District Project Engineer, and the Superintendent of District was held on November 29. Subject of the meeting: The continued lack of progress at the construction site.

It was pointed out to the contractor that if the hauling of spoils was started at once, 150 to 175 truckloads would have to be removed each day from the Foundation and the tunnel, in order to complete the contract on time. It was also stressed that something would have to be done about the recurrent equipment failures. The contractor promised that another truck would be sent out to the excavation that day, and that whatever additional equipment was necessary would be obtained immediately. The contractor also said that a 30-cubic-yard dragline would be put to work in the pit, as soon as it became apparent that the shovel could no longer easily handle the job. The contractor said he planned to re-schedule the entire job to insure completion within the allotted time.

During the first week of December, muck removal from the new penstock tunnel began to catch up, and excavation continued on a three-shift-per-day basis. Three trucks and the contractor's old shovel were in operation. A grade of about plus-1 degree remained between the bottom of the excavation and the penstock tunnel invert, as of December 2. On December 4, the overcut excavation north of the powerhouse was filled with water, and a 12-horsepower 6-inch diameter pump was installed to remove the water.

Jumbo Begins Tunnel Drilling

As soon as the jumbo was completely assembled and ready for use, the first line-drilling and blasting at the face of the penstock tunnel was done on December 4. Results were good. The contractor's "jumbo" rig, a potential belt number for the name of the jumbo, was used with a connected power line. Another satisfactory blast was done on December 5. The next day, the "jumbo" developed trouble when it was

discovered that the 50-horsepower motor on the rear of the timber frame caused the jumbo to rock considerably during mucking. Work was started immediately to strengthen the jumbo frame.

On December 7, graveyard and day shifts were spent in cleaning the jumbo and reinforcing its frame. Two days later, another round was shot in the penstock tunnel during graveyard shift.

Despite the fact that the contractor was operating three shifts, progress continued to be very unsatisfactory. Progress in the tunnel work since December 4th had averaged about one round per day, with an average depth of eight feet. The tunnel heading on December 8 was at approximately Station 0 plus 94.5 "PE" line, or a total of 36 linear feet of tunnel drilled to date.

Blasting effect on the tunnel, as recorded on the accelerograph, were moderate up to December 9. Only a small amount of "target tripping" in the Powerhouse took place as a result of the blasting -- a maximum of two targets were tripped by a single blast. The firing schedule was therefore maintained at the same level.

Three shifts continued the tunnel excavation through the middle of December. The contractor tried to shoot at least one 8-foot round every 24 hours and muck out the spoils during the same day. Mucking-line tracks were laid in the tunnel for the first time on December 17, thus enabling a transfer of part of the work-load to the 4-cubic-yard muck cars. All previous mucking had been done by the "slusher" from outside the portal. By the third week of December, the tunnel heading was at Station 1 plus 62 "PE" line, with a total of 104 linear feet excavated.

Further Slowdown Noted

Beginning the middle of the month, operations slowed down to the point where drilling and shooting averaged one round every 36 hours by December 22. With three trucks broken down, hauling was done by a

and to travel for a number of days. When the tower was returned to operation, there was the usual stalled by day results that had not been started. Both the pump and the blower are contained in a room, requiring constant maintenance. The job superintendent had to leave the construction site because of illness, and the project manager led the job himself.

All three shifts were operating satisfactorily. The contractor had considerable field daily in building experience, business and competent workers. He planned to use three shift workers of 10-12 hours, but this did not seem immediately possible in view of the fact that he was having trouble keeping the help he had. But the contractor went ahead with plans to employ the workers to operate the additional work.

Water Seepage in Excavation

The excavation pit for the powerhouse foundation was rapidly filling with water seeping in from the river, even though the pump was in continuous operation. A second 10-horsepower pump was installed on December 18. The large 100-horsepower pump which had previously been used was not disconnected from the supply.

Another conference with the project manager on December 18 resulted in the fact that the contractor had not yet had sufficient time to the river building of the powerhouse excavation. He made a proposal to shift the working line back to the bank and bring the work back to the excavation area. Up to that time, such work had been done out of the tunnel to dump the material. The powerhouse foundation area. There it was picked up by the derrick and loaded into trucks. City officials pointed out to the contractor that this was not only a costly process, but it also hindered the entire excavation work. The contractor said he did not want to definitely permit it, but that he would do it just for the work was to proceed, but he would have to be notified

increased operations by Monday, December 27.

The contractor said that a mining expert would be on the job three days each week by the end of the month, with some additional miners. At this conference, every conceivable effort was made to get the contractor to take decisive action to speed up his work. (Following the meeting, the contractor withdrew his caterpillar which had been working in the spoils area. He said the engineers were bringing pressure on him to proceed with the construction work. The "cat" had been borrowed).

Excavation in the Adit

Along with the other excavation, several rounds had been shot in the adit invert, but the muck was not being removed. The adit invert was about 40% blasted by December 22. The contractor's attention was called to the fact that he still had some shooting to do in the sidewalls at the intersection with the penstock tunnel, and that if he continued to take out the invert, it would only increase the height above the floor at which drilling would have to be done.

The General Construction Company ceased operations at 8:00 a.m. December 23, for the Christmas holidays. Work was resumed on Monday, December 27.

As the year 1948 drew to a close, the contractor reported the following developments regarding the works at Gorge:

1. More chuck tenders were being brought in to replace the jackhammer men who had been working at chuck tender jobs. Consequently, the contractor said, increased progress in drilling operations could be expected.

2. Tunnel drilling would be done entirely separate from the Powerhouse excavation. As soon as the tunnel as adit intersection was completed, muck from the tunnel would be taken out of the adit for the

first time.

3. The grades next to the Powerhouse would be excavated first. Then the shovel would change over to a dragline, and would be backed out of the pit, bringing the excavation down as it moved out.

4. The man who had been superintendent at Ross Dam for General-Shea-Morrison would be transferred to the Gorge project as outside superintendent.

Because of the shortage of experienced men, work in the adit and penstock tunnels continued to be extremely slow. Four drills worked at the tunnel driving, and a small jackhammer crew continued the foundation excavation which had arrived at elevation 503. The additional crews which had been promised by the contractor, had not arrived by the end of the month. The job was very short of experienced chuck tenders. Blasting was resumed in the penstock tunnel December 27, with no significant vibrations recorded on the instruments.

The jumbo continued to be the main bottleneck in the mucking job, because various steps in its operation and maintenance continued to consume a great deal of time. Trucks were intermittently idle because, once they had hauled the spoils from one round, there would be long intervals when no additional muck was available. A four-man jackhammer crew began drilling December 30 at elevation 503.

Safety Precautions Instituted

In late December, a State Safety Inspector visited the excavation area and recommended that the contractor build a new shed for storing blasting powder. He also suggested that the tunnel portal should be shored up in the collar area. Work on the latter began early in January. At the same time, the Skagit Project Engineer requested the contractor to hire a safety man to inspect all the rock workings. This request was prompted after a falling rock from the scaling work in the

penstock tunnel narrowly missed one of the workmen.

The tunnel heading on December 28 was at Station 1 plus 86 "PE" line, with a total of 128 linear feet removed.

In the adit invert, a caterpillar and a shovel were at work mucking out spoils, while one wagon-drill worked on the excavation. Nearly 40% of the adit tunnel floor had been excavated, after the floor had been dropped about five feet to grade. On December 28, the contractor began dumping spoils in a newly-approved area on the west bank of the Skagit River, across from the Powerhouse and between the railroad and suspension bridge abutments.

About the time the General Construction Company hired their new outside superintendent, drilling and removal of muck picked up considerably. But this accomplishment was minimized by the insufficient supply of experienced manpower. During the first few days of 1949, drilling and blasting continued slowly. Work was started on the laying of blower pipe into the penstock tunnel, and the shovel began to remove part of the berm against the crib.

On January 3rd, the key at the south intersection of the penstock tunnel with the adit tunnel was shot out. Two days later, blasting uncovered a fault seam about two feet thick extending down at approximately a 45-degree angle. This appeared to be the same fault seam which had been encountered previously in the adit. The same blast which uncovered the fault also reached the adit tunnel in the upper north corner by breaking through the adit floor. The adit offset at the intersection of the tunnel was blasted out over this breakthrough.

As soon as the intersection of the adit and the penstock tunnels had been accomplished, rock from the adit was diverted through the latter in sufficient quantity to allow continued shooting. None of the invert back of the tunnel line (toward the tunnel) had been removed. As a result

of the aforementioned blasting and mucking operations, muck was beginning to fall through the adit into the penstock tunnel.

It was decided to move the fall road out of the pit, at this juncture. But, since this would involve cutting into the slope next to the bridge abutments, concern was expressed by both the City and the contractor. It was doubtful, in the minds of those at the scene, that the slope would hold up with a 3/4-to-1 incline, as shown on the drawings. If this work had been carried out according to alignment and grade, the road approach to the east end of the Powerhouse bridge would have been eliminated. With respect to this problem, the following alternatives were considered:

1. Cancel some of the excavation called for by the contract in order to preserve the bridge, leaving the unfinished excavation for a future contract, or,
 2. Make a cut of about 1/4-to-1 at the east (Powerhouse) end of the bridge and place sheet pile in order to retain the approach road, or,
 3. Build an access road out and under the east bridge abutment.
- This road could be used to clean up the excavation for the contract and provide excavation for future contractors.

Four jackhammers and a separate foreman had worked in the Powerhouse foundation pit all week, preparatory to blasting rock away from the corner of the Powerhouse. Shovel and trucks were doing satisfactory work in hauling away spoils, during this early part of January. About 390 cubic yards of excavation were taken out during the week ending January 6.

Increasing water seepage was beginning to flood the excavation, as the volume of water became too great to be handled by the 40-horsepower pump. The City's 100-horsepower pump was again installed, but mechanical failure prevented its use until January 9.

The contractor was given permission to build an access road from the Powerhouse foundation to the spoil dump under the Powerhouse railroad bridge, thus applying the third alternative mentioned above. The contractor was also in the process of shifting his access road to the limits of the excavation on the river side. This was done to give him access to materials for excavation in the bottom area.

Excavations Speeded

The contractor's ability to organize his excavation crews showed considerable improvement by the middle of January, and his operations attained a certain amount of long-sought speed. Progress continued to be somewhat slow in the penstock tunnel, but this was understandable and, in most cases unavoidable. A dangerous situation had been encountered by the undependable nature of the rock in the adit roof. The roof could easily have collapsed, if considerable care were not taken in the blasting. In pushing the tunnel over and past the adit, great care had to be exercised because of the instability of the adit roof.

There was an ever-present danger that additional blasting might caused the roof, and possibly the entire area, to collapse. It was imperative that some decision be made immediately regarding whether to continue blasting at considerable risk until the roof could be timbered, or whether to delay drilling operations several weeks in order to build a steel and concrete reinforcement.

It was decided to exercise extreme caution and use a specially--reduced program of firing, and proceed through the danger area. Following the recommendations of the State Safety Inspector, the contractor began scaling down and planking over the adit roof above the penstock tunnel intersection. He did this after shooting a round on January 13.

Blasting rounds were reduced and special shooting procedures

were carefully calculated and successfully employed for the next several days. On January 13, the tunnel passed the adit with only a slight loss of minor rock. The tunnel heading on that date was at Station 2 plus 53 "PE" line, with a total removal of 195 linear feet.

At the foundation excavation, jackhammer and wagon-drill work continued on two shifts, with blasts being made as the holes were drilled. About fifteen men were employed in this work, and progress was exceedingly slow. Benches were nearly complete in the southeast corner of the pit, next to the Powerhouse. About 180 cubic yards of excavation were hauled out of the pit for the week ending January 13, and nearly 300 cubic yards were removed the following week.

On January 18, a blast at elevation 503 at the berm near the north wall of the Powerhouse knocked out several window panes in the operator's room and the floor immediately above.

Planking of the adit roof was almost finished in late January, considerably reducing the falling-rock hazard. Timbering of the adit according to the original plan was to proceed, as soon as final cross sections were taken and a design was made. In the meantime, occasional falling rock in the adit continued to be a source of danger.

Mucking Time Improved More Than 100%

Near mid-January, the contractor changed the operational setup of his "slusher" by installing a heavy plate chute. He also moved the controls forward to enable the operator to follow the scoop movement more closely. After this changeover, mucking time was reduced to about seven hours, whereas the previous average mucking time was near sixteen hours. The time between rounds was also substantially reduced until, by the end of January, it had been cut to eighteen hours (compared to the previous average of 36 hours).

Thus, the contractor was making a concerted effort to rectify

the slow-moving rate of progress. Only drilling and loading remained to be speeded up, and to do this it would be necessary to obtain more experienced miners. To add to troubles at the Powerhouse site, the weather became very cold, causing a further slowdown.

Drilling and blasting was resumed in the penstock tunnel on January 17 -- on a slightly reduced basis. The caterpillar had been in the repair shop for several days and the spoils dump had not been leveled off during that time. Mucking time had been considerably improved; it now took six hours for an eight-foot round. Trucks were hauling on the day shift only. The spoils dump adjacent to the school house was almost filled by January 20, but it was decided to continue dumping in the area until the spoils reached the school building, with a small space to be left to allow for opening of the basement doors. After this point had been reached, it would be necessary to find a new dump area.

During January, two 50-horsepower Pomona-type pumps were set up in the foundation excavation area. This enabled the contractor to use the 100-horsepower City Light pump on a standby basis exclusively. The contractor began to add more sheeting on the tailrace side of the old timber crib, also pumped in bentonite to seal the backfill.

After the contractor shot rounds in the heading and in the foundation area, on January 22, Gorge Powerhouse generators were shut down and the tunnel was unwatered during the night. The next morning, survey crews checked the alignment and grades of the existing power tunnel, and found that these conformed to the design drawings. Strain meter installation in the tunnel was checked and, found defective, a new one was installed as a replacement. All strain meter leads were hooked up to United States Bureau of Reclamation instrumentation. Readings during blasting were subsequently taken from these instruments, instead of the City Light accelerograph which had been used since October.

While no water was encountered, the contractor struck the ten-foot pipe valve at the last blow, and capped the pipe waterline. The tunnel was drilled until the next morning, January 29.

Drilling Depth Reduced

As the puncture in the lower tunnel was closed, the D. C. project engineer, G. A. Butler, ordered the depth of the tunnel below section ten feet to six feet. He also ordered that chamber pumps along the waterline should be used for going around the curve. When the tunnel heading reached the curve, two of the chamber pumps were fired -- this was January 31. The following day, a revised blasting pattern was put into effect for the third round of blasting around the curve. These actions were taken until the rock of water section had had been discovered during an inspection by State health officials. It was thought that this curve might extend through to the next section, but since it was there, a more important reason, however, was to determine whether strain had been caused on the lower tunnel section. Later, as a result of blasting in the new tunnel.

Work on the new tunnel was shut down for the weekend of January 29-30.

The foundation excavation continued to be hindered by water seepage. It was impossible to work with the excessive amount of water which was coming through the foundation west of the powerhouse. When another day failed to halt the flow, the contractor turned his work more strictly on the hillside side of the old timber crib. A concrete pump was pointed into the crib to fill in an effort to consolidate and seal the rockfill. These efforts proved equally fruitless. And when the pump was still down for one hour on January 1, still more water entered the excavation because the electric wires could not operate.

When the lower tunnel was again started (January 13) a mixture

of sand, bentonite, and straw was shoveled over the tailrace side of the south cofferdam in an attempt to seal off the persistent leakage, but this attempt was similarly unsuccessful. Later in the day, the contractor installed a well-point system in the west cofferdam, hoping this would keep the cofferdam dry and in a stable condition. During these attempts to stop the water seepage into the foundation excavation area, almost all work there had stopped. All work was being done on the day shift on this excavation.

Work Begins on Access Road

The shovel began excavation on the 3/4-to-1 slope at the east end of the railroad bridge on February 1st. The contractor planned to re-route his access roadway out of the pit, in order to clear the north pit area for excavation as soon as possible. On February 7, the shovel began digging west of the excavation area, adjoining the one-to-one slope between the foundation and the river. This work was stopped the following day when considerable washing of sand through the west cofferdam gave indications that further excavation in this area might wash out the dam. It appeared that a sand bar under the outside berm (next to the river) was sluffing. It was extremely doubtful whether the berm would hold long against the water. Protective measures to insure against, and remedy, the sluffing were immediately planned.

The occurrences, combined with adverse weather conditions, brought foundation excavation to a near standstill. A heavy snowfall added to these difficulties and made it particularly hard to continue shovel excavation and jackhammer work. There had been no foundation excavation on any shift for quite some time.

In driving the penstock tunnel, the average time between rounds remained at about eighteen hours during the first week of February. The tunnel heading on February 3 was at Station 3 plus 71 "PE" line, a total

of 210 linear feet of tunnel having been driven. On February 2, a survey crew checked the tunnel for high spots and marked them for plugging during the final clean-up. The tunnel, as a whole, was found to be well clean up to the 430 line. Work on the vent pipe leading into the tunnel had been completed earlier in the month, and the pipe was being used to clear the tunnel of muck resulting from the blasting.

Disposition of Muck Decided

On February 3, the contractor finished boarding up the remainder of the new penstock tunnel in the adit area, and set to work mucking out the adit invert (from the power tunnel to the portal). An especially-rigged Catloy hoist, an air winch, and a caterpillar were used for this job.

On February 4, the Skagit Project Engineer notified the contractor that he should drill only as far back as the end of the adit invert, leaving mucking operations to the next contractor. The front end of the adit, however, was to be cleaned up to grade in the invert side of the arch. In conformity with the specifications, no timbering was to be done.

At this time (early February) the tunnel had rounded the second curve and was proceeding on the tangent. The tunnel-shooting diagram was revised at the job to a pattern similar to that employed early in January, except for the retention of fast delays to blast out the core. However, during an inspection February 6, C. A. Cutler, Skagit Project Engineer, asked that the diagram be returned to the revised pattern for remaining tunnel excavation. The only change in this revised pattern, as suggested by him, was the use of slower delay caps for shooting out the core, instead of the fast ones then being used.

Tunnel-driving continued through February 11, with the shovel excavating in the pit. A small jackhammer crew was working, but only on day shift. The contractor was working on cables and cable anchors

For suspending a third pipe to be used in watering the foundation. Tunnel work ceased for the weekend out, February 12-13.

Tunnel Unwatered for Meter Installation

On February 13, Lawrence Lighthouse Tunnel was unwatered for the installation of two strain meters a considerable distance up the tunnel. These instruments were to observe future shifting reactions to shock in the new ventstack. One strain meter was installed on the sidewall of the houseless tunnel at the downstream point where the new tunnel was to intersect with the main tunnel. Another meter was placed 100 feet downstream from this point, also on the sidewall. These two new gauges replaced the ones previously installed upstream from the point where the split joins with the main tunnel. Lead lines were run from the two new instruments through a ten-luck wire in the split plug. The following day, the lead lines were extended to the powerhouse and connected to the indicator. Readings were slated to be taken during the next shift.

Special train was run to the construction site on January 10 from Portland, bringing contractors and suppliers who wanted to inspect the tunnel and excavation work for which bids were soon to be opened, under specification 896. Included in the group were representatives of the Guy F. Atkinson Company, Macaulay-Hillings Construction Company, the Lewis and Hudson Company, Central Construction Company, the Federal Construction, and Seattle City Light.

The visit coincided with the unwatering of the power tunnel. Consequently, the windings were able to inspect the entire length of the tunnel with a view toward the impending struts, repairs, and maintenance work. The intake and surge tank were observed from the tunnel. Following the inspection tour, a comparison of the work with the schedule was the construction manager's review of the job. This left the special train there all morning (January 10).

Heavy snow began falling during the afternoon of February 14, and assumed blizzard proportions through the night. By morning, more than eighteen inches had fallen, closing the road to Newhalem, and stranding many of the workers away from the job. Thus, the contractor had only a skeleton crew available for work after the weekend out.

Slides, Snow, and Rain

Work was resumed during the day shift, and drilling continued in the penstock tunnel, and excavation went on in the Powerhouse foundation. A tunnel blast on February 15 was recorded on the new strain meter hook-up, with no adverse effects recorded. The tunnel heading on February 16 was at Station 4 plus 46 "PE" line, showing a total of 388 lineal feet of tunnel driven.

Snow and rain continued intermittently throughout the week, resulting in a series of dangerous slides. On the 16th, slides between the Powerhouse and East End Dam blocked the normal flow of water for a half-hour during the afternoon. When the river finally broke through the slide, the high crest coming down the channel topped off at 498.5, with at least a foot-and-a-half going over the west berm (elevation 500). Powerhouse reports were that a current of about 9,000 second feet were flowing during this crest. Several similar crests occurred during the day and night, as a result of succeeding slides.

The 26,000-volt line between the East End Dam and Gorge Powerhouse was knocked out by slides on February 16. As a result, the contractor was without power for an extended length of time until a break could be made in the line a few hundred yards upstream from the job site.

During the power failure, the contractor was set up to blast in the elevation 459 bench area. However, he decided not to shoot because of possible danger to his main pump. He thought it might be damaged by flying rock.

To lessen the danger of damage by flood conditions, the tail-race holds for the west end of the suspension bridge sway bracing were moved to a higher elevation. Guy wires were fastened to temporary "dead-men" in the river bottom. This work was done by the contractor's chief rigger, assisted by City Light survey crews and inspectors.

Several loads of riprap were dumped around the side of the east railroad bridge abutment where excavation was taking place, during the afternoon of February 16. This raised the elevation at that point to 498.5 to 500 feet. Additional riprap was dumped in this area on February 20, further raising the elevation to 501.5, to insure the water remaining below the cofferdam.

The contractor's work in the Powerhouse foundation excavation was sporadic. Since February 15, a six-man drill-and-jackhammer crew had been working on the day shift, but the continual, persistent snow hampered work in the pit. This made it especially difficult to get to the dumping areas.

Work Continues to be Slow

Another five-inch snow fell during the night of February 18. Operations were closed down the next day, except for minor jackhammer work, for the weekend out. Over the weekend, the shovel was taken out of the pit, and changed to a dragline. And the jumbo was being repaired.

February 21st saw the completion of an eight-inch storm drain behind and downstream from the schoolhouse. This enabled the resumption of spoils dumping in this area. A fleet of City Light caterpillars, which had been cleaning out the switching yards near the Newhalem warehouse, scattered a stockpile that General Construction Company had piled there for use in road maintenance work.

On the same day (February 21) the contractor resumed work in the new penstock tunnel, and began excavation with the dragline in the foundation.

Drilling was done for eight-foot tunnel blasts, with the average time between rounds being about 24 hours. The contractor blasted in the elevation 497.25 bench.

Trucks dumped several loads of muck on the toll of the 3/4-to-1 slope at the east railroad bridge abutment on February 22 and 23. Cement was ordered for the proposed guniting of this slope. The Skagit Project Engineer, C. W. Cutler, gave orders to keep a constant check on the Skagit River flooding stage and be prepared to flood the pit whenever advisable in case the river threatened to overflow the elevation 500 cofferdam.

The jackhammer crew working in the adit invert, began to drill for "plugging" on February 25. Carpenters were planking the adit over the tunnel, and preparing to muck out the rear end of the adit. Plugging rounds were shot out on February 28.

Strain meter photographs, taken during blasting in the tunnel, showed there had been no strain in the tunnel lining since the new meters had been installed. But an 8-foot round which was shot in the tunnel on February 27 showed an increased strain on the tunnel strain gauge at the intersection with the old tunnel. Only a slight effect was noted on the downstream meter.

Dragline Catches Up With Muckers

While the dragline was being repaired during the early part of February, mucking operations fell far behind schedule. By February 28, however, the machine had caught up on mucking and was moving out the foundation rock. On the same day, a City Light crew began the work of removing the 100-horsepower pump from the south cofferdam.

As March began, the tunnel heading was at Station 5 plus 44 "PE" line, and a total of 486 feet of tunnel had been driven. The remaining portion of the contract was therefore represented by fifty feet of

slot-iron section, plus fifteen feet of regular driving.

Special driving pattern was put into effect on March 1, in order to reduce the directional shock against the old tunnel. Measurements had indicated that shock in the direction of the tunnel itself was being felt to be felt at the bifurcation point. This development had been anticipated earlier. It was decided not to drive the pilot tunnel as called for in the specification, since changed driving methods were thought to be less injurious to the old tunnel.

Excavation in the Longhouse foundation area was continuing at an increased rate. During the first week in March a number of beams of various sizes had been laid out, and the excavation was deepened about three feet. As a result of a number of errors in level, however, at the deepest foundation point. Water seepage through the beams continued to be in some water, but the leakage was minor. Likewise, sluffing was not excessive. A large part of the dirt fill in the area was isolated. The remaining sluff remained to be made in the open area north of the foundation excavation.

Bridge Piers Reinforced

The Lane Re-tiling Group, contractors for Lane Division, have been working on the protection of the suspension bridge pier on Highway 2. Early in March, the work was going on the raising of the pier, and the installation of beams and reinforcing steel bars. All this was being done in preparation for connecting the bridge. Concrete pouring began March 7, and the entire pier from one wall on for some distance both up and down slope. The work was completed, however, between March 10th and 11th.

The bridge work continued through March 11th, including the installation of the last of several (water) pipe sections. Further details to be revised instructions -- the best results -- should only

a slight increase in the strain meter reading, and no reductions were made in the blasting. The contractor was asked to use timber mats on all future shooting in the higher elevation foundation benches, because flying rock from the blasting had been getting by the steel cable nets which were in use at that time.

The contractor was working day and swing shifts on the foundation excavation. Mucking had begun in the adit invert back of the point where it intersected with the penstock tunnel. Jackhammer and wagon-drill crews continued working on day and swing shifts.

The contractor began stockpiling tunnel and foundation spoils near the railroad tracks at the lower end of camp, on March 10. This rock was for use in riprapping the Skagit River Railway embankment about $3\frac{1}{2}$ miles below Newhalem. At this point, the river was washing out the railroad bank. On March 12, trucks began dumping in the lower spoil road area, filling spots in the highway.

Special Conference Called

A conference between City Light officials and the contractor was held at the office of the Skagit Project Engineer, concerning the failure of the General Construction Company to fulfill some of its promises. The contractor had agreed the previous week (in a meeting with the Superintendent of Lighting) to employ three shifts drilling in the pit, and two shifts to do the mucking work. This had not been done. Nor had the additional trucks arrived, as promised by the contractor. Also, the contractor had promised to put on a graveyard shift beginning March 14.

After the contractor was notified of the termination of tunnel drilling, he set to work removing the track and invert material. He said he would try to carry out clean-up operations on a three-shift schedule. The contractor also agreed to clean up the schoolhouse spoils

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as it extended. The grade was pronounced satisfactory.

Final Clean-Up Operations

A good job was being done in cleaning up the tunnel, with two shifts working. But the work was not going fast enough to assure completion by the end of the week. A high spot was found in the tunnel invert; it was drilled and blasted March 16. The following day, the contractor fired a clean-up blast on the elevation 502.87 bench, when it was found unsatisfactory as to final grade. Tunnel clean-up was at Station 3 plus 18 "PC" of the upper curve, on March 17. Clean-up work in the adit invert was completed March 20, and all tight spots had been plugged. The school house spoils area was still in use. The contractor had graded it down as much as was possible, but frozen ground prevented immediate completion of this work.

During the morning of March 18, the contractor began excavating to final grades on the berm next to the crib. However, excavation was stopped by order of the Skagit Project Engineer because both water leakage and sluffing had been discovered. Either one of these factors could result in damage to the crib cofferdam, in case of high water. The total amount of water coming into the pit did not exceed the capacity of the pumps. The contractor went ahead with removal of muck, but took out only as much as was safe to prevent sluffing of the bank. The last muck was picked up and dumped at the site which was to be graded for a concrete testing laboratory.

The final shift for this contractor was completed at midnight, Sunday, March 20, 1949. The next few days were spent dismantling and loading equipment, compressors, dragline, etc., using a City Light derrick to load onto cars. Cleaning up of the work site was accomplished at the same time. The last personnel of the General Construction Company, contractors for the Gorge Powerhouse Extension, Excavation and Penstock

Tunnel Unit 24, left the camp site on Tuesday, March 29, 1949.

Work under contract Specification No. 824 was completed.

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GORGE POWERHOUSE EXTENSION

Record
of
Construction

Seattle City Light
Skagit Project Division

66 1055 - 3 of 1000

This volume is a compilation of essential facts and photographs taken from the daily diary written by the field forces of City Light Project Engineer.

P R E F A C E

This is a record of construction and installation activity during contract work on the Gorge Powerhouse extension project. Having been written in retrospect, some explanation and qualification should be made regarding its content.

Because the passage of time has relegated all events to their respective roles of importance, this review has had the advantage of hindsight and post-judgment. And while the report may be devoid of minutia and petty detail, it may also lack the color and continuity which a day-to-day contact would have provided.

Points of conflict, personalities, minor labor squabbles, and individual biases have been completely rejected, except in cases where they seem to have had a definite bearing on progress.

No attempt has been made to define, clarify, or explain certain technical terms, because it is assumed that this report will be read only by persons to whom such terms are familiar.

This, then, is merely an account of construction.

* * *

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Early in 1949, Seattle City Light embarked upon the final step in the Gorge Powerhouse Extension Project, when construction began on the Powerhouse addition, the penstock tunnel, and appurtenant works.

Preliminary excavation for the expansion of facilities at Gorge Powerhouse was done by the General Construction Company. This work was done under Specification 824. When this work was completed, the Board of Public Works for the City of Seattle opened bids for the final phase of construction.

Only two bids had been submitted when the bids were opened on February 23, 1949. The Guy F. Atkinson Company, of San Francisco, tendered a bid of \$3,188,268.00 and was awarded the new contract on March 9, 1949.

The unsuccessful bidder for this contract was the General-Shea-Morrison Company, which had been contractor for construction at Ross Dam. Their bid was in the amount of \$3,240,595.00 -- more than \$52,300.00 over the Atkinson bid.

The new contract was to be carried out in accordance with City Light Specification No. 895. It included construction of a reinforced concrete addition for Unit 24 at the north end of the old Powerhouse, completion of the penstock tunnel and intake by pressure grouting, and excavation and completion of the tunnel bifurcation and surge tank.

The Powerhouse extension itself was to provide for the installation of 60,000 kilowatts of additional generating equipment, the output of which would be about 40,000 kilowatts with the existing head of water at Gorge Dam. Completion of the concrete Gorge Diversion Dam was designed

as a means to provide considerable increased head at the Gorge Powerhouse.

The new addition at the upstream end of the existing Powerhouse was to be approximately 95' x 106', and comparable in height to a three-story building. The new penstock tunnel was to be 600 feet long.

Atkinson Representatives at Site

A preliminary investigation of the construction site was made by seven men from the Guy F. Atkinson Company on March 14-15, in order to determine their first course of action when employees and equipment began streaming in to the job, beginning March 21.

The Superintendent of Lighting issued the official notice to commence work on March 23. The contract was to extend 600 days from that date. Thus, the completion date was set at November 13, 1950.

By agreement with the General Construction Company, the new contractor took over certain building materials, warehouses, sheds, pumps, piping, and powder magazines which remained at the site. Immediately after the cross-sectioning of the pit had been completed, the Powerhouse excavation was flooded to stop leakage through the berm. The first construction to be started by the new contractor was the erection of a 120-man bunkhouse on March 23. The area had been previously bulldozed and surveyed. At the same time, the contractor built a walkway into the penstock tunnel, installing a portable air compressor. Both of these were for use in the core drilling operations. Selection of locations in the tunnel for pressure gauges and core drillings was made by men from the United States Bureau of Reclamation, on March 24. A three-man drill crew arrived a few days later and, on March 29, began chipping, grinding, and taking test cores.

A good indication of how well things were progressing under the new contract can be found in the construction of the bunkhouse and messhall. Both were well over half completed by the first week of April. Installation

of heating equipment and electrical wiring was going full-pace, and the sewage disposal system was ready to be put in, as soon as it was approved by the State Health Department. Early in April, work was hastened on another bunkhouse -- this one to accomodate 140 men. An office building and carpenter shops were more than half completed by mid-April.

Aggregate Pit Site Approved

After arrangements had been made with the District Forest Ranger, the site for an aggregate pit was located, and a road was bulldozed into the pit. This aggregate was to be used later for the cofferdam and fill around the camp and roads. Dragline excavation of the river bed, and work on the cofferdam were begun April 8; hauling gravel from the upper Goodell gravel pit was initiated on that day, too. Cofferdam work (preparatory to the pouring of concrete) was begun on the day of April 7. More than a dozen trucks were being used in the operation. The pouring of concrete facing began April 10.

Cofferdam facing had been concreted to elevation 498 the next day (April 11), but about 35 feet of the new facing was lost before the day was out. This happened because the concrete had not set sufficiently by the time the morning discharge over Gorge Dam passed the cofferdam. The break was protected temporarily by placing large rock in the area.

The diamond-drilling crew, continuing the United States Bureau of Reclamation work, was ready to take core tests after completing facings on two rings. One test core was drilled at the heading on April 6. The next day, five cores were drilled. And on April 10th, the crew completed drilling all the test cores on the second ring. By the end of the week (April 15) the entire job was practically finished.

For the next several days, a City Light crew moved the transformer bank to the north end of the construction area. Within a week, a transformer

bank had been installed at Devil's Elbow adit. The contractor ran a feeder cable from City Light's 750-kilowatt transformer bank to his own 2500- to 400-volt bank in the construction area. Meanwhile, a crew drilled anchorages for the skyhook on the west anchor, and ran an air line to the east anchor. Toward the last of April, linemen started on the 26,000-volt line change to clear the skyhook.

Work on the main part of the cofferdam was completed April 15, and more concrete was poured on the upstream side of the rock jetty at the north end of the cofferdam, three days later. Erection was begun on the forms for a five-foot protection wall on top of the cofferdam, reaching from the upper end to approximately 50-feet south of the bridge. This latter portion of the cofferdam was left low, to permit trucks and shovels to pass under the bridge. On April 18, work was begun on grout holes in the crib wall south of the Powerhouse excavation. Meanwhile, excavation of the west river channel continued under the bridge to the Powerhouse.

Camp Site Alive With Activity

Construction of camp, shops, and office building continued full-scale, and an area was cleared for a trailer camp and parking. The contractor also cleared the plant area, preparatory to the construction of his own plant. Plans called for filling the old mill pond, and removing old sheds in the trailer camp area.

Upon completion of the penstock tunnel strain gauge drilling, the staging was removed, and preparations were made for drilling the bifurcation. Air and water lines were installed, and crib platforms were erected in the heading.

By the end of April, the contractor's messhall, bunkhouse, camp office addition, and warehouse were practically complete. Work continued on the parking space, trailer area, 140-man bunkhouse, and sewage system septic tank. All these latter improvements were in lesser

stages of completion. In the construction area, the contractor's office building, saw shed, 440-volt bank, and cofferdam were complete — or within a few hours of being completed. Work on the electric shop, machine shop, skyhook installation, moving and rebuilding the warehouse, and cofferdam grouting were going extremely well. The 140-man bunkhouse (as far as it was completed) was capable of housing 60 men, and the construction crew was already occupying the building it was building. The camp facilities were adequate to take care of all the men needed at that stage of the operation.

The skyhook was already on the job, and the skyline was expected in operation before May 3. An inspection of the hairpins and anchors showed them to be very satisfactory; each had been sunk seven feet into rock, and had been sulphured in. Each hairpin was made from two-inch stock, there being seven hairpins on each end of the gut. The 26,000-volt line had been placed in a wooden trough under the area crossed by the skyline. Wooden guards over the trolley system were practically complete.

No Work On Overlapping Excavation

Up to this date (late April) no work had yet been started on the excavations which had be left unfinished by the General Construction Company. This work had been assumed by the Guy F. Atkinson Company when they received the new contract on March 9. The left-over work was being held up, until grouting could be completed on the cofferdam.

First-round drilling in the heading of the penstock tunnel was started April 22. Plans were being made to begin shooting during the next tunnel shutdown, April 30. Four engineering crews were lined up to enter the tunnel immediately after the unwatering, to locate, mark, and record all leaks and weep holes in the concrete liner, for references to be used in grouting and re-weeping the liner. This work had to be accomplished by May 1, so crews would be out of the way when full-scale

operations began in the tunnel on May 2.

By May 6, drilling and shooting in the adit had been carried almost through to the steel bulkhead. The contractor was completing the access road into the tunnel, through the adit plug. He was planning to use an electrified jeep (already on the site) for moving men and material into the tunnel.

Pumping out the Powerhouse pit was started the last of April, and by May 5, it had progressed to the point where excavation could be started there. The excavation in the foundation had to be halted soon after it had begun, however, because of seepage through the cofferdam.

As work on the cofferdam tailrace extension continued, two of the three lifts were placed during the week of May 10, and the third was finished within a few days. Work was also begun on setting up the pumps for dewatering the tailrace. The contractor completed the roadway across the cofferdam to the Powerhouse. When this had been accomplished, the remodeling equipment was moved in and work began immediately on the existing Powerhouse.

When one of the anchor pins broke in the main cable of the skyhook on May 6, the contractor decided to re-anchor both sides. Consequently, the skyhook was out of operation for a week. A manufacturer's representative conducted final tests on the skyhook on May 18, and it was found that the headtower next to the surge tank was weak at the saddle. Reinforcing was placed on the cross beam to remedy the weakness.

By May 20, three rounds on side cuts had been made in the upper half of the penstock tunnel. Mucking was being done by the electric shovel, electric dump truck, and electric jeep. While three jumbos and an air compressor were being moved into the construction area and readied for use, a fourth jumbo was being built.

At this stage of the operation, divers were lowered to inspect

the intake structure. They came up with the information that the intake had not been built in accordance with the drawings which had been approved; rather, it had been built according to an unsigned drawing which was later found in the files. As a result, the construction program was altered to include a trestle for the dragline to replaced the jumbo-and-highline method previously contemplated.

In the surge tank excavation, a rigging crew had erected a working platform while excavation was begun for steel supports for a heavy platform at elevation 742.

It was decided on May 19 that the contractor would execute the streamlining work in the steel tunnel, by chipping away the high curbs. He began this work during the last week of May. The cutting was started at Station 26 plus 00 to 30 plus 00 (both sides), and the following week was done between Stations 19 plus 00 and 31 plus 50. The tunnel-repair crew ground down high spots and chipped out around the old anchor bolts between Stations 109 plus 00 and 113 plus 00.

Seepage Slows Work

Preparation for starting work on change order #1 began with the pumping-out of the unlined section of the tunnel, on May 25. Results were minimal, however, because although the Broome gates satisfactorily sealed off the water, a considerable amount of flow was seeping in through the leaks in the concrete lining. The contractor recommended that some grouting should be done before starting work on schedule #2.

The seepage area was inspected (May 26) by City Light engineers and contractor officials. Several bad holes and a number of poor construction joints were found, giving rise to a belief that extensive concrete repairs might be required. The Skagit Project Engineer planned to discuss the problem at length with the Superintendent of Lighting. Meanwhile, pumping water from the tunnel continued, in preparation for cross sectioning the

unlined section. The contractor was instructed to cut off the outside portion of the high curb only, since the bottom of low sections might later be filled with concrete. This had been tentatively decided the previous day, and the issuance of a change order was planned.

On May 27, the Skagit Project Engineer asked that some test holes be drilled in the temporary tunnel where the concrete had eroded, and also through the logging, for inspection by the Superintendent of Lighting and engineers from the Bureau of Reclamation. Arrangements were made with the contractor to build drill staging in the tunnel. He also agreed to supply the drillers.

Meanwhile, the grinding down of "pour windows" continued in the main tunnel. In this area, the contractor was proceeding with work relative to the chipping out of anchor bolts and the chipping away of the high curbing.

The temporary tunnel was inspected during the afternoon of May 28. The inspection party (including representatives of City Light, the Bureau of Reclamation, and the contractor) observed the grinding operations in the main tunnel, the three penstock liners, the Powerhouse foundation, the invert, and Gorge Diversion Dam.

The contractor worked through Saturday, May 28, then took off the next two days (Memorial Day weekend). During the month of May, the contractor had increased his work force from 187 men on May 10, to nearly 300 men at the start of June. As soon as quarters were available, more than 400 men were expected on the payroll.

As project work continued into June, the degree of completion of the various jobs and areas was estimated as follows:

Parking Area	85% Complete
Trailer Area	95% "
Fire Main and Water System	98% "

P H O T O G R A P H S

All stages of construction and installation at the Gorge Project were recorded on film. Usually, each phase was photographed from several angles to record progress and procedures.

The pictures were taken chronologically. However, no particular order has been adhered to, in the assembly of pictures for this report. Comparative stages of development may be determined from the dates which appear on the face of each picture.

Pictures of the preliminary excavation (under Specification S24) are not included in this report. The review of this phase has been set apart by the letter "A" which follows the first 37 page numbers. Pictures for this section appear in a separate volume on file in the Seattle engineers' office.

The pictures and text of the intake work are necessarily sketchy. This phase of the extension work was originally scheduled under Specification S95, being done by the Guy F. Atkinson Company. It was soon discovered that much of the Atkinson work either overlapped or interferred with work being done by the Cascade-Phillips Company, contractor for the Gorge Diversion Dam. Consequently, the intake work was transferred to the latter firm. Since the intake work is properly a part of Gorge Diversion Dam construction, a more informative and concise description of it may be found in the volume devoted to the Diversion Dam construction, beginning on page 35 of that report.

Five Temporary Houses for

Contractor's Key Personnel	60% Complete
Four Tent Houses	90% "

Construction Area -

Concrete Mixing Plant	85% Complete
Dewatering Powerhouse Excavation	90% "
Penstock Tunnel Excavation	50% "
Adit Tunnel Concrete Excavation	95% "
Devil's Elbow Plug Removal	95% "
Railroad Spur to Construction Area	90% "
Powerhouse Alterations	60% "
Jumbos in Tunnel	75% "

The drilling of grout holes was carried through the first week of June, between Stations 31 plus 00 and 54 plus 00, and also between Stations 112 plus 80 and 111 plus 00. By June 4th, more than 100 feet of tunnel was ready for grouting. Some trouble was experienced with the new pumps while the grouting operations were being organized, but by the time of actual grouting, all equipment was working.

The contractor did no grinding of the invert during May, because he had not been able to find terrazzo machines for vertical grinding. The contractor was requested to grind a small area experimentally with small air grinding machines. When he did this on June 4th, the attempt showed unsatisfactory results. A large terrazzo grinder (weighing 750 pounds) was rented, and experimentation with the new machine was started June 10. The trial with the heavier grinder proved no more successful than had the first attempts with the small grinder. Next, an attempt was made to chip off the exposed aggregate with air chisels. These also proved inadequate. It was suggested to the contractor that he make a steel block to use in place of the grinding stones, since the latter were continually breaking.

This was taken under advisement.

Experts Called In

On June 14, the contractor began making bars for the grinding machine, impregnating them later with borium pellets. Later the same day, a manufacturer's representative arrived at Gorge to look over the grinding situation. After careful study, he recommended the use of silicon carbide 6-inch-diameter stones, $2\frac{1}{2}$ -inches thick, adapted to the terrazzo grinder. Since none of these were available at the construction site, the contractor ordered six by air express from Chicago. It was planned to go ahead with the borium pellets until the new material arrived.

Steel grilling work was in place in the surge tank, by June 5, and was ready for concreting in the footings. During the next week, the floor was completed and preparations were made to start excavation. A two-inch water line was installed, leading from Ladder Creek to the surge tank. Drilling and shooting in the main excavation of the surge tank, and drilling of grout holes there were started June 13.

In the main tunnel, meanwhile, work continued on grinding off "windows", high spots, and chipping around the old anchor bolts. By June 9, this work had reached Station 80 plus 00. A week later, work had moved to Station 67 plus 40. By June 23, when Station 50 plus 60 was reached, this work was halted, in order to divert crews to the chipping and repairing of the concrete liner in the temporary tunnel. Rock crews continued to drill and shoot in the bifurcation.

With the contractor's equipment ready to begin excavating the unlined section of the temporary tunnel, work there resumed June 10th. Preparations were made to cut out the bad concrete in the lined section. This tunnel repair work was being done on force account.

To reduce the amount of time lost in transporting crews to this job, the contractor arranged to carry the men between East End and Devil's

Elbow adit by City Light train. At the request of Cascade-Phillips Company (contractors for Gorge Diversion Dam), a new trail was broken to the Gorge Tunnel permanent intake. This was done to keep crews who were traveling on the City Light train from trespassing in the Cascade-Phillips warehouse and work areas.

The contractor had been repeatedly asked to begin grouting work in the tunnel. But this work had been delayed. Difficulties were faced in putting up the grout pumps and, on June 6, two factory representatives arrived to oversee their installation. On June 8, most difficulties had been ironed out, and grouting finally began. Progress was unusually slow because only one pump was in operation, and it appeared that it had not been set up right. The first grout holes were very tight.

The following stipulations, regulations, and instructions were forthcoming from a meeting on June 13 with the Skagit Project Engineer:

- (1) Grouting could be started at Devil's Elbow and proceed down, providing that grouting was done downhill.
- (2) Grouting was unnecessary on holes showing tight during water testing.
- (3) On low-pressure grouting, six holes would be used, placing one in the invert.
- (4) On high-pressure grouting, where the tunnel was in good condition only the three top holes would be grouted; and in areas of considerable leakage, sufficient holes would be added to assure a complete job.
- (5) A maximum of 150 pounds would be used on high-pressure grouting. In some cases it might be necessary to grout the high-pressure holes a second time.

By June 15, low-pressure grouting had been completed between Stations 31 plus 50 and 34 plus 80. Water testing had been carried to Station 35 plus 20. The drilling of grout holes through the concrete lining had been done from approximately Stations 32 plus 00 to 54 plus 00, and from Stations 112 plus 80 to 87 plus 00.

During early June, the access road to the south entrance of the Powerhouse was completed. All the parts of generators #21 and #22 which had to be shipped out for repairs were hauled over the new road. Powerhouse

remodeling was progressing according to schedule, with only trimming to be done in the concrete excavation. And forms were being constructed for remodeling the control room.

Timber Crib Sump Installed

The contractor began installation of a timber crib sump well. This was intended to lower the water table and prohibit sand from sluffing into the pit. Work in the Powerhouse excavation was delayed while this was being done. By the middle of June, the sump was down to elevation 464, and it was being lowered even further. Excavation for the Powerhouse foundation began about the same time, cautiously and on a small scale.

During June, the contractor was allotted a site for stockpiling aggregate. The site was located west of Goodell Creek bridge, on the north side of the road. When approval was granted by the District Forest Ranger, a portable screening plant was built at the county line gravel bar, and processing began. This was mid-June.

Grinding of the tunnel floor was being delayed until a special grinding machine could be designed and built. Drawings for the new machine and an estimate of materials and cost were submitted by the contractor on June 23. The grinder was designed to have a horizontal mandrel, using a special wide-faced circular stone. The plans were approved by the Skagit Project Engineer, C. W. Cutler, and construction of the machine began immediately.

In the surge tank, all tremieing above elevation 828 was finished by June 19, and the contractor had set up a small diesel shovel in the shaft, to begin excavation. The contractor concentrated his efforts on the surge tank, during the last week in June. Most of the drill crews were shifted from tunnel work to the surge tank. And while the surge tank was being mucked out, crews from that construction were shifted to the tunnel where they were employed chipping and drilling the concrete in the

lined portion of the temporary tunnel. Surge tank drill crews were also used in the bifurcation and Powerhouse excavations. On June 30, the excavation was down to elevation 810, and less than a week later it had reached 794. This work picked up speed as it moved along; by July, it took about 24 hours to drill and shoot, and about 48 hours to muck out for an eight-foot round. Beginning early in July, mucking operations slowed down considerably, when the skyhook line began twisting.

The contractor planned to complete the surge tank excavation by July 15. The steel form for the concrete lining, which was fabricated in Portland, arrived July 7.

Drilling Progresses in Bifurcation

Bifurcation drilling and shooting had progressed during late June to the point where excavation was essentially complete by July 1. Construction of forms for the concrete lining was started at the site. After the Fourth of July holiday, a small crew began cleaning up the invert, and plugging tight spots. An inspection of the bifurcation on Jul 6th showed that there were three serious leaks which the contractor was told to grout before he started to place the concrete.

By the 23rd of June, drilling for first-stage grouting had been completed from Station 112 plus 80 to Station 7 plus 20, on 20-foot centers. First-stage grouting had also been done between Stations 31 plus 50 and 46 plus 00, but progress was hindered by equipment troubles. Grouting machines broke down a number of times because of careless handling by operators. A new grouting machine arrived and was put into operation on June 19, with an additional machine due within a few days. The contractor was advised that his nine-man grouting crews could probably be cut down to five men per crew, with the same results.

By June 26, first-stage grouting had reached Devil's Elbow adit and was continuing at good pace, with holes taking the grout very well in

this area. The new grouting machine had still not arrived by June 28. On that date, the contractor was requested to speed up his operations. He was told that water for grouting was getting to the stage where it would soon be unsuitable. If this happened, water lines would have to be installed. The contractor said pipe for the water line was on order.

Post-Holiday Progress Slow

Tunnel grouting was not resumed for several days after the July 4th holiday. When it did start, the work was unusually slow. To lessen the work of final clean-up before finishing the invert, it was suggested to the contractor that cleaning up around the grout pumps should be done every day. It was also hoped that this procedure would reduce the number of breakdowns that were occurring because of improper maintenance.

The contractor's new grout pump was to be put into operation as soon as a new compressor could be installed. Meanwhile, two grout pumps were in operation -- one at Station 93 plus 00 for low-pressure grouting, and the other at Station 31 plus 50 for second-stage grouting. Water-testing from Station 96 plus 00 to Schedule #2 was completed for first-step grouting. A two-inch waterline had been put into the tunnel for grouting operations.

Toward the end of June, drill crews working in the unlined section of the temporary tunnel had drilled more than half the excavation, and nearly $\frac{1}{4}$ of the invert had been shot out. No mucking had been done to the end of June, because installation of a mucking skip trestle at the permanent intake was not complete. During the first two weeks of July, the balance of excavation was drilled and shot out, and installation of the hauling skip was completed. However, the latter was not long in operation; it broke down after only 25 yards of muck had been hauled. Because of this faulty operation, design changes had to be made in the mucking trestle.

On June 25th, the contractor tentatively agreed to do some diamond-drilling work on the Newhalem crib dam. This agreement was made pending an inspection by Lynch Brothers Diamond Drilling Contractors, so they could give an estimate. Arrangements for doing the actual drilling were made later in July by the Guy F. Atkinson Company.

Meanwhile in the Powerhouse foundation excavation, the contractor was attempting to get the rock excavated soon enough to allow him to get the concrete work above water before taking out the tailrace cofferdam. Progress in this phase of work was excellent. Fabrication of concrete cribbing for the tailrace crib wall was started the last of June, along with removal of the existing tailrace wood crib cofferdam. This work continued throughout July. Work was also started on building the forms and installing reinforcing steel for the Powerhouse alterations.

Preparations were launched the last of June to test-gunite a small section of the invert below the bifurcation. Sandblasting of this section was begun July 1st. The contractor held up further guniting work because he had no velocity meter specifications as required. However, permission was granted to try this first section without the meter. The guniting proceeded.

When completed, the finish appeared to be excellent. But when checked a week later, it was found there was poor bond as well as good bond. Further checking was done by concrete technicians later in the month, and it was decided that the majority of the guniting had been unsuccessful. Plans were made for another test later, this time under the supervision of a gunite expert.

During the first week of July, considerable discussion was held, in an attempt to get the Guy F. Atkinson Company to speed up their operations. Work had fallen behind, to a marked degree. This situation was due largely to the timing which had resulted in a three-week period,

followed by a long Fourth of July holiday.

Officially, there were only three days lost, but some of the men had begun to leave camp Friday afternoon (July 1), and only about half the working force returned to the job in time Tuesday (July 5). It was Wednesday morning before a full force was back in operation. The Atkinson Company re-scheduled the entire project and increased the work force to 415 men in an effort to regain lost time and speed up operations. This re-scheduling had been requested by the City late in June.

Efforts Concentrated on Surge Tank

Uppermost in the mind and effort of the contractor during July was the surge tank excavation. Most of the drill crews were shifted from the tunnel and Powerhouse operations to work in the surge tank. Some delay was encountered when the skyhook tractor engine broke down, but repairs were soon made, and mucking work continued. By July 29th, the excavation was nearly complete down to elevation 760.5, with only final cleaning — and trimming of the high spots — remaining to be done. Preparations were made for placing reinforcing steel and concrete forms, and drilling and grouting before they were placed.

Meanwhile, the bifurcation invert excavation had been cleaned preparatory to placing reinforcing steel and setting forms for pouring concrete. The first section of the bifurcation invert concrete was placed July 14, with other sections being poured regularly during the rest of the month. The bifurcation pouring was completed by July 29, and work proceeded on forms for pouring the penstock invert sections.

Water seepage into the temporary tunnel began to assume increasingly serious proportions early in July. Little work could be carried on in the concrete-lined section, because it had been flooded July 10. An extra three-inch pump was installed to try to lower the

water, but the hydraulic gradient appeared to be higher on July 11. This was probably caused when the river by the Gorge Dam core wall was shut off, resulting in greater seepage through the tunnel. On Jul 13, a four-inch pump was put into operation and the water began to slowly subside.

The shooting in the temporary tunnel was complete by mid-July, but mucking and repair work was not started until July 19. Reason for the lag in mucking work was the concentration of attention upon the surge tank excavation. Most of the crews were working there. The mucking car and trestle were still showing deficiencies in operation, causing extra labor to be diverted for their maintenance. Toward the final days of the month, mucking work began to speed up, and further improvement was anticipated for August.

Water Hampers Excavation

A good start was made on tunnel-repair work during the latter half of July, although operations were handicapped by the presence of a great deal of water in the temporary tunnel. All the contractor's forces which had been employed in grinding and chipping were shifted to repair work on the sidewalls and arch. Satisfactory progress was noted.

While water conditions were somewhat improved, considerable trouble was expected in drying up the section for repairs to the invert. It was suggested to the contractor that the sump hole might be deepened, in an effort to pump the water table lower.

Work on the experimental grinding machine (for use in the invert) was completed, and a test run was made July 15. The trial was considered satisfactory. E. R. Hoffman, Superintendent of Lighting, visited the site while on an inspection trip. He approved going ahead with work on the machine. He said the machine could be used to grind the entire invert, if it could be improved sufficiently. Specifically, the

machine needed a more positive control of steering and a greater depth of grinding.

While the grinder was being altered, experimental grinding was being conducted through the remainder of July. The chief engineer from Willamette Iron and Steel Corporation and a representative of the Pacific Stone Manufacturing Company observed a test grinding on August 1st and made further recommendations for improvement of costs. These changes were approved by C. W. Cutler, Skagit Project Engineer, and the contractor promised to speed work on them. This work was done on force account. The contractor was told that grinding operations would probably be reduced. August 3 was the date set for beginning actual grinding, thus ending experimental grinding as of that date.

Grouting Baset by Delays

Grouting of the tunnel continued slowly to the end of July. Only two grout set-ups were in use. The third pump was ready on July 25, but it had not been placed in operation by the contractor. Some delay was experienced by the breakdown of an electric compressor and a power failure in the tunnel electric system. A great deal of trouble was encountered in sealing off leaks in a bad section of the tunnel at Station 70 plus 00. Two water-testing crews were working in the tunnel simultaneously. And one crew was chipping and burning off bolts, and dry packing. Lights were installed in penstock #22 so crews could clean out trash and open the drain.

On July 27, the contractor complained that the City was compelling him to use only one type of grouting mix. However, an immediate check of the grouting records showed that a good deal of flexibility was allowed in the use of mixes having varying stiffness. High-pressure grouting continued through the upper end of the tunnel. A special crew was set up to catch the bad spots which were still not sealed off after second-stage grouting had

been completed. By July 29, first-stage grouting was finished from Station 31 plus 50 to 112 plus 00. Second-stage grouting was completed from Station 31 plus 50 to 70 plus 00. The second grout pump was working on second-stage grouting from Station 93 plus 00 toward Station 112 plus 00.

Thus, as work continued into August, the following stages of completion of various phases in the project had been attained:

1. Excavation:

Powerhouse Foundation (Uncompleted contract, General Construction Company)	80%	Complete
Powerhouse Foundation (Atkinson contract)	25%	"
Penstock Tunnel (Removing road ballast only)	95%	"
Temporary Tunnel (Unlined section)	50%	"
Powerhouse Alterations (Excavation for doors, etc.)	80%	"
Surge Tank (Excavation to elevation 760.5)	98%	"
(Trimming above elevation 828)	90%	"
Bifurcation (cleanup)	97%	"

2. Forms, Reinforcing Steel, and Concrete Placement:

Powerhouse Alterations (Furnishing and placing concrete)	65%	Complete
Bifurcation (Forms and reinforcing steel)	25%	"
Bifurcation (Concrete placement)	25%	"
Temporary Tunnel (Repairs to concrete lining)	60%	"

3. Grouting:

Grouting equipment in tunnel	50%	Complete
Tunnel drilling- (For first-stage grouting)	95%	"
(For second-stage grouting)	70%	"
Tunnel grouting (First stage)	70%	"
(Second stage)	40%	"

The last week in July, diamond drillers arrived at the Newhalem Creek damsite and set up their equipment to begin driving the casing. The actual drilling was started July 27 at #4 hole. A week later this hole had been drilled to 58 feet, without striking bedrock. On August 10, the drilling was discontinued. The diamond drillers set to work in the

Powerhouse foundation on August 12.

By the end of July, excavation of the Powerhouse foundation was showing more progress than most of the other phases of work. Most of the turbine excavation was down to grade at the beginning of August, and the main excavation was nearly complete by that time.

Excavation under the Atkinson contract was somewhat less than half-finished by the middle of August.

Fault Found Below Powerhouse

With the main pit excavation complete except for pipe trenching, the area was drilled to determine what was below the proposed machinery location. Drilling disclosed a faulty seam section approximately 95 to 100 feet below the turbine pit foundation rock area. This fault ran horizontally along the entire length of the Powerhouse. Its thickness was not precisely determined, but it was known to be between two and six inches. Above this fault at other elevations lay cleavage plates partially filled with mica. The extent of the latter was very slight.

Discovery of the fault led to the decision to drill a number of grout holes to the 100-foot depth. This would effect solidification under the draft tube at the Unit 24 foundation. It was decided that 20-foot grout holes would be adequate under the extreme north end of the foundation where no machinery was installed. The 100-foot fault took a considerable amount of grout, proving the wisdom of having the area explored at that depth. Grouting was begun August 12. It was rushed to completion, so the placing of concrete could begin.

On August 17, the first concrete pour was begun in the Powerhouse foundation. It turned out to be highly unorganized and not in accordance with specifications. The contractor was asked to correct this situation for future pours.

Work in the surge tank during the early part of August was directed

toward the pouring of the first concrete. The contractor pushed work on cleaning up the bottom, as he began placing forms and reinforcing steel. These preparations were completed on August 6, and the first pour was begun. Pouring had to proceed slowly because the rock was overbroken, and the reinforcing steel was very tight. The following morning the pour was still going on, at a rate of about 15 cubic yards per hour. It was completed after three more shifts.

On August 9, work began on the forms for the second surge tank pour, and four days later the contractor was ready for the concrete to be poured. This work had to be held up when inspectors found that the cleanup was unsatisfactory and the forms were not too well braced. After additional cleanup work was initiated, permission was given to begin the pour. This work would raise the surge tank to elevation 768. The third pour was begun on August 22, after work was rushed on the forms and "re-steeling".

Water Seepage Finally Stopped

In the bifurcation a great deal of trouble was encountered with water leakage early in August. The contractor wanted to lead the water off through pipes in the forms, rather than do any more grouting, but he was requested to try grouting once again. He agreed to this, and put one grout set-up to work in the bifurcation rock, before placing concrete in the sidewalls and arch. This job, when completed, appeared to have sealed off the leaks satisfactorily.

Bifurcation cleanup work proceeded through the middle of August, when the contractor began pouring the penstock sidewalls. An inspection on August 15, however, disclosed that the forms were not sufficiently tight to the invert, the reinforcing steel was too close to the forms, and the sidewalls were not washed down. These discrepancies were called to the contractor's attention and were soon corrected.

On August 16, two sidewall sections of the penstock tunnel were poured (from Station 5 plus 09 to 6 plus 48.5). Two more sections were subsequently made ready to pour.

Completion of the bifurcation invert had the tightest schedule of any phase of the work by the end of August, 1949, inasmuch as it was thought the concrete work could just about be completed by September 15. The concrete was to be allowed to age for fourteen days before the final grouting, and the grout was to stand 36 hours before water re-entered the tunnel. A last-minute rush was expected in the bifurcation, since the equipment would have to be moved out through the temporary adit plug, and the manhole would have to be secured -- all after cleanup was completed. For this reason, it was planned to speed up the work in order to allow a bit more time clearance at the end of this particular operation.

Tunnel Work Behind Schedule

Work in the temporary tunnel continued to lag at the beginning of August. This was due mainly to persistently faulty operation of the mucking trestle and cars. Some slight progress was made, however, because a large labor force had been detailed to the specific job of keeping the mucking machinery in operation. On the whole, the tunnel was about 75% complete. And, as August came and went, tunnel progress improved. By August 17, crews had just about completed the rock excavation and trimming of tight spots in the elbow. Placement of forms for the first invert section was also being done.

Repair work in the temporary tunnel was being done on force account. It had been speeded up during the waning days of July, and by August 5, nearly 90% of this work (excluding the invert) was complete. Most of the crews engaged in these operations were shifted to tunnel-grinding and invert work, when the job was finished. Some of the men were put to work in the Powerhouse foundation trenches -- also being done on force account.

Another phase of the work which was being done on force account was the tunnel streamlining job. On August 12, the heavy grinding machine built by Willamette Iron and Steel Corporation was delivered and taken to the upper end of the tunnel, to start invert grinding from that point down. At first the grinder operated well, but after a few days, electrical and mechanical troubles began to harass the operator. The manufacturer supplied replacement wheels without charge, when those on the machine burst repeatedly during use. A stock was ordered from Chicago, since the local manufacturer could not maintain the production required. Various other repairs and modifications had to be made during the month of August, resulting in the machine's being out of operation most of the month.

Because the large tunnel grinder was accomplishing very little, a large part of the grinding job fell upon the smaller machines. It was decided on August 21st that they would be used to grind the center portion of the invert. A small grinder had been working in the invert for a week, and had about 75% of that area ground to a smooth surface. It was also decided that two more small grinding machines would be ordered from the Willamette Iron and Steel Corporation, and that these would be used in place of the large grinder.

Construction Schedule Criticized

Tunnel grouting was progressing slowly by the early part of August, and there were still a number of leaks after second-stage grouting. In order to get the operation moving and avoid continued delay, the Skagit Project Engineer instructed the contractor on August 12 to get the best job possible within the time remaining, and to start drilling weep holes above Station 70 plus 00 immediately. Only two grout set-ups were working in the tunnel, since the others were being used in the surge tank and bifurcation. However, the job was moving along with satisfactory results. In the Powerhouse foundation, all groutings were completed by August 24 and

the leak into the Powerhouse was sealed.

A survey of the entire Guy F. Atkinson project in August indicated a wide variation in the progress of the different operations. Work continued slow in some areas, while considerable acceleration was noted in others.

A difference of opinion existed between City Light engineers as to whether the contractor could complete the surge tank, bifurcation, penstock tunnel lining (to the temporary bulkhead), temporary tunnel lining, grouting behind the liner, and allied work by October 1, as called for by the specifications. A re-scheduling of the work was being effected, to place emphasis on these operations as the key to whether the deadline could be met. The contractor had nearly 550 men on his payroll, and expected to have more than 600 by September. Work was going forward on a three-shift basis, under tremendous pressure. There was a concerted attempt to offset inefficiencies of organization and use of manpower. The vice president of Guy F. Atkinson Company moved to Newhalem to assist in direction of the work.

Bifurcation work slowed down considerably near the end of August. Because the reinforcing steel was not bent correctly, a delay was encountered in making the #3 invert pour. The outside wall form for the elbow was completed and checked August 25, and found to be satisfactory. It was decided at the same time to let the reinforcing steel section (TL-1 arch pour) pass as it was, since the distance between front and back steel was correct.

Pouring in the TL-1 arch began August 27, but proceeded slowly because the concrete was being poured ineffectively. The contractor was asked to remedy the situation, and he promised to get additional equipment and change the pouring method for future pours. An inspection of the arch, after pouring, revealed a need for some corrective concrete work proposed to do by chipping out a little, then pouring the rest with the new

equipment. The contractor was informed that a portion of the arch should be taken out, because of incorrect placement. Chipping work was begun August 29.

After completing the third pour in the surge tank late in August, the contractor set reinforcing steel and raised the forms for the fourth pour. He continued with succeeding pours through the rest of August and into September. By September 15, eight pours had been completed, raising the tank to elevation 816. At this point, the work was more than one-third completed. Only two more 8-foot lifts were necessary to get above the 828.5 level called for by October 1.

The ninth pour (to elevation 832) was made September 26, and the form work for the next pour was ready two days later. Of the work remaining, installation of the floatwell steel casing to elevation 828 was to be made September 29-30. This would leave only cleanup of the surge tank bottom, grouting between concrete and rock on five holes, and placement of a guard over the surge tank shaft, to be completed.

Foundation Work Proceeds

Excavation of the Powerhouse foundation trenches was a temporary point of concentration near the end of August, but little actual progress was made. During September a small amount of additional work was done, but it was estimated on September 28 that only about 15% of this work had been completed.

Meanwhile, in preparation for concrete pouring, carpenter and reinforcing-steel work was done in the Powerhouse foundation. On September 14 pouring was begun in the Powerhouse draft tube piers, but this work was impeded by torrential rainfall. Work finally had to be stopped for a few hours because of a pumpcrete failure.

However, succeeding pours made better progress, as the contractor pushed the work to complete the draft tube concrete to elevation 485 floor

level. On September 23, preparations were begun to pour the 6B section (next to the old Powerhouse), using Hi-Early strength cement because the new tailrace crib-wall would be braced against this concrete. The tailrace crib-wall protection was approximately 75% complete on September 22. Removal of the tailrace cofferdam had been started.

Toward the end of the month, the 6A and 6B pours had been completed, bringing the concrete in the draft sections to the 485 level. The tailrace crib-wall protection was complete, and the tailrace was cleaned of all tunnel muck prior to final removal of the cofferdam. During the morning of September 28, the tailrace was flooded, and final removal of the tailrace cofferdam proceeded.

Alterations to the Powerhouse control room progressed slowly during the first half of September (the work was less than 30% complete by September 15). Beginning September 19, however, this work was speeded up to a marked extent. By September 22, plastering, staircasing, and step surface work was completed. Installation of the acoustical ceiling had begun. The latter was completed the last of the month, except for minor work which would follow the installation of lighting fixtures. The only uncompleted work on the Powerhouse alterations at the end of September was the removal of switchboard protection, and cleanup.

Work on the forms for sidewall pours in the temporary intake tunnel was resumed September 1 and 2, and on September 7 (after a weekend out for the Labor Day holiday -- September 3, 4, 5) pouring of the TL-4 arch and the sidewalls was begun. At the contractor's request, permission was given to increase the cement content of the concrete mix in this area. (This was to be done at the contractor's expense). On September 12, the TL-2 pour was started, using the new mixture, and it appeared to progress exceptionally well.

Throughout the rest of the month the contractor put considerable

effort into completing the temporary intake and bifurcation. The last pour in the bifurcation was completed September 22, leaving only the repair of faulty arch sections and finishing of second-stage grouting to be done in this area.

The last arch pour in the temporary intake was also made on September 22, thus completing the concrete work in the elbow (except for removal of forms, finishing, and cleanup). Installation of the center pier streamlining tailpiece was done from September 22 to 29.

New Grinders Improve Progress

Grinding in the tunnel invert proceeded through September, with recurrent breakdowns and mechanical failures. The two new grinders arrived September 1 and were put into service immediately. By the middle of the month grinding work was showing better progress, with four grinders on the job. The contractor, anticipating future troubles, ordered spare parts for the grinders. By September 22, 1300 feet of tunnel from Station 40 plus 50 to 53 plus 50, and 4300 feet of tunnel from Station 108 plus 00 to 65 plus 00, had been completed. Grinding was accentuated during the rest of the month, with plans to continue the work until the deadline for moving from the tunnel. By September 28 the invert had been ground from the elbow transition to Station 40 plus 00.

Toward the end of September, all scaffolding and equipment was removed from the lined section of the temporary tunnel, and the gate streamlining pier was formed and poured. Only the repair of the invert concrete lining remained to be completed. The elbow transition forms had been removed; the faulty concrete in the arch section had been repaired; the voids in the arch had been grouted. This completed the elbow transition work, except for final cleaning of the permanent adit access, and the final closing of the access mandoor. Similarly, the Devil's Elbow plug concrete and mandoor were finished, with only the

closing of the plug mandoor left to be accomplished.

Work was rushed in the bifurcation during the final week of September. Faulty arch sections were repaired by guniting and dry-patching, all forms were taken out, and the final finishing and grouting was nearing completion. Subsequently, the temporary steel bulkhead was installed in Penstock 24, with welding and riveting almost finished by September 28.

Early in September, the contractor had begun painting the steel liners of Penstocks 21, 22, and 23. This work was finished, except for repainting a three-foot strip along the invert of #23. This section was damaged by an accidental flow of water over the freshly-painted surface. Repair work and final painting was completed September 29.

With completion of the construction adit plug concrete, and the mandoor placement on September 27, all concrete work prior to letting water back into the tunnel had been concluded. Final cleanup remained to be done, and the actual closing of the adit fairing plate and bolted mandoor, too.

Here is the way things had progressed, up to the end of September:

1. Powerhouse Foundation			
Excavation:			
General Construction Company (uncompleted contract)	95%	Complete	"
Atkinson Contract	50%		"
Foundation trenches	15%		"
Grouting	80% to 90%		"
Concrete Placement	25%		"
2. Powerhouse Alterations			
Excavation for doors, etc.	80%		"
Concrete — finishing and placing	75%		"
Piping and tunnel work	50%		"
3. Penstock Tunnel			
Cleamp remains — excavation	95%		"
Concrete in invert, sides, and arch	10%		"
Grouting — first and second stage	100%		"
Grinding and chipping sides and arch	98%		"
Grinding of invert	60%		"

4. Bifurcation		
Concrete placement		99% Complete
Grouting		75% "
5. Surge Tank		
Concrete Placement (to elevation 832)		40% "
Grouting (prior to placement of concrete)		90% "
6. Temporary Intake Tunnel		
Concrete in elbow or unlined section		100% "
Grouting in concrete-lined section		100% "

The official inspection of Gorge Tunnel, preparatory to filling, was made on October 1 by Hoffman, Cutler, Nelson, Forsander, Shevling, Fahlstrom, Lees, and Mattila of City Light; and Hawkins and Fairman of the Guy F. Atkinson Company. The work of moving equipment out of the tunnel and cleaning up was still being done, while the invert was still being ground. After the inspection trip, E. R. Hoffman, the Superintendent of Lighting, decided that grinding should be continued until October 4 (including October 1-2, scheduled as a weekend out) and that the tunnel should be filled the morning of October 5. It was also decided that the drypacking of areas below the bifurcation, and the grinding of penstock splitter piers would continue at the same time. The contractor then made arrangements for crews to stay on the job over the weekend to carry out these decisions.

Atkinson Cuts Work Force in Half

When grinding operations had been completed, another inspection was made of the tunnels on October 4. The invert grinding and tunnel cleanup were judged very satisfactory. And since all major work scheduled for the tunnel shutdown period had been completed, the contractor reduced his work force from 500 men on September 30 to 244 men as of October 5.

On the morning of October 5, the downstream gate at the intake was opened several inches, permitting water to re-enter and fill the tunnel. After about two hours, it was reported that several leaks were occurring at the steel bulkhead in the penstocks, and several at the adit

plug. Therefore, the gate was ordered shut and the tunnel was drained once again. The contractor was instructed to correct the leakage by repairing the steel bulkhead, grouting upstream from the bulkhead ring, and re-grouting the adit plug.

When the tunnel unwatering was completed later in the day, an inspection disclosed extensive leakage on all sides of the broome gate -- probably, it was thought, because the gate was not seated properly. Arrangements were made to check the gate every fifteen minutes, and report to the Powerhouse in case the leakage became more serious. Later that evening, grouting of the adit plug and caulking of the steel bulkhead was begun. Grouting above the penstock bulkhead liner was started the next day. These repair jobs were completed by the morning of October 7; all equipment was immediately moved out of the tunnel; the adit mandoor was closed and bolted. The East End gates were opened at 11:30 a.m. and tunnel-filling began. At 4 o'clock that afternoon (with tunnel pressure about 68 pounds per square inch) the bulkhead ring showed no leakage, and there was only a small trace of leakage at the adit plug.

All this time, work was going ahead on the surge tank, with the erection of forms for the next concrete pour (to elevation 848). This pour was completed October 18, proving to be an exceedingly good job. However, since the weather had suddenly turned cold, difficulty was expected on future pours. The contractor was told that if the unusually cold weather persisted, he was to use "salamanders" to protect the concrete, and to heat the mixing water.

The surge tank was about half finished. On October 19, miners were put to work on two 12-hour shifts removing tightrock from elevation 848 to elevation 856. This work was finished by October 22. A huge safety net had been installed before this work began, to prevent debris from falling into the surge tank. Reinforcing steel was placed and the

steel form was raised for the next pour. The pouring was done on October 25, to elevation 856. Work then went ahead on the removal of tightrock and the placing of "re-steel" and forms for the next lift to elevation 864.

Excavation Rushed in Foundation

In the Powerhouse foundation, rock crews started work early in October to complete the remaining excavation. This work was done on a 24-hour basis by two shifts working 12 hours each. Very satisfactory progress was made. At the end of the month, the two shifts were reduced to eight hours each.

During October, the butterfly valve pit area was brought down to the required grade. All that remained on November 3 was cleanup of tunnel muck which had accumulated behind the small barricade dam used by the contractor for water diversion. Some rock trimming of the wall around the penstock entrance also would be done.

Removal of overburden (remaining from the General Construction Company's contract) from the area of Piers 2 and 3 was begun soon after the middle of October. This work was done in preparation for beginning work on the rock trenches for pier footings. It was agreed that the contractor would take out all overburden to elevation 461 at the stipulated price. He would drive necessary cribbing to this elevation, and if it became necessary to go lower, the City would for all work below elevation 461 (including cribbing) on force account. This applied to walls 2 and 3 exclusively; wall #1 was entirely the contractor's responsibility under Specification 895. By the end of the month, the number 2 and 3 footings had been excavated to approximately elevation 460. Excellent progress had been made, and it was expected that they would be down to grade after another week's work.

At the same time, the contractor was building forms for the

draft tube elbow, and erecting the draft tube bulkhead gates. Foundation area rock in the draft tube elbow section was completely excavated by the end of October. Consequently, cleaning work was being done, in preparation for placing the steel form and concrete. The form for the elbow section was finished and was being checked by a survey crew, as November began.

Labor Disputes Hinder Progress

The penstock tunnel was showing substantial progress by the latter part of October. Grouting, drilling, and other grout work in the invert (to Station 54) were carried on and completed late in the month. Two invert pours were made, bringing the invert concrete to Station 3 plus 86. In the week beginning October 31st, two more short sections of invert and one section of arch were poured, thus completing the invert to the point where the steel lining starts. The sides and arch were poured to Station 4 plus 49. The date was November 2.

Although most concrete work had been going well, a great deal of trouble was experienced with the contractor's personnel during the last pour. The concrete foreman refused to take direction from the City Light inspectors, and he was backed up in this attitude by the contractor's concrete superintendent. When the Project Manager finally intervened, the work went along fairly well for a time, but the foreman continued to be reluctant to use the desired pouring methods.

Work on the Powerhouse service water filter system went ahead during October. Filter tanks were moved into place and piping work was begun -- the latter was more than half finished by October 25. Toward the end of the month, however, this work began to lag; by November, it was at a standstill. Once in awhile, a pipefitter and a welder would work there when there seemed to be nothing else to do. The installation was about 75% complete on November 1.

As an incidental "fill-in" job, Powerhouse alterations were being

carried on in the visitor's gallery. Carpenters were laying out and placing the partition foundation angles. Preparations were being made to install a sound-proof partition in the control room.

Contractor Revises Organization

Early in November, the Guy F. Atkinson Company changed their organization for the Gorge Powerhouse Extension work from that of a "major project" to a "district job". This required the establishment of a district office in Seattle. The project management was moved to Seattle from the job site. The Seattle office was given authority to make the contract without going through the main office in San Francisco. The Atkinson Company vice president who had previously been in charge of the project was transferred to another assignment. The man who had been area manager at the site was put in charge of the Seattle office. And the contractor put a new construction superintendent on the job.

The contractor's work force fluctuated between approximately 245 men (at the beginning of October) to 190 men (as of December 1). During November, reductions in personnel were continual.

As work carried over into November, the surge tank pour to elevation 864 was completed, leaving two more 8-foot lifts necessary to bring the concrete above ground level on the lower edge of the tank. A negligible amount of tightrock remained to be taken out, from this elevation on up. On November 6, another pour was made -- to elevation 873. Miners were then put to work removing tightrock from this point to elevation 880. Two shifts were doing the work, and soon the forms were raised and the reinforcing steel was in place for the next pour, the latter being made November 16. The succeeding pour, to elevation 888, was made November 22. This was the last concrete to be poured in the surge tank during the month. All surge tank pours had come out well, but unless progress was hurried, there was some doubt as to

whether the tank would be completed by December 23, as planned.

In the Powerhouse work, the number 2 and 3 pier footing excavation which was being done on force account was completed November tenth. Immediately thereafter, the erection of forms for concrete placement in this area was begun. Concrete was poured shortly before the Thanksgiving weekend out, and work proceeded on forms and reinforcing steel for the next pour, to elevation 486.

The overburden excavation at pier #1 was started near the end of November, but made slow progress because the northwest excavation bank (next to the bridge) had to be held back by heavy timbering and sheathing.

Progress was satisfactory in the Powerhouse substructure, where all but one of the foundation walls were in. The remaining wall was the one next to the railroad bridge. Excavation of this area continued, as the sidehill was cribbed up on November 25 to allow for installation of footings.

During the early part of November, the contractor also worked on the removal of danger rock from the Powerhouse foundation, in preparation for draft tube pouring. After completion of reinforcing steel and form work for the lower half of the draft tube elbow section, the work was checked by the survey crew November 18, and the lower half section was poured during the following two days. This pour had to be made with particular care, because of the complicated form between the bifurcation of the draft tubes to a point within six inches of the turbine metal liner. Placing of re-steel and drain-piping for the top half of the same section went on during the next week, preparing for the pouring which would raise the section to elevation 482.5.

Soundproof Partition Installed

The Powerhouse control room's soundproof, glazed metal partition,

purchased from the E. F. Hauserman Company of Cleveland, Ohio, was installed at the beginning of November by Frank L. Dixio, a general contractor from Portland, Oregon. The installation was complete, except for some additional reinforcing of the door jamb section which had not been satisfactory.

Work on the Powerhouse service water filter system began to pick up early in November. After the filter aggregate had been placed, piping was leak-tested and found satisfactory. A concrete curb was installed around the tank area, to prevent damage resulting from water running over the highroom floor. Suitable floor drains were also put in. The tie-in to Ladder Creek was accomplished. After the middle of the month, the Powerhouse system work was again at a standstill because of a delay in floor-reinforcement plans.

The contractor started installation of the tank for Ladder Creek water supply. Several loads of bulkhead steel were moved to the plant area from East End, between November 14th and 23rd. Fabrication was slated to start November 28. A check of the foundation site for the water tank was made on November 21, and it was discovered that it consisted mainly of sand, with almost no rock. Additional tank foundation footing plans were therefore required before this work could proceed.

After the last pour in the penstock tunnel (November 2) an inspection revealed that the concrete job was not entirely satisfactory. The forms had been poorly fabricated. This situation was taken up with the contractor's carpenter foreman and concrete superintendent. Both promised to see that the forms were strengthened.

Other tunnel work showed some improvement. The recurrence of rock pockets in the concrete was believed due to insufficient vibration. Although the contractor was told to remedy this situation, some rock pockets were found after the wall pouring to Station 4 plus 09 and arch

pouring to Station 4 plus 49. These pourings were made on November tenth and fourteenth, respectively.

Since that time, reinforcing steel and forms were placed for wall pourings to Station 3 plus 89.63, and arch pouring to 4 plus 09, and then to 3 plus 89.63. These pours were made later in November, leaving two wall pours and two arch pours remaining to complete the concrete lining to Station 3 plus 18.59 (where the steel liner starts).

On the first of December, the contractor started pouring the Powerhouse draft tube to elevation 483.5, completing it late that night. Powerhouse pour #93 was also started, but excessive water from a steady rainfall made it difficult to maintain a uniform slump. It was necessary to constantly use the drilled holes in the forms to remove the water which was accumulating on the pour. Meanwhile, the contractor's miners removed the rest of the tightrock in the surge tank, and carpenters built forms for pour #17, from elevation 888 to 896.

Early the same day (December 1), the contractor was told to complete the piping for the filter tanks, because their need was becoming urgent. Penstock 21 was connected to the filtered water system the next day, and tanks #1 and #2 were flushed. The flushing process took about two hours. A leaky manhole gasket was repaired in tank #1.

The excessively heavy rains were not only slowing the actual work at Gorge, but they were also caused considerable indecision when plans for the immediate future were being considered. For instance, it was believed that the torrential rainfall would delay the pouring of walls #2 and #3, B and C. The contractor did not have enough concrete at the job site to make this pour. It was then decided he would haul concrete by truck, providing the road along Bacon Creek was passible. This road had been washed out and/or blocked by slides caused by the heavy rains. Meanwhile, carpenters were finishing forms for two pours,

the one in the Powerhouse foundation area, and another one in Penstock 24.

The Powerhouse pour along 2, 3, B, and C lines to elevation 483 was made on December 3rd. When pouring began, the temperature of the concrete was 44 degrees. Hot water was added, and an average temperature of 51 degrees was maintained during the pour. Three salamanders were used in this pour, but they were not essential because the weather improved and the temperature rose. By the end of the day, a total of 150 cubic yards had been laid, and was now being finished off.

At this time, a total of 184 men were listed on the contractor's Direct Labor Payroll.

On December 4, the contractor asked for survey points on pour #15 at elevation 482.5, the draft tube at elevation 482.5, and wall pours "1" and "A" in preparation for additional work on these sections. During this period, the contractor concentrated his efforts on preparations for future work. No other pours were made until the 5th of December, when the surge tank was completed to elevation 896.

Also on December 4, a further check on the operation of the filtering system showed that the valves would not regulate to the proper differential. C. W. Cutler, Skagit Project Engineer, gave instructions to set the regulator springs on the valves to between 20 and 55 pounds of pressure. Because the valves apparently didn't have the proper range for this purpose, a call was sent out for a factory representative.

The removal of material from the job was progressing at a satisfactory rate. By the 5th of December, the contractor was excavating along #1 line and "A" line to elevation 468 at the Powerhouse. And he was mucking out Penstock 24 in preparation for pour #16. The Skagit Project Engineer set a sub-grade of 496 on the storage area, and relayed this information to the contractor.

The main topic of a conference on December 6 was the Atkinson

Company's working schedule. It was learned that the contractor planned to maintain a working crew of about 40 men, to work on day shift only, during the months of January and February, 1950. This decision was subject to approval by the contractor's San Francisco office. If it was not approved, they said, the job would be shut down until the first of March. The contractor also announced that he did not expect to finish the surge tank within the allotted time, but that he would make two more pours there before the Christmas holidays.

No additional pours were made until December 8, when tunnel lining pour #11 was started. When finished, this would complete the first of the two remaining sections of the tunnel.

Protective Measures Instituted

Winter had taken a firm hold on the Skagit, as work became increasingly difficult and slow-moving. The contractor experimented with several protective measures designed to guard the new concrete pours. He placed a salamander on the most recent pour in the surge tank. His intent was to get heat into the forms by attaching welding machines to the steel. The tops of the pours were to be covered with dirt or straw. It was believed that the two-inch wood forms would provide added warmth to the sides of the pours.

The contractor's request to use the "V"-type metal seal, instead of the "N"-type shown on the drawings, was approved on the ninth of December. This type of seal simplified the construction of forms for the pours.

Some force account work was required December 10th. Solid granite was discovered at the "A" line between "1" and "2" line, and two 11-foot holes were drilled along the "A" line to determine the minimum depth of exposed rock.

The contractor was informed on the 12th of December that the

City wanted to have the north crane rail footing (at the storage yard) finished and the rails installed, before the crews went out for the Christmas holidays. The crane contractor would be ready to start the assembly immediately following the Christmas vacation. At the same time, the contractor was told not to pour against frozen ground. He proposed to thaw out the foundations if the cold weather continued. The City agreed that the bulkhead along the #1 line could be left in place and poured against, if the contractor would stand the expense of extra concrete.

Excavation for the foundation of the north wall of the Powerhouse (between lines A and C) disclosed the presence of good rock. The discovery prompted the contractor to request a change in the excavation step lines. He also asked permission to pour to elevation 472.5 in one lift. Following a discussion with the Skagit Project Engineer, it was decided to shorten the steps of the footing, rather than dig deeply in the rock. Subsequently, the contractor was given permission to pour to elevation 472.5 in one lift, providing the pours were stopped at places designated by the City, and providing they were held long enough to allow for shrinkage of the concrete.

By the middle of December, another pour was completed in the surge tank. This brought the elevation up to 904. With this pour, a total of 144 feet of concrete had been poured, with approximately 56 feet to go, before the surge tank would be finished. At this date, the lower edge of the tank wall was about 19 feet above ground level.

The north crane rail footing was poured at this time, with a covering of paper and straw to protect it from the temperature changes.

An average of 80 men were employed through the month of December. The lower half of the draft tube was poured during the last half of the month, and the floor slab for the butterfly valve was started.

A rather extensive overbreak in the floor slab area required a considerable amount of extra concrete, in order to reach the proper elevation.

Two-Month Shutdown Announced

In late December, the contractor gave definite notice of an intention to shut down his operations at Gorge during the months of January and February. A small crew was set to return to work on the third of January to backfill behind the walls and piers at the Powerhouse and, at the same time, complete as much of the Ladder Creek supply tank as possible.

Rototrol excitation equipment to replace the exciters on generators 21, 22, and 23 were purchased from Westinghouse Electric Corporation during December. Cost of the new equipment was \$26,412.00. In addition, a contract in the amount of \$187,171.60 was awarded to the same company for bus structure, switch gear, and unit sub-stations for the Powerhouse extension. This equipment was detailed and provided for in Specification No. 958.

Before he shut down for the holidays on December 23, the contractor completed pouring the floor slab under the butterfly valve; poured the footings for the Ladder Creek supply settling tank; finished the pour for the floor slab over the draft tube; and finished the pour #14. The latter was the wall on line "1", lines B and C to line "2" — all to elevation 483.62. In order to maintain the temperature in the pours, the contractor found it necessary to keep a small crew in constant attendance, firing the salamanders on the new concrete. At the mixing plant, the contractor had difficulty preparing batches because of the frozen aggregate and too-cold water.

By the end of 1949, the contractor had completed 65% of the excavation for the Powerhouse, with a total removal of 3,456 cubic yards. In addition, the concrete sub-structure was 94% complete, and

the surge tank was 86% complete, with the latest pouring bringing it to elevation 904.

In the penstock tunnel, the last pour had been made. The concrete lining had been completed to Station 3 plus 18, where it joins the steel liner.

In the area behind the contractor's camp, 100-feet of track had been laid on concrete footings for the installation of a 50-ton Whirley crane.

This crane, incidentally, was at the Swan Island Shipyard in Portland. It had been purchased by the City from the War Assets Administration for \$21,000.00. A contract was awarded to the Morrison-Knudsen Company of Portland to dismantle the crane at Swan Island, transport it to Newhalem, and assemble it on the already-prepared footings.

Purchase of this crane had been made in October, 1949, but when it was realized that moving the crane and preparing the area for its location would take longer than expected, a request was made to the War Assets Administration to leave it where it was for awhile longer. In the meantime, the Swan Island Shipyard facilities were purchased by the Port of Portland, and the request was forwarded to them. The extension was granted, and it was expected that the crane would be moved shortly after the first of the year. The bid price on this work, as submitted by the Morrison-Knudsen Company, was \$17,494.00.

Just after Christmas, 1949, several small slides blocked the Skagit River Railway above Newhalem, for varying periods of time. These were all cleared away by the end of December, however. But south of Newhalem, approximately 100 feet of track belonging to the Great Northern Railroad was washed out. GN's Chief Dispatcher estimated that repairs would be made, and rails replaced, by the 10th of January.

When the contractor's small crew came back in on January 3, 1950,

he found the job covered with snow, and the well frozen solid. So his first efforts were the removal of snow from the work site and the thawing out of the water lines. It was exceedingly cold. Work was very slow.

Until March, when pouring would resume, the contractor's limited crew would backfill around the piers, finish the Ladder Creek tank and the concrete crib protection wall, and strip the forms from the last pours made in December. Aside from that, all that remained for the contractor was a periodic check of the concrete's condition.

When the forms were removed from tunnel lining pour #12, a small rock pocket was found on the right side. This was January 7. The contractor set to work repairing the pocket by plastering. He was stopped by the City inspector and told to wash out, chip, and drypack the area. Chipping and drypacking the defective areas of concrete is the best insurance for a properly-reinforced, strengthened wall, it was pointed out.

The contractor was stripping forms and preparing for the laying of concrete, when a severe storm struck on January 12, bringing high winds, blinding snow, and intense cold. All effective work halted until the sixteenth, when the storm moderated and the contractor was able to put a small crew back on the job. Low temperatures continued, however, and workers were plagued by sudden heavy snowfalls.

Progress was very slow during this period, and the crew of 23 men did what work they could on backfilling, finishing in the tunnel, and completion work in the Ladder Creek supply tank. On the 18th, the Skagit Project Engineer told the contractor he could stop work on the Ladder Creek tank until such time as the weather would permit a reasonable rate of progress. The supply tank was a force account item, and slow progress -- no matter what the cause -- would raise the cost of its construction.

Request for Pump Removal Denied

About the middle of January, the contractor asked permission to shut down the pumps used for unwatering the Powerhouse pit. This would allow the pit area to fill with water, because there was extensive seepage. The Skagit Project Engineer, C. W. Cutler, refused the request for the time being, since there was a definite possibility that the flooding water would cause sluffing away from the east bridge pier.

The City was especially interested in getting the concrete protection wall completed before spring, and this matter was taken up with the contractor. The contractor replied that he would try to get the crib wall in, as soon as the weather moderated. But, he added, the rest of the work would be shut down until March 1.

Some cement finishing was done in the penstock tunnel during the middle of January, but a sudden worsening of the weather on the 20th caused a shutdown of all operations. With temperatures skidding to the zero mark, and snow piling ever-deeper on the site, all work was paralyzed. Only the care and maintenance of equipment could be done.

The new 3000-3917 KVA Core-Type Transformer (for installation in the Powerhouse) arrived at Newhalem on the 21st of January. Inspection discovered a cracked shell. This damage was first investigated when oil was seen on the bed of the flatcar carrying the transformer. A close inspection showed that the oil was leaking through hair-line cracks next to the point where the tube-cooler headers entered the tank. They appeared to be just outside the backing plate which was installed inside the tank.

Following a report to the Westinghouse Electric Corporation, supplier and shipper of the transformer, a representative arrived to survey the damaged equipment. It was decided to ship the transformer to Seattle for repair, since facilities at Newhalem were inadequate for a

job of that size. The Great Northern Railroad did not send a representative to check the condition of the transformer, but accepted the report of Westinghouse and City Light.

Very little progress was made on contract work during January. Except for the unwatering of the foundation area, work was at a standstill. The average number of men on the job was 17.

The weather continued to be severe during the first part of February, and it was not until the 20th that the contractor was able to resume limited operations. In the meantime, the American Pipe and Steel Company of Portland began fabrication of the plate-steel penstock liner for Unit 24. Part of this work was to be done in Portland, the remainder at Newhalem. It was decided to move the manhole to a point 12-feet 3-inches from the upstream end of penstock section #11. Original plans called for installation seven inches closer to that point. It was intended for these sections to be formed and shipped to Newhalem for final fabrication. This was to be done in time for the work to be done by the prime contractor, and was scheduled to begin near May 1.

When the contractor came back to work on February 20, he began stripping forms from the draft tube pour. And he was cleaning up the area, preparatory to starting construction of the main phases of the project. Representatives from the American Pipe and Steel Construction Company arrived to make arrangements with the Atkinson firm for the fabrication of the steel liner for the penstock. The Portland group expected to start unloading at the railhead about March 6.

By the end of February, some surface grouting had been completed in the Powerhouse foundation, and holes had been drilled and were being water-tested for pressure grouting. While grouting holes 1, 2, and 3, a considerable amount of return was caused from holes 4-to-8. It was necessary to wash out and re-grout all these holes.

Besides grouting, the contractor started excavation of the cofferdam (down to elevation 500), and was about ready to start the next pour over the draft tube (to elevation 487.50).

By the first of March, the contractor had increased his work force to 95 men and was going ahead with pressure-grouting in the Powerhouse foundation. Holes 6, 7, and 8 between lines "1" and "2" and C and D walls were grouted and tested. The bench at elevation 495 still had to be grouted.

The manhole which had been proposed for the floor of the sump pump room was found to be too small for practical purposes. So it was decided to use an Olympic Foundary Standard Model No. 5779 which is 30 inches in diameter, allowing a 29-inch inside opening.

The contractor also resumed excavation in the tunnels. The bottom of the adit tunnel had been removed to elevation 516, all the way to the concrete plug and the invert of the penstock.

The American Pipe and Steel Construction Company began to organize and gather their fabrication facilities early in March. By the 15th, they were unloading the first section of the steel liner for the penstock. The material began arriving regularly in Newhalem from Portland.

When the forms were removed from the walls which would form the interior of some of the rooms, it was discovered that the surfaces were, in many cases, unsatisfactory. The contractor had used inferior lumber for his forms, causing deep grains and scratches to be preserved in the concrete. The contractor was instructed to use a better grade of lumber for his forms.

The top pour over the draft tube was made on March 8. This pour was being worked on during the morning of the 10th, when temperatures ranged four-to-five degrees below freezing. The pour was left unprotected

and it was not known immediately whether it had been damaged. A considerable amount of laitance was found on the surface, requiring several hours of additional washing.

Pouring Continues in Sub-Structure

Shortly after the middle of March, two additional pours were made in the Powerhouse foundation. The first pour was #15, the floor slab from line "1" to line "4", and line "1" to 21 feet east of line "C". The second pour -- #19 -- was on lines "2", "3", and "B" between construction joints in wall "2" and "3". This was at elevation 496, and included the 12-foot curtain wall. Both pours were completed by March 20, and preparation was underway for the next two pours. The new pours would be for walls extending from the old Powerhouse, and the walls around the butterfly valve room. Because he was pouring walls which would be the interior surface for Powerhouse rooms, the contractor was reminded again that he was using a poor grade of sheathing for his forms. He replied that the lumber he was using in the wall forms was grade #1, or better.

The surge tank had been left untouched during the December-to-March shutdown. Now he focused his attentions on the tank. The final December pour had been to elevation 904. Carpenters began building forms for new pours, as work was also being done on the ladder section.

In late March, the American Pipe and Steel Construction Company crew set up the first half of section two of the steel penstock liner. These were drawn into alignment for welding. A representative of the Linde Air Products Company arrived to adjust the Unionmelt machine and make a test weld. The first machine weld was made on the 24th of March. From all outside appearances, the weld looked satisfactory. All welds were to be X-Rayed, to assure the quality and strength of the weld.

When additional welds were made of the 27th (March), they proved

to be rough and irregular. It was decided to suspend all welding work until radiographs could be made. A few days later, it was discovered that the X-Rays had been under-exposed and would have to be re-taken. After they had been inspected on the job, the X-Ray negatives were to be studied in Seattle. As March ended, sections 3-A and 3-B were being set up for alignment.

Pressure grouting had been completed in the Powerhouse foundation and was moved to the cement sections of the penstock. Grouting began at Station 4 plus 82 and was performed to Station 5 plus 18. Several tight holes were discovered while moving toward Station 1 plus 54. By April, grouting in the tunnel had moved to Station 5 plus 70.

In the foundation, meanwhile, excavation of the crib wall nearest the Powerhouse was completed, and the main foundation area was 72% complete. Concrete pours in the extension had been completed to elevation 496, and the backfilling of the concrete crib had reached elevation 478.

The contractor for the fabrication of the steel penstock liner had completed construction of his fabricating area (at the job site) and was rushing minor repair work on the Gantry crane. A part of one section of the steel liner had been welded and X-Rayed.

The fabricating firm finished welding the fourth leg to the crane early in April, completing repairs and modifications. Many difficulties were being had with the X-Rays. If not under-exposed, they were over-exposed. The thrust rings were hand-welded for section 2-C, after X-Ray negatives proved failures again.

While this was going on, pressure-grouting continued in the penstock tunnel. By the 5th of April, the contractor had finished the first-stage grouting, and was drilling at Station 5 plus 81 for second-stage operation.

C. W. Cutler gave instructions for resuming work on the supply

settling tank on Ladder Creek. The contractor told the Skagit Project Engineer that the tank would be completed by April 10. When April ended, the tank had still not been finished.

Sections #2 and #3 of the steel penstock liner were finished by April 11. After the installation of spiders recently brought in from Portland, both ends of section #3 checked within one-eighth of an inch. A new X-Ray machine was used to take pictures of section #2. It was decided that one-eighth of an inch was not sufficient for roundness. The Skagit Project Engineer interpreted Specification 905 (fabrication of the steel penstock liner) as meaning that the ends would be round to within one-sixteenth of an inch on the radius. And these sections were to fit together within one-sixteenth of an inch on the surface.

C. W. Cutler halted assembly work on the steel liner until the contractor used such equipment as would execute the job according to the specifications. American Pipe and Steel Construction Company crews had begun assemblage of the liner without the benefit of spiders or trams.

Officials of the fabricating firm said buckling of the liner at weld points could not be held to within one-sixteenth of an inch. They also said they had not been in any particular hurry to finish the liner above ground, because they were planning to sign a contract with the Atkinson Company which would allow final assembly of the liner in the tunnel. The Skagit Project Engineer reminded the fabricators that their contract was with the City, and that that contract called for assembly above ground.

The fabricators then asked what the City's reaction would be to a half-inch variance at the welds. The Skagit Project Engineer told them they were bound to the one-sixteenth of an inch called for in the contract and that this requirement would not be waived, despite the fact that the firm had counted on such a waiver when submitting its bid.

To add to the difficulties, a strike prevented use of the welders needed for the fabrication job. The contractor said that another reason for slow assembly was the fact that he could not get qualified men to work on the job.

While sections #2 and #3 were being checked for proper alignment, section #1 was placed on the rolls and prepared for welding.

Speed-Up Urged in Tunnel Work

Near the middle of April, the contractor was told to speed-up his work schedule for the penstock tunnel so he would be able to accept the steel liner sections as they were finished by the fabricator. The Atkinson Company had planned to pour the invert only as far as the adit. It was pointed out to the contractor that the invert should be poured past the adit intersection because the liner would be dropped straight down at that point. Otherwise, they would not be able to handle the liner as soon as was required. According to the contract, it was the contractor's responsibility to take the liner sections as soon as they were assembled.

In other matters with the contractor at that time, the City suggested that the Atkinson Company alternate the various trades at work on the forms and stagger the different phases of work. This would enable the construction of several forms simultaneously. Too much concentration on one pour caused considerable congestion among the crews. Crews often had to wait until the preceding group had finished their portion of the work, before they could begin.

In preparing for pour #17 (floor slab and beams), it was found that beam steel was too long. It was decided to cut those bars which were too long to be bent back into adjoining beams. The pour was made on April 12th, with good results. (Twenty yards of this pour were charged to the contractor, in lieu of his forming a closed section on line #7.)

At the Ladder Creek water supply dam, the contractor planned to place a small cofferdam above the dam site, with a flume to carry water over the dam work. A rainmaker pipe would carry water to the Newhalem water supply system. Atkinson was informed on April 20 that the rainmaker pipe by-pass from above the site would have to be installed first, because the Newhalem water supply would have to be maintained unpolluted.

On the 21st of April, City inspectors discovered that the contractor's cement finishers were using a cement wash for covering up ground surfaces. Cement washing was not called for by the specifications. Because cement wash peels, if used as a cover-up surface, the contractor was instructed to smooth the surfaces by grinding and chipping, and to stop all work with the cement wash.

The Resident Engineer, J. U. Mattila, discussed work progress with the contractor on April 21. The contractor said he was expecting to hire three or four additional laborers. This appeared to be insufficient, in the mind of the Resident Engineer, who reminded the contractor that he was short of labor for clean-up work, short of iron workers for the re-steel work, and was already far behind the schedule submitted during the winter of 1949. The contractor countered by saying the schedule submitted earlier was merely a tentative one and was therefore not strictly binding. The Resident Engineer then pointed out to the contractor that the later portions of the contract schedule were heavily loaded with work and that, if operations were allowed to fall behind, there would be no time to make up lost labor.

On the 24th of April, permission was requested of the Seattle office to pour the butterfly valve pedestals at the same time the butterfly valve-room column was poured. This procedure would aid the contractor

considerably. Permission was granted.

A group of five army engineers visited the job site April 24, and were shown the Skagit projects by City officials.

Wall pours #29 and #31 were made on the 26th of April. The contractor made these pours at six o'clock in the morning. If these were to be the forerunners of other future early pours, a re-scheduling of City inspectors would be necessary. There didn't seem to be any advantage in the early-morning pour, since such work could be carried over to swing shift. Inspectors' schedules could accommodate late pours ^{more} easily than pours made at daybreak. The contractor agreed.

Manpower Shortage Discourages Progress

At this point (late April), the contractor was four pours behind schedule, lagging in the concrete crib placement, and behind in the surge tank construction and cleanup work. Enough steel was on hand for pours #32 and #33, and the steel for pour #34 was due April 28.

It was discovered, during discussions of job progress, that the contractor did not have enough steel on hand to warrant working a full swing shift crew. And it was necessary to employ a full crew on swing shift in order to maintain the rate of construction.

The contractor was told that the City expected progress according to the schedule submitted previously, inasmuch as other work along the Skagit was contingent on these plans. The City requested an estimate of the additional manpower which would be required in order to keep up to the schedule. On the 27th of April, the contractor reported 168 men on his payroll.

On April 29, Marine-Industrial (Atkinson sub-contractors) installed the "A" frame in the old construction tunnel to handle the penstock liners for the new tunnel.

A great deal of concern was being shown at this time over the

progress of the Ladder Creek supply tank. It was the City's desire to have this completed by the end of May. In addition to the fact that he was performing the job with an insufficient working force, it was discovered on April 29 that the contractor was taking welders off this job to be used in the tunnel. He was thereupon requested to employ a steady force of welders at the supply tank — a force account job.

By the end of April, the American Pipe and Steel Construction Company had completed the fabrication of liner sections #3, #4, and #14. Section #2 was 75% complete, and section #13 was 90% finished. Also, sections #4 and #12 were almost half done. Those sections which were completed had been X-Rayed and found satisfactory.

By the end of April, Atkinson had completed pours #32 and #33 in the Powerhouse foundation, and #21 in the surge tank (bringing it to elevation 920). The Powerhouse had been brought up to elevation and was now ready for the pouring of the slab under the transformer banks.

Cleanup work in the tunnel was being rushed, in order to be able to pour the invert from the adit to the portal early in May.

The contractor's last action in April was the assignment of a two-shift work force to the Ladder Creek supply tank, with welders providing the bulk of the force. With this development, completion of the supply tank was expected early in May.

Work Shows Some Progress

The tunnel invert from the adit to the portal was poured on May 5th, with pouring beginning on the Ladder Creek dam during the same day. The Resident Engineer had some difficulty expediting this work, having to work some crews overtime. But the possibility of warmer weather called attention to the fact that an increase in the water run-off would endanger the portion of the dam already completed.

On May 5, section #1 of the steel penstock liner was moved from

the American Pipe and Steel Construction Company's fabricating yard to the north of the portal.

No work was done May 6-7; it was the contractor's weekend out.

By the middle of May, Powerhouse pours #35A and #37 were made. Pour #22 was made in the surge tank. (#35A was a continuation. Because of wet conditions, pouring took two days.) Flooding waters stopped all work on the Ladder Creek supply tank for a time, but the water receded slowly and work was resumed during the last week of the month.

Work on the placement of the steel liner was rushed during this period, with sections #12, #13, and #14 in longitudinal positions being jacked into alignment. Section #1, which had been moved to the tunnel portal previously, was not put into position at this time because the contractor had not completed cleanup and placement of supports.

Section #2 of the steel liner was lowered into the hole on May 18, but because it had been lowered in a reverse position, it had to be lifted out and turned around. It was expected that the contractor would be able to pour backfill in sections #12, #13, and #14 by the first week of June.

While this activity was taking place at the Gorge Powerhouse project, the Gorge Diversion Dam was completed.

Returning to work after the long weekend, the contractor took soundings at the tailrace and found that nearly three feet of material had sluffed back in front of the south gate, between piers 6 and 7 at elevation 468. The contractor wanted to leave this material where it lay, believing it would wash away when the gates were opened for water through Unit 24. Since this was a considerable amount of material, the Skagit Project Engineer, C. W. Cutler, thought it should be taken out to grade. Consequently, the contractor was instructed to make the necessary excavation.

Faulty Wall Forms Still In Use

On June 4, it was again necessary to remind the contractor about the quality of lumber he was using in making the forms for concrete wall pours. In pours #40 and #41, he used lumber consisting of approximately 30% hemlock and cedar, instead of fir. Hemlock was not suitable for this purpose because of its tendency to dry out, shrink, and warp, causing uneven forms. It was called to the attention of the contractor that the specifications stated that the lumber used for the concrete forms should be of fir, No. 1 grade or better. Failure to procure fir for this work was the result of a shortage of that type of lumber, according to the contractor.

Installation of the penstock liner was halted June 8, when the contractor notified the City that his sub-contractor, Marine-Industrial, alleged that sections #1 and #2 were off grade and would have to be lowered. A check by the Resident Engineer showed that all errors on the grade were made by the contractor, except for one appearing at the portal end of section #1. This latter error was caused by the failure of a survey crew to change the punch marks (on a railroad iron bench mark) from one foot to .99 foot. Consequently, this end of the section was placed too high. However, the wedges were loose under the front end of section #1, causing it to shift during the placing of screw jacks and welds. It would have to be re-aligned before placing the concrete, anyway. This particular error was of little consequence, since it was discovered before the section was placed.

At a June 12th conference between City Light officials and the contractor, C. W. Cutler tentatively agreed to put the lowering of the section on force account, pending the result of further survey checks.

The main floor slab, and the beams between line "B" and "D" and line "1" and "4" were poured to elevation 515.75 on June 9. This pour was

left in a rough condition and it was necessary to ask the contractor to put on some men to smooth out the top. Carpenters removing the two-by-four starter wall cross-ties and the two-by-fours holding stub re-steel on part of the pour had to be taken off, because this activity would loosen stubbed re-steel in the partially-set concrete.

On June 13, plans were made to start finishing the floor surfaces in the switchgear room and the fan room, elevations 499 and 485 respectively. Because it offered little opportunity to control the mix, the contractor's proposal to use a small $\frac{1}{4}$ -yard portable mixer was cancelled. Inspection of the floors showed quite a bit of sludge on the floors, and a lot of cement-finishing work to be completed before the contractor would be ready for finishing. It was decided that if floors could be made clean enough by other methods, sandblasting would not be required of the contractor.

Pour #41, scheduled for June 16, was almost cancelled when it was discovered that the contractor did not have one-inch and $1\frac{1}{2}$ -inch extra-heavy pipe for the Generator 24 CO₂ lines. This pipe could not be obtained on short notice, so it was agreed that the contractor could use steel tubes in the pour, if the pipe was of a size which would permit the insertion of the proper pipes when they became available.

A check of the walls on June 16, showed that the "E" line wall form was $\frac{5}{8}$ " out, and "2" line wall was $\frac{1}{2}$ " out. On the "E" line error it was found that the carpenters had measured 1.3' instead of the correct 1' 3".

While assembling the folding doors for walls "D" and "2" on June 17, it was found that the doors would not fit as shown on the plans. It was discovered that the shop plans were in error, since the hinge-backing-strip hit the top door shield. The contractor, upon instructions from the Resident Engineer, removed the $\frac{3}{8}$ " and $2\frac{1}{2}$ " backing-strips, and cut $\frac{1}{4}$ " off

the top edge of the door. After this had been done, the door fit was satisfactory.

Lack of Plans Delays Tank Work

Ladder Creek was still at flood stage, when a check showed that the area in front of the dam and intake was filling with gravel. It looked as though some changes in design would be necessary to insure the satisfactory operation of the water supply system. Lack of plans for the tank protection house delayed work on the project.

The total absence of cooperation between the contractor and the subcontractor increased the problems attending the placement of the penstock liner and pouring the tunnel backfill. The contractor wanted to get ready for pours in sections #12, #13, and #14 on June 20, but the concrete inspector said he didn't think they could make concrete flow under the section. Trying more head on the other side didn't work, so concrete had to be poured from the other side without assurance that the invert would fill.

Some difficulty was encountered in placing section #4 and #5 in proper alignment. In spite of considerable adjustment and calculation, section #5 could not be made to fit. After extensive study, it was decided by the Skagit Project Engineer (on June 23) that the ends would have to be cut to make the sections fit.

A City Light survey crew was called upon to help the contractor at the surge tank, on June 23. The contractor's surveyors had given steel crews an elevation for the placing of re-steel which they countermanded the next day with an elevation $2\frac{1}{2}$ " lower. Consequently, the steel crew had to cut $2\frac{1}{2}$ " off the steel they had already set.

As a result of this, the normal relationship existing between the crews had deteriorated to such an extent that the contractor felt moved to request a City Light survey crew to ascertain the proper grade.

This measurement involved shooting level from a bench mark 10-feet from the tank, to the tank, then chaining up the side to the top.

As work moved into the last weeks of June, the contractor concentrated his efforts on pours #41, #42, #45, and #46 in the sub-structure of the Powerhouse, and #25 in the surge tank. The septic tank on line "1" and "A" was poured on June 15th. The 515 elevation slab, "D" to "E" and "2" to "7", was poured on the 17th. The surge tank was poured to elevation 952 on June 18th, and the tunnel portal recess to the spring line was poured on the 20th. Construction was begun on forms for pours #45 and #46. And following sandblasting and cleaning, the first bonded floor pour was made in the fan room on June 25th.

Plans for the 12' X 100' shed, which was to be placed 30-feet north of the railroad tracks opposite the 100-foot crane, were forwarded to the contractor on the 26th of June. This area required additional fill, and arrangements were made with the contractor to supply this fill of pit-run gravel at \$3.00 per cubic yard. A change order covering this work was prepared in the Seattle engineer office.

By the end of June, pour #45A (consisting mostly of walls at elevation 515.75 to 525.75) had been completed, and was being finished down. Section #6 of the penstock liner had been set to line and grade in the tunnel, and final fittings were being made on sections #5 and #6.

No progress was made on the project from June 30 to July 5, this being the Fourth of July holiday weekend.

Hot weather came to the Skagit during the first part of July, causing melting snow to add to the water behind Ross Dam. It was expected that water would shortly leave the spillways, creating a minor flood condition downstream. As a precaution against such an eventuality, the Skagit Project Engineer instructed the Atkinson Company to place riprap under the Powerhouse railroad bridge and at the end of the concrete crib

to protect these banks from cutting by the flood waters. The contractor began placing this riprap on July 6.

Construction Started on Protection House

The contractor began building the protection house for the Ladder Creek supply tank on the 6th of July. Only the lumber had arrived for this work, however, with the aluminum roof-sheeting and doors due to arrive by July 12. The dressler couplings had not arrived, and work was at a standstill on the six-inch waterline.

Pour #45B was started on the 6th and finished on the 9th of July. This particular pour consisted of several walls and keyways. On the "D" line of pour #45A, it was found that sand seams had developed as a result of over-vibrating which forced water through the small seams in the 2-inch tongue and groove removable panels.

The lack of an adequate welding force was still delaying the completion of the steel liners; consequently, the pouring of concrete for the tunnel backfill was also slowed. Where adequate performance of the job required at least eight welders, the subcontractor was employing four. Atkinson promised to take the matter up with his subcontractor in their Seattle office.

Work on pour #46A, starting on the 10th of July, was continued on the 12th at the "C" line and retainer wall. Too much curing water, running down from the upper floors, prevented the contractor from successfully laying the hardening compound on the bonded floors at the 485-foot level. It was necessary to hold the work over until the next day, to let the floors dry.

A number of parts for the Westinghouse generator #24, including poles, coils, and punching (spider), arrived on the 13th of July and were placed on the siding at the crane storage yard. These were to be unloaded and stored in the shed which was being constructed in that area.

Work Begins on Superstructure

By July 19, the contractor was well along with work on the superstructure, having completed wall pours #46A and #46B to elevation 532.99. In addition, sections 5 and 3 of the retaining wall and the catch basin had been poured. In order to push the work so it would be possible to deck over the roof by September 1, the contractor made plans to employ a full two shifts on the concrete pouring. When carpenters became available for form-making, the contractor expected to put on a third shift. Installation of grounds and metal laths was started on the north wall of the old Powerhouse on July 17. And with the exception of painting, sections #12, #13, and #14 were complete. Sections #1, #2, and #3 were more than 95% complete, sections #4 and #5 were 90% done, section #6 was 75% complete, and sections #7, #8, and #9 were half finished. The last sections to go into the tunnel, #10 and #11, were 5% and 40% done, respectively. The contractor put three welders on each shift, and progress was picking up.

The Dressler couplings had arrived during this activity, and work had gone ahead on the 6-inch water pipe. Framing on the 12' X 100' warehouse was complete, and the top and sides were being placed. Meanwhile, the Westinghouse equipment was being stored on the dunnage floor.

With the intention of accelerating the work in order to meet the September 1st date (when the Westinghouse contractor would begin installation of electrical equipment), a conference was held between the contractor and City Light officials on July 21.

The contractor outlined a program calling for two full shifts to work on the concrete pours. It was suggested that they drop off the valve house section "C" to "D" lines. By this move, the contractor believed he could get the building up to the stage where roof trusses would be in place and the roof could be formed. This would allow the Westinghouse

contractor to start his work on schedule. The City gave permission for this change, but requested that the contractor's proposal for the construction joints along "D" line should be submitted to the design office for study.

According to the above schedule, the contractor would concentrate on completion of the wall sections next to the old Powerhouse, and roof protection in this area. Then, the temporary protection wall could be removed and the crane could be brought into the new section and used to start the Westinghouse and turbine work. The existing crane was being considered for this work. Installation work which would be performed by the new crane could be made at a later date.

In an attempt to speed up the pours, the contractor asked permission on July 22 to strip the forms from the pours before the required 24 hours had elapsed. He said he had been interpreting the 24-hour period as beginning from the time the pour was started, instead of from the time when the last concrete was poured. Naturally, the City was interested in maximum speed at this juncture, so the Resident Engineer granted permission to remove the forms sooner than 24 hours from the actual pouring, providing that no damage to the concrete would result.

By July 22, the downstream sections #1, #2, #3, and #4 had been poured. A large void over section #2 was filled with considerable difficulty, and when done, it was not certain that the pouring had been complete in this area. With these pourings, the tunnel was progressing steadily toward intersection with the adit, where the final closure would be made with the laying of section #10. This was the section containing the manhole to provide access to the penstock for inspection purposes.

On the 26th of July, the contractor began applying the first coat of stucco to the north wall of the existing Powerhouse. On the 23rd

C. W. Cutler had approved a plan to place extra steel in the north wall of the Powerhouse, to form backing for the furring channels for stucco and plaster between steel H-beams and the existing concrete on the "D" line. Metal laths were attached to the wall before stucco was spread.

Before the crews went out for the weekend of July 29-30, the contractor finished pour #47A, a series of walls in the superstructure along lines "C", "D", and "E". He had started pour #47B, walls on line "I" and "E", and keyways on lines "D" and "C".

By the last of July, concrete in the immediate structure of the Powerhouse extension had been poured to approximately elevation 544. The bonded finish had been applied to the concrete floors below elevation 485. Concrete stairs had been finished to elevation 491. The new roof slabs of the old Powerhouse had been poured, and the structural steel with metal laths set in the north wall were receiving the first coat of cement stucco.

At this point (late July), alterations to the old Powerhouse were 80% complete.

Surge Tank Almost Complete

The contractor was nearly ready to pour the first lift of concrete which would close up the temporary skyhook access way on the surge tank. The extension ladder, platforms, and float well tube had all been finished by the last of July.

The north retaining wall in the yard, with duct bank manholes, had been poured and some backfill had been placed in the rear of the "E" column line wall. The septic tank was also poured, and the concrete crib wall had been backfilled above elevation 500. Removal of the tailrace cofferdam for the Powerhouse extension was also completed.

Good progress had been recorded in the penstock tunnel during July. All the steel liners had been backfilled with concrete, with the

exception of sections #8, #9, #10, and #11. These were awaiting final fitting and welding by the Marine-Industrial Company, subcontractors for the Atkinson Company.

The contractor's payroll for July showed an average employment of 159 men. A shortage of carpenters prevented the contractor from making better progress -- especially in his concrete pours. Had more carpenters been available, the contractor might have been able to work three shifts pouring concrete.

Construction was rushed on the shed being built in the storage area, in order to protect the equipment that was being stored on the floor there. Although the weather remained good, the prospect of rain spurred the construction. The building had been covered with Homosote, but the removable roof sections were only 20% complete.

During the last week of the month, piping for spray equipment in the air washer hoods was installed. Installation of the hoods had been started, but was soon postponed until the stoplog gates for the generators could be removed.

Because the superstructure had risen to a considerable height above the ground, the contractor found it necessary to use additional care in bracing the forms for the concrete pours. The need is illustrated by an incident happening August 1, when a wall in pour #48A was found to be one inch out of plumb after the concrete had been poured. Additional bracing was required for the pumpcrete line which had been shaking the forms, and causing them to get out of plumb.

Early in August, plans were made for lowering the water in the surge tank and tunnel for the purpose of cleaning the bottom of the surge tank. Several extra laborers were put on the cleanup crew, and the job started before dawn August 12 while the rest of the contractor's crew was out for the weekend. The cleanup had been completed by noon, and

the railroad safety grating had been removed from the top of the shaft. The material taken out of the tank was half muck and half wood debris which had floated down the tunnel and popped up into the tank.

Except for sections #10, #11, and #12, all the steel liner sections had been completed in the penstock by the first week of August. The area had been backfilled with concrete, and on August 16th, the last seam was welded between section #10 and #11. Work on this particular weld required much more time than those that preceded it. It was necessary to peen after each pass of the weld, in order to relieve the strains. And water had to be run constantly over the two adjacent sections to keep the temperature of the liner as low as possible. This minimized the amount of strain. The only things remaining to be done in this installation was the backfilling around #10 and #11, and the grouting of the entire liner from section #14 to the portal.

Ladder Creek Supply Tank Completed

On August 15, the Ladder Creek supply tank and intake work was completed, and turned over to D. E. Forsander, Generation Superintendent, for operation. Some trouble was encountered with sand and gravel which clogged the intake, following a heavy rain which raised Ladder Creek to flood stage. Several cleanings during the afternoon and evening, however, solved the difficulty.

The Westinghouse TC transformer was returned to Newhalem from Seattle on the 15th of August. This was the transformer which had been damaged in transit the preceding November. It had been sent to Seattle for repairs which could not be performed at Newhalem.

The pours for the wall and crane-way beam on line "C" and "D" (to elevation 558.85) were started during the middle of the month, and completed on August 23. This was the beam which would support the huge 150-ton crane. On this same day, the contractor poured the floor

slab in the adit access plug. Work was also well underway on the cleaning of the rock below and to the side of the lines at the adit, and steel was being placed around the lines. The adit access to the main tunnel had been excavated over-size so his jeeps would have free passage in the tunnel. The contractor was now replacing this material, and was going ahead with plans to pour the invert side wall and arch to a minimum thickness of four inches.

The welding on section #10 of the steel liner in the penstock was finished on the 25th of August, and the final pour for closure was begun. In order to properly secure this last section, props were placed from the top of the adit to the top of the stiffener ring on section #9. Then a one-inch cable was pulled over it and fastened to eyes sulphured into the rock on both sides.

Efforts were made during the latter part of August to push the installation of a railroad spur, leading from the main tracks into the adit and to the Powerhouse. On the 26th (August), the contractor began excavating from the adit to the Powerhouse and railroad bridge, for the railroad bed and ballast. Enough excavation had been made by the end of the month to permit the placing of a temporary railroad track (with switch work) from the end of the bridge. This spur, branching at the adit portal, led from there to the railroad bridge, and the Powerhouse. It would provide the trackage necessary to transport the heavy butterfly valve and transformers to the Powerhouse for installation.

In order to carry out plans to pour #49A-3 on August 26, the contractor was allowed to pour the wall despite the fact that the block-out for window sills was one inch off. He made the pour after promising to chip out one inch, and then drypack one inch, in order to shift the sills to the right place after the forms had been taken off. Had they decided the forms would have to be removed and re-built immediately, the

pour would have been delayed a day. By the end of the month, the contractor had completed pour #49A and was preparing for pour #51A and #51B. This brought the "C" line wall up to the truss elevation. He was within two days of his work schedule (proposed July 21).

Powerhouse Equipment Arrives

A considerable amount of the equipment and machinery which would be installed in the Powerhouse arrived during late August. This material was immediately unloaded and stored. It included parts for the turbine, steel girders, and railings for the 150-ton crane, and Rotatrol equipment.

Alterations for the old Powerhouse were progressing smoothly and relatively quickly. The walls were being plastered in the visitors' gallery and battery room. The air-washer hoods had been installed on the three old power units, and covered with a trial coating of gray paint.

When he had completed the backfilling of the steel liners, and the closure made on section #10, the contractor started planning the grouting of the entire steel liner from section #14 to the portal.

The contractor employed an average of 153 men during August. A considerable drop in manpower was expected to follow the long Labor Day weekend out, September 2, 3, and 4. Since much of the work had reached completion or near-completion, many of the men anticipated a drastic cut in the labor force. They were already making plans and moves for employment on other jobs. Consequently, when the contractor returned from the holiday, he was shorthanded. By late afternoon of September 5, he was able to start placing the roof trusses.

While placing the first truss, a chain broke on the motor crane. This dropped the truss about two feet and bent both the top and bottom girders. This was straightened during swing shift and held over for placement the next day. By mid-September, the last of

the trusses was in place, and the contractor was busy placing diagonals and false timbering for the pouring of the roof slab.

On the 9th of September, tragedy struck in the construction area. While working on the roof, a rigger fell from a plank high atop the trusses to the bottom of the pit. He was rushed by ambulance to the Sedro-Woolley hospital, where he died a short while later.

Work on the railroad spur was halted on the 13th of September, in order to put a maximum effort into the pouring of the valve house roof slab. This necessitated placing the pumpcrete line across the railroad track, so it is probable that no work could have been done there, anyway.

New Contract Awarded

Mechanical installation in the new Powerhouse extension was scheduled to be done under Specification No. 1035. The contract included installation of one 92,500-horsepower vertical shaft hydraulic turbine; one 200,000 foot-pound, cabinet-actuator-type governor; one 180-inch-diameter butterfly valve; and furnishing and installing a complete piping system (with accessories) for Unit 24 of the Powerhouse extension.

Two firms submitted bids for the contract. The Morrison-Knudsen Company's bid totaled \$602,120.49. This was almost twice the amount of the winning bid which was submitted by the Guy F. Atkinson Company, of San Francisco. Their bid was for \$375,744.00.

On August 24, 1950, the Guy F. Atkinson Company was awarded the new contract.

Since the contractor was instructed to begin work on the installations called for under Specification 1035 on September 11, it was important that the railroad spur be completed by that date, to provide the means of bringing the heavy equipment into the Powerhouse. It was not until the 21st of September, however, that a temporary hookup was made with

the Powerhouse switch. During the first to weeks of September, work on mechanical installation had been limited to unloading the machinery which was to be installed. This condition would continue until the contractor had completed installation of the 150-ton crane in the Powerhouse. Actually, execution of the contract would begin the minute the railroad car arrived with the draft tube lining. This piece of equipment had to be installed before any of the rest.

Some personnel problems developed on September 13. The carpenters working above the cement finishers had dropped several pieces of wood which hit men working on the crane ram grouting job. The cement finishers were not entirely guiltless, either. Some of them had been kicking she-bolts off the beam, to fall on riggers working below them. Apparently, no one was working below the riggers because there are no reports of their dropping anything. As a result of this indiscriminate exchange of material, the cement finishers refused to work. The contractor solved this dilemma by sending the carpenters home for the rest of the shift. Peace was restored, and work went on.

In order to test the Cyclops crane after its installation, the contractor proposed to build four 12' X 12' X 3' concrete blocks in the Powerhouse. It was pointed out that blocks of this size would hamper other operations in the area. So it was decided to build the same amount of smaller blocks (3' X 4' X 12') using railroad rails for re-steel, instead of I-beams. These blocks were to be built on force account; they were poured on September 18.

A Skagit River Motor Lines truck was brought to the site to move the 48-foot steel girders for the crane. The truck was not large enough, so the contractor decided to use two trucks. One end of the girders were placed on one truck, while the other ends were put on the second truck. With one truck backing, the contractor was able to move the heavy

girders to the Powerhouse.

While the rest of the contractor's crews went out for the weekend of September 16-17, ironworkers and riggers remained to install the Cyclops crane. Within a few days, the girders had been riveted, and the trolley section had been lifted and put into place. By the end of September, the crane had been tested (by lifting the concrete blocks) and was put in operation.

The turbine draft tube liner arrived in Newhalem September 20. Work started immediately on removal of the coat of preservative. A portable steam cleaner with caustic solution was used for this work. Installation of the liner began the next day, and by the 27th, the top was in place and being welded, and the bottom cover had been fitted.

Grouting Completed in Penstock

By the end of September, the contractor had finished grouting in the penstock (behind the liner) and the construction joints around the concrete plug in the "E" line wall. Holes tapped for grout nipples in the liner were being plugged.

Moving the heavy rotor spider across the bridge and into the Powerhouse posed quite a problem, and considerable time was spent in planning just how the equipment would be moved to the site. Since there was a bare 17-foot clearance on the Powerhouse bridge, it was necessary to raise the trolley power line. Once across the bridge, the problem was to shift the car carrying the spider from the main track to the spur leading into the Powerhouse. In order to switch, the car would have to be backed a considerable distance into the adit portal. This was not feasible, because the car was too large. Many methods of switching the car were considered before it was decided to jack the car up, place it on skids, and slide it over to the other track. This was done on September 29, but before the machine could be moved into the

Powerhouse, the contractor's crews left for the weekend. On October 3, the spider was moved into the Powerhouse and placed on the erection pedestal which had been prepared several days before.

During the first week of October, the contractor completed the roof slab pours and most of the parapet walls. In addition, the transformer slab was cleaned in preparation for placing the membrane waterproofing and the installation of the railroad tracks. New window frames had been installed in the old Powerhouse, and the contractor's glaziers had begun putting new glass in the frames. Some cleaning was also done in the area around the east Powerhouse entrance. This was in preparation for the construction of the east approach and entrance to the bridge.

On October 3, the turbine bottom cover was placed in position and bolted to the top of the draft tube. Section #1 of the turbine, ^{scroll case} ready at the yard October 4, but it could not be brought into the Powerhouse because the pumcrete line was blocking the railroad tracks. However, it was brought in October 5th, and section #2 followed it later in the day.

The last section of the parapet wall was poured October 7, and the contractor began stripping the roof and wall forms. In the meantime, finishers were working on the walls and window openings, drypacking the frames. Excavation was started for the placing of a 4-inch waterline along the east wall of the Powerhouse.

Also on the 7th, ^{scroll case} sections #2 and #3 were brought in to the turbine area, and bolting began immediately on #2. By the next day, turbine section #2 was in place, and work was progressing on the placing of #3. Meanwhile, section #4 had been brought in from the crane yard.

Labor Efficiency at Low Ebb

Considerable dissention had arisen between the various crews, regarding responsibility, methods, and schedule. Crews working in the

Powerhouse on machine installation and electrical equipment argued over use of the crane. Interference by other crews was alleged. Therefore, a meeting was called by the Skagit Project Engineer. The City was naturally interested in smoother labor relations at the Powerhouse, but the primary topic for the meeting was a discussion of schedule and progress. C. W. Cutler wanted to know, at the meeting's outset, why the contractor was not operating on a three-shift basis. The contractor's representative replied that delay was due to "crane interference". But he reported that a third shift was scheduled to start that night (October 9).

Grouting in the penstock plug began October 9 with 8/1 concrete. This work was to continue until all the small weep holes in the east wall had been sealed. This was accomplished by noon of the 10th.

By October 11, the contractor had placed a canvas covering over the valve house roof, with initial preparations for the roof surfacing. A primer coat was applied to the cleaned surface, but it was several days before the contractor could apply asphalt. Reason for this delay was that the primer coat had been thinned with kerosene and drying was very slow.

By the last of the month, the roof had been covered with two layers of felt and sealed with gravel and asphalt. This work was hampered by a shortage of workers, and intermittent rainfall.

On the 13th of October, the final embedded parts of the scroll case were placed in position in the turbine pit. Sections #1, #2, #3, #4, and #5 had been bolted together and were being leveled. Placement of the inlet sections was finished on the 25th, and the test ring and cover plate had been installed. Hydrostatic tests of the scroll case were completed October 25-26, following which the case was emptied. The contractor proceeded to install grout and vent pipes, piezometer lines, and other piping. This work, completed November 8, was tested satisfactorily

at 300 pounds per square inch. The contractor had some difficulty making the vent pipe water tight. This was the vent pipe leading from the bottom of the speed ring through the test ring. When final tests had been completed, the first lift of concrete was poured around the draft tube liner. This occurred on the afternoon of November 8.

By mid-October, the contractor had leveled the rotor and started stacking lamination for generator Unit 24. By the end of the month, only four inches of stacking remained to be done. The contractor was ready to heat the rotor and drive the wedges.

First-Stage Pouring Completed

In the Powerhouse addition, the contractor made the final concrete pours on first-stage pouring, during October. All forms had been stripped, and cleanup had begun. Bonded concrete surfaces had been placed on the "7" line stairs leading to the control room. A similar surface had been put on the valve house floor. The wall and window openings had been equipped with steel frames or sashes. And glazing was almost complete. Along the river bank, a concrete gutter had been cast to carry water from the 18-inch drain.

The Misco firm, Atkinson subcontractors, had begun sandblasting in the steel liner in preparation for applying final coatings of paint. This work started October 24, and was completed November 8. Painting began immediately. During the sandblasting of the lower part of the liner, a canvas cover was put over the portal to prevent dust from entering the Powerhouse.

The forms for second-stage concrete were placed early in November. The second lift (encasing the scroll case) was made on November 11. The entire pour was completed in 36 hours.

Considerable difficulty was encountered in attempting to stop leaks in the vent and grout pipes. The contractor found it necessary to

drain the case several times, for tests to determine the location of the leaks. The contractor also had trouble with the pumpcrete line. It was continually clogging, and stopping the flow of concrete.

By the 14th of November, the contractor had his carpenters at work raising the forms for the third pour. This pour was made on the 16th, followed six days later by the fourth and final pour.

During the early part of November, the contractor finished sandblasting in the penstock tunnel, and started applying the first coat of paint. The fourth (final) coat of paint was applied November 16. Except for an area of approximately 150 square feet, the painting of the liner was complete. This latter space could not be painted until after the butterfly valve had been installed.

The Atkinson company continued installation of conduit, re-steel, and forms for the last pour in the pit, as force account carpenters, iron workers, welders, laborers, and electricians installed anchor bolts and recesses for the generator base plates.

The contractor completed second-stage grouting of the speed ring and lower cover plate, on November 21.

Work was progressing satisfactorily on the construction of a Quonset hut gymnasium in Newhalem. This work was authorized by Change Order 66.

All sixteen stator plates were in place by midnight of the 29th of November. During that day, the bonded floor was placed around the air housing at elevation 515.75. Laborers were chipping sides and bottom of the sole plate blockouts, as sole plate installation began. When the Skagit Project Engineer, C. W. Cutler, inquired about the progress being made on sole plate installation, he immediately ordered the work on a 24-hour basis. That evening (November 29), a swing shift was started, with four mechanics and five laborers.

The contractor was employing 11 men, as November drew to a close. Progress was exceptionally slow during this period, due mainly to the long Thanksgiving weekend.

In the Powerhouse proper, the contractor had concentrated his last-of-the-month efforts on the removal of blackout forms, and the setting of generator sole plates. Final grades on three plates were established November 29. The gate storage area had been completely cleared by the contractor, and he was beginning cleanup of debris in the butterfly valve room. Also on the 29th, the contractor began preliminary work on the adit portal.

With regard to Specification 1035, the contractor had taken out the grout pipes from the test ring and speed ring sections. The liner of the turbine pit was being sprayed continuously with water. Concrete temperature readings were discontinued at the end of November, but scroll case temperatures were being recorded hourly.

Assembly of the rotor was approximately 75% complete, at this time. On the 29th of November, filing of the rotor slots for the field poles and spring washers was finished. The lower bracket and stator sole plates had been sandblasted and put in place, as final leveling and locating began (preparatory to grouting).

On December 1, 1950, the Skagit Project Engineer altered the adit portal dimensions, by extending the opening from Station 0 plus 77. The contractor was told to spread the steel that was already in place.

A conference was held on the afternoon of December 2, to discuss the progress the Guy F. Atkinson Company was making on its second contract -- Specification 1035. C. W. Cutler requested that work be done on a three-shift basis. Sandblasting of the draft tube liner was to start immediately, followed by blasting of the scroll case. During consideration of the adit portal it was decided to put additional

anchor bars, and a two-foot batter, in the left wall. Final changes in the portal design included alterations in the north wing wall, the two-foot batter mentioned above, an increase in the depth on the concrete over the arch, and the addition of a steel dowel.

The contractor grouted the stator and lower bracket sole plate. At catch basin "D", the four-inch waterline was extended and a drain valve was installed. After the 504 elevation floors had been bonded with floor topping (in the galleries and pipe trench to the servomotors), laborers set to work clearing the debris and form lumber from the area around the Powerhouse.

Meanwhile, construction had started on the adit tunnel portal, progress there being somewhat hindered by a shortage of re-steel. The west bank of the river, between the railroad bridge and the footbridge, had been dressed for slope. The Guy F. Atkinson Company had 73 men on its payroll for the period ending December 14, a decrease of two men ^{from} over the preceding week.

Mechanical installation, under Specification 1035, was showing the following progress. The scroll case bulkhead had been burned off and stored in the crane storage area, the interior surfaces of the draft tube liner and scroll case had been sandblasted and painted with GA-50, and the pit liner had been cleaned and coated with red lead.

Construction had reached the point where seemingly insignificant occurrences were inflated and exaggerated. Daily reports of the period tell of numerous personality conflicts and minor problems. Inefficiency and "cutting corners" delayed progress in important areas, causing slow-downs in other sectors while the mistakes were being rectified.

By mid-December, installation of Generator 24 was progressing, with the rotor installation 75% complete, and the stator about 5% finished. All stator sections had been temporarily stored around the pit. Split

bolts and shims were being cleaned, in preparation for bolting and packing the splits. Jacking bolts had been placed around the stator for alignment checks.

Work on the Newhalem school gymnasium had reached the floor-pouring stage, by December 6. The original plans called for a special floor covering, but this idea was abandoned when it was decided to assign a single crew to the finishing work.

On December 3, a small fire was started in a packing case full of excelsior, when a welding team allowed sparks to fly into the box. No damage was done.

The contractor spent the entire day shift December 8, scraping lower turbine seals to the required clearance. This work was not finished until December 11, after the contractor's weekend out. While this was going on, Westinghouse crews began placing field poles on the rotor. The Marine Industrial Supply Company (Misco) removed the top cover from the turbine pit on December 11, and began placing wicket gates. This work continued for several days.

Delay in Delivery of Butterfly Valve

The California firm which had contracted to assemble and deliver the butterfly valve encountered a combination of circumstances which caused a protracted delay, not only in delivery of the valve, but also in related activities at the Powerhouse which were contingent upon the valve's installation. Westinghouse's work on the turbine was to be completed in time for immediate installation of the Butterfly valve when it arrived. However, since the valve was late, turbine work was not rushed -- in fact, it was done on a single-shift. Work on the turbine was scheduled accordingly.

Proceeding with the installation of non-embedded parts, Misco lowered the top cover on the turbine pit for final placing on December 13.

When the cover was bolted down, it was discovered that vane clearances between the top and bottom cover were inadequate. With as much as .002 and .003 variation in the fit, the contractor began making aluminum shims to take up the slack. When this procedure was discovered by City representatives, the contractor was told to use the brass which the manufacturer had provided for this purpose. A man was thereupon dispatched to Seattle to pick up the material.

At this time (late December, 1950) the contractor was focusing his attentions on the adit portal and adit liner work. A single day shift was doing this work. The north and south wings of the tunnel had been poured to the spring line, and miscellaneous pickup work was being done coincidental with the other tunnel work. Trimming was in progress, after the east wall and steps had been cut to final grades.

On December 12, the turbine top cover plate recess pour was made. And on the same day, the 24-ton trolley support column and base were installed.

Meanwhile, a crew of pipefitters was installing the CO₂ system, and assembling materials for the other piping work.

Two 12-hour shifts were working on the turbine at this time, removing the top cover plate, cleaning and painting, while the top recesses were filled with concrete. When the runner was placed in the scroll case, workers immediately began installation of the guide vanes. Shiming became necessary at this point, as mentioned above.

Work on the rotor was approximately 80% complete. Much time and effort was being expended on packing the splits.

Assembly of the field poles on the rotor had started, with 13 poles in place, as of December 19.

With much of the future construction and installation dependent upon the early arrival of the butterfly valve, officials at the site were

attempting to anticipate difficulties which would be encountered during the installation. It was first thought that the contractor would have the same trouble with the butterfly valve that he had with the spider, when the time came to move it over the tracks to the Powerhouse. Clearance at the adit portal was 17-feet, 5-inches, from the top of the track. According to measurements of the butterfly valve, the total height on this piece of equipment would be 19-feet, 3-inches -- much too high to permit entry into the portal far enough to allow for the switching of the flatcar to the spur leading into the Powerhouse. It was tentatively planned to slide the car from one track to the other in the same manner that had been applied in moving the spider.

On December 17, the generator rotor was checked by turning it with a lifting beam. The test was satisfactory, and Westinghouse went ahead with its installation of field poles.

The contractor inquired about the portal arch dimensions, when he found discrepancies in excavation measurements, on December 18. Above the center of the arch the pour was to be 30-inches high, tapering to 24-inches at the ends.

At this point, Westinghouse workers began having trouble with the crane, as the Shaw crane had to be disconnected and changed from the trolley to temporary leads.

Misco had been using a section of the Powerhouse for cleaning parts before installation. Oil had been dumped or spilled on the bonded floor. The contractor was told to clean the area and, if the floor proved to be permanently stained, put in a new bonded floor.

During this period, City officials had kept a day-by-day check of the progress being made by the butterfly valve, now enroute to the construction site. It was important, from a financial standpoint, that the valves and parts be unloaded before the Christmas holidays arrived.

Holiday "Walkout"

Rumors became more and more persistent that the men were planning to take a full week off at Christmas, instead of the five days they had been granted. According to the contractors, the workers were to be given time off during December 23, 24, and 25. They were to return to work December 26 and work through the 30th. Then they were to be given the days of December 31 - January 1 to celebrate New Year's. All crews were to report back to work January 3, 1951.

Two carloads of parts for the butterfly valve arrived on December 21. One car was brought in and unloaded in the storage yard. Approximately two carloads of material waited to be loaded in the yard, by this time.

Immediately following lunch, December 22, the men working for all contractors left the job for the holiday.

On Tuesday, December 26, City officials returned to work to find that workers for the Guy F. Atkinson Company and Misco had stayed away en masse.

The butterfly leaf arrived in Rockport on the 26th. A check showed the load had shifted during the trip, and it was thought the shift might have caused damage to the leaf. Half the tie-rods on the load were broken. An inspector for the City ordered the car to remain loaded, until an inspector for the Great Northern Railroad could inspect the freight. This was done in case a claim for damages would have to be filed. Because the extent of the damage could not be determined until the leaf was unloaded, no representative of the railroad was sent out, but the train dispatcher at Rockport noted on the billing that there might be possible damage. Pictures were taken of the shipment.

The Atkinson Company decided to pay demurrage costs for leaving the car loaded, rather than go to the expense and trouble of trying to hire men

for the job when none were observable on the job site. Only the Westinghouse crews had returned to work when they were supposed to.

In the meantime, batteries and battery equipment arrived at the site from Seattle. A three-day check of the cargo showed four battery cells had been broken in transit.

The crew which had been working on the quonset gymnasium was down to three men and a foreman. Considerable finishing still remained to be done, and the short-handed crew placed insulation and $\frac{1}{4}$ -plywood in the 40-foot unit. City Light electricians were stringing wire and installing light fixtures. A City Light paint crew had done some preliminary work on the woodwork and doors, during late December.

During installation of the rotor brake shoe runner, the Westinghouse workers had to grind the bottom edge of the rotor lamination backing plate in order to make the runner fit. In preparation for changeover work which would be done during the spring and summer of 1951, the contractor began plans to remove Unit 23, an 11kv bus tie breaker, bank 20 bus tie breaker, and the altering of the Diablo line breaker for easy removal at a later date.

The thrust bearing jacking hollow boots had become badly rusted in transit, due to the lack or faulty application of rust preventatives at the factory.

On New Year's Day, more than two inches of snow fell at the construction site. A discussion was held that afternoon concerning the amount and types of work which would be given preference in order to get it done before cold weather set in permanently.

Miners were removing tightrock in the adit, for wall construction, and the north bank of the railroad had been excavated for permanent railroad installations. This was the final week of December, and the Powerhouse work had been practically completed — at least, as far as

excavation and construction were concerned. The roof trusses in the Powerhouse were finished, except for some lower chord bracing which couldn't be installed until a permanent trolley for the Cyclops crane could be built. The sidewalk under the main entrance bridge had been poured, by late December, and gravel surfacing for the main and spur tracks had been finished.

As regards the progress of mechanical installations by the end of 1950, servomotors had been put in, packing had been completed, the deflector cone, oil slinger ring, oil pan, and bearing extension ring had been installed -- all this work having been done on the turbine.

Westinghouse completed setting all the field poles on the rotor, and work was progressing by ramming and driving the keys to lock on the poles. All splits had been packed and bolted, and all lower supporting ring connections had been riveted and tapped.

The New Year Begins

None of the Guy F. Atkinson crews reported for work between Christmas and New Year's. Even after that, the return to work was not spontaneous, with several days being required after the holiday before crews were at full strength.

When work did get underway, stripping of the forms at the adit portal began.

There were likewise no crews from the Marine Industrial Supply Company on the job between Christmas and New Year's. When they did return, their numbers had been augmented by several newly-hired pipefitters.

On January 2, another fire was started in a bucket of cleaning fluid by a Misco welder. Repeated warnings had been issued by City representatives at the site, regarding the fire hazard at this stage of the operations. Many crates, boxes, and other inflammable materials were lying around the floor. Ironically, this fire broke out less than

an hour after inspection and warning by City inspectors.

On the afternoon of January 3, workers for the Misco firm began unloading the butterfly valve. Before the leaf was unloaded at the Powerhouse, an inspection revealed that a brass seal on one side had been marred and dented. Since this damage had not been discovered during the earlier inspection, it was probable that the marks and scratches had been caused by a load sling being used by the subcontractor to remove other parts from the flatcar. The unloading was being done in the crane storage yard. When it was well-established that the damage had been done by Misco workers, the subcontractor was instructed to repair the equipment at his own cost. Actually, the damage was minor and comparatively inexpensive.

Many disagreements had arisen over the use of the Cyclops crane. Oftentimes, the crane would be badly needed in several places at the same time. It soon became a case of which contractor had priority on its use. On January 7, one of the subcontractors was using the crane on a relatively minor job, causing a 4-hour delay in moving the butterfly valve into the Powerhouse. It was thereupon decided that the crane would be used by Westinghouse. If any of the other contractors needed the crane, they were to make arrangements with Westinghouse. And if further disagreements arose, they were to be settled by the inspection force.

Quonset Gymnasium Completed

By the end of the first week of 1951, the gymnasium in Newhalem was finished. Only painting and interior decorating remained to be done. Completion of the electrical work on the gym was being held up by the slow arrival of 115v control coils.

In order to check alignment, piano wire was strung between the centers of the penstock and the scroll case. The lower half of the butterfly valve was lowered into place, and Westinghouse was told to

make room for two unit subs which were being moved into the Powerhouse.

Two City Light railroad cars were in the storage yard, loaded with air housing and miscellaneous material. The contractor wanted to leave the material where it was but was told by the City's representatives that work on the adit tunnel liner would tie up use of the railroad for at least a week. And because workers in the Powerhouse would need the materials on the flatcars within a few days, they would have to be unloaded and moved into the Powerhouse at once.

Installation of the crane trolley was completed on January 9, and it had to be operated on a cable borrowed from the contractor, since no cable was provided by the City. In the meantime, a flatcar loaded with a Westinghouse transformer arrived at Rockport and was detained there for inspection by the City.

On January 10, the south wall of the adit was poured. Forms were immediately set up for pouring the north wall the next day. Misco completed drilling expansion joints, went ahead with work on the guide vane linkage, cleaned up the butterfly leaf, and stood by to install the lower trunion. Pipe fabrication continued at a good pace.

By this time, assembly of the rotor was 95% complete, and the stator, 35%. All the spring retainer-bar keeps had been driven, on the rotor. Key extensions on the bottom had been cut off, and all key keepers had been bolted in place. The pole adjusting screws were still to be tack-welded on the bottom of the rotor.

Work continued on the stator with the winding of splits. The top connections on two of them had been finished, with the bottom connections soldered. On one of the completed splits, mica separators had been inserted in preparation for taping.

A platform was built in the turbine pit, serving a dual purpose. It would be used while building the lower guide bearing, and it would also

be used to hold the runner while lowering and aligning the lower bracket.

With the north sidewall of the adit completed, the contractor began building forms for the arch. Considerable tightrock was found above the upper end. The arch had been held high to save concrete, causing a six-inch discrepancy between the archway and portal arch. This change was approved by the City.

Misco requested (on January 16) that the lower leaf base be set on wedges, the leaf lowered onto it, and the top half set in place. Thus, the whole valve could be adjusted to the companion flange holes, which the contractor said did not fit. The flange setting was checked by inspectors found to be 1/8" off in rotation.

The contractor was instructed as follows: (1) turn the flange to the right position, (2) set the bottom half to match the lower half and companion flange, (3) level the bottom half in all directions parallel to the center line, (4) set the leaf jack pedestal in the right position, and (5) grout both the bottom half base plates and the jack pedestal plate, to set them permanently.

Unless these measures were taken, there would be no control over the butterfly valve when the City Light wire was removed (after the leaf was set in).

On January 19, a representative of the firm which made the butterfly valve launched a protest with City inspectors, saying Misco was not employing competent men for work on the butterfly valve. He pointed out that riggers and laborers are not competent to do such technical installation work.

The top half of the butterfly valve was installed during the late afternoon of January 23, as work continued on the turbine and water piping. The contractor was making the forms for the adit tunnel arch pours. Removal-oil storage foundations were being excavated.

Bridge Cables Too Short

During the same day (January 23), a City inspector discovered that the bridle cables on the suspension bridge were too short. After discussing the matter, it was decided to lengthen the cables by using pieces of 5/8" stud plates.

On the 24th of January, considerable trouble was encountered with the traffic bridge controller. The specific trouble-spot that day was the trolley traffic controller. It had arked across the finger. The drum contactor had been misplaced on the drum, opening the circuit on the last contact. The controller shaft was off center at the bottom approximately 1/16". Consequently, the drum contactors operated eccentrically, making it difficult to evenly adjust the contact fingers. In fact, some of the contacts were actually too short. When this was discovered, all controllers were thoroughly checked.

The quonset gymnasium had been finished a scant few days when a laborer was assigned to work grinding its floors. With this finished, the gym was complete.

It was reported on the 25th of January that the contractor was hauling aggregate for the arch pour which consisted of 50% snow. The pouring operation was called to a halt, until the aggregate could be dried. The pouring resumed later the same day. Form work was then started on the second pour.

The installation of the turbine oil system was going full tilt. The scroll case expansion joint was riveted and completed during the final week of January. Because the workers had been diverted to other jobs at the site, work on the rotor was slow. The lower blower sections were assembled for mounting, the top keys had been cut off, and the key keepers were in place. Assembly of the top blower sections was begun toward the end of January. Coils in the splits had been high-potted at

29,000 volts, and tested satisfactorily.

On January 25, Misco reported that it would started drilling the companion flange early the next week. They were thereby directed that the valve, taps section, and straight section should be aligned to the expansion joint before drilling started.

Drilling started the next day, January 26.

The contractor's foremen wanted to drill and rivet the companion flange before welding the make-up section — despite the fact that the Specification called for welding to be done before riveting started. City Light, when apprised of the dispute, instructed the contractor to follow the Specifications.

The weather was extremely cold at the construction site during the last few days of January, with thermometers hovering near 15 degrees above zero. Atkinson Company employees were put to work thawing out water and air lines.

Representatives of firms expecting to proffer bids for the electrical installations at Gorge visited the site on January 30, to inspect the construction area and conditions.

A check of the work progress on the closure piece alignment showed that the contractor had checked the alignment to within $3/16$ ". He had checked the closure section required length — $43\frac{1}{2}$ " to $44-1/8$ " — with plans to cut the closure section to $43-3/4$ " for the rough cut. He had then moved the expansion piece back, and the place section in, to make the final cut. But the contractor had not checked whether his $5/8$ " difference was due to the taper section edge, or the expansion joint edge. He therefore had no assurance that he was leaving enough to take care of the fitting.

By the middle of February, forms for the remaining concrete pours had been completed. The base for the air braking and jacking unit was poured,

and two of the three oil pump bases (in the oil purifier room) were poured.

Weather Prohibits Concrete Pours

The Guy F. Atkinson Company called a halt to productive operations at the end of the day shift, February 1, 1951. Stormy weather and low temperatures prohibited further pourings. All crews were therefore laid off, until the last pour could be made. If the weather cleared, the contractor expected to call the men back to work on February 12.

Regarding the mechanical installation work, four of the 29 men who were on the Misco payroll were taking time off until additional piping material arrived. The straight closure section had been installed but, because of an excessive gap at the root of areas which were to be welded, the section had not been okayed for welding.

The drilling and reaming of the extension ring (from the butterfly valve to the penstock) was completed, and ready for riveting. Hangers were installed for the turbine gauge lines and governor piping. But no progress was made on air and water piping, because no pipe had arrived.

Work on Generator 24 was moving ahead, as the upper bracket was set in place and bolted to the stator frame for preliminary aligning of the shaft and stator. It was to be removed later for setting the rotor.

The rotor was about 99% complete in mid-February, stator winding had been finished, and the thrust bearing was more than half complete. One-fourth of the work on the installation of the neutral main leads was finished, and a good started had been made on the air housing.

By this time (February 15), all inside field coil connections had been bolted and soldered, while outside connections were being brazed. On the rotor, both blower sections had been bolted in place, and the main field leads were assembled on the spider arm.

Workers were cleaning and painting the interior of the air housing, having completed about half the job. The thrust bearing shoes were fitted to

the compression tubes, and the shaft and runner had been lifted. The thrust bearing had been installed in the lower bracket. The device which had been used for lifting was removed from the shaft to make way for staging which would be used in work on the bearing.

All stator coils had been soldered, taped, and painted. The six 2000/5 current transformers had been assembled on the neutral leads, and these connection joints were being taped.

At this point — mid-February — the generator was about 65% complete.

Electrical Contract Awarded

On February 7, 1951, the Board of Public Works for the City of Seattle opened bids on a contract for "Electrical Installation for Units 21, 22, 23, and 24, Gorge Powerhouse Extension Project".

Three electrical companies submitted bids. The Morgan Electric Company joined with the Casey Electric Company to tender a bid amounting to \$400,479.14. This sum was more than twice as high as the winning bid. The Industrial Electric Company's bid of \$207,956.59 also failed to win the contract.

The electrical installation work, under Specification 1085, was given to the Donald W. Close Company, of Seattle, for their low bid of \$193,887.11. They began operations during the first week of March.

Concrete Work Finished in Adit

During the final days of February, the concrete work in the adit neared completion. Only chipping and drypacking the slick line access holes remained to be done there. In the Powerhouse, the bases for pumps in the oil purifier room were completed. Also finished during this period were the bases for the air receiver tank at the 485 level.

Workers had begun stripping out the adit liner, and clearing away the form material. This work was half done, as February ended.

When the oil and air tanks were removed from the old Powerhouse, the floor area they left vacant was badly in need of repair and refinishing. After the tanks had been moved to the new addition, the workers returned to the old building to work on the floors. This work was completed in late February.

At this time, the Atkinson Company had 19 men on its payroll.

By the end of the second month of 1951, the turbine assembly was 90% complete, as were the oil lines leading from the generator jacking unit to the turbine pit. The contractor had connected the six-inch fire protection and service water lines to the old Powerhouse. They had been tested from the valve to the "7" line.

Two-inch lubrication oil lines had been installed from the governor cabinet to the oil pump, and work was beginning on lines leading from the pump to the tanks.

Because the prefabricated transformer oil piping was found to be very dirty when it arrived on the job site, none of it could be installed until workers had devoted most of an entire shift to inspecting, cleaning, and working on each individual piece.

The riveting of the companion flange to the penstock liner was completed February 21. The operating cylinder and the control cabinet were placed and grouted in. Fitting of the by-pass assembly was started, as the filler section was welded to the reducing section. The latter work was completed except for grinding. One pass had been completed on the welding of the filler to the expansion section.

Meanwhile, Westinghouse was conducting alignment checks in conjunction with the generator installation.

The 37-man labor force which had been working on the generator was soon to be reduced, because boilermaker and rigger work was almost completed. By early March, the generator was 68% finished.

Quality of Brazing Assailed

When all the brazing for the outside field poles had been completed, a City Light representative reported "... (they) do not appear very neat." Several persons at the scene questioned the appearance and strength of these connections. Pictures were immediately taken of the more obvious bad connections.

The total resistance of the field was taken, together with millivolt drop measurements, of each field coil connection.

The generator shaft had been given preliminary alignment, and was satisfactory for a rotation check after the rotor was placed. A delay was expected in placing the rotor, because an engineering change in the baffles design had to be completed before installation could begin. The thrust bearing supporting the blocks was too narrow, and it had to be replaced before the shaft could be brought to its proper height.

The conduits for the heaters inside the stator, the conduit for the neutral current secondary leads, and some of the conduit for the brake limit switches and alarms had been installed. After the air housing side sections had been cleaned and painted, the erection of these sections was started. As of March 5, seventeen of these sections were in place, with approximately 20% of the air housing assembly complete. On the same day, the layout was started for the location of cinch anchors (for the columns supporting the air housing between the generator and the "C" line wall).

During the second week of March, the contractor worked on the forms for the transformer slab, but progress awaited installation of the conduits. And conduit installation was impeded by a lack of help, supplies, and inclement weather. A labor crew had been cleaning up the adit, removing nipples and opening weep holes. Fourteen men were on the

Atkinson payroll (March 14) and they were employed mainly in general cleanup.

By this time, the seat for the butterfly valve was in place, awaiting tests. The test had been delayed because of a lack of wire which would be used to connect the electrical system. This wire finally arrived (March 14) and work started. The contractor was waiting for authorization from the Seattle office to make the cross-over on the old Powerhouse piping, and to fill Penstock 24 to test for leakage.

Welding of the filler to the expansion section had been completed, and workers were awaiting the results of the radiograph. Meanwhile, work started on the packing gland, as painters finished covering the butterfly valve installation with a coat of red lead.

On March 7, pipes were connected to the generator coolers.

The generator itself was about three-fourths complete. The work on the air housing was 65% done, and only half of the wiring remained to be done.

All wiring for the CO₂ and brake limit switches was in and hooked up, except for the connection between the stator frame and the "GA" box. Wiring was done for the air thermostats and 3 KW heaters, except for that to the "GA" box and heating units. These heaters were slated to be installed when workers finished welding the baffle plates. The heater thermostat was soon installed.

The 4000/5 neutral CT's had been put in, taped, and painted.

The re-designed air baffles had been fitted on the lower bracket, and installation was complete except for some of the inside supporting sections. Welding had been started on this baffle, and when it was finished, the rotor could be set.

The columns, beams, and angle irons on the "C" line wall had been put in to support the deck plates in this area. It was planned to

soon be able to align the air housing wall section to these beams.

All material had been removed from the storage area and shed, and put in the Powerhouse.

First reports of progress by the Donald W. Close Company (installing electrical equipment under Specification 1085) noted that the contractor had unloaded the take-off structure and the isolated-phase bus material. Welders and linemen had already erected about half of the take-off structure, when all crews were forced by bad weather to halt work on it. But electricians continued to assemble materials for the bridge conduit installation. Nine men were working on this contract on March 14.

Early in April, the contractor finished work on re-steel and ground cables, then set the channel iron for a pour at elevation 498.88 to set the 11-KV switchgear. He poured the base, and a portion of the air housing at elevation 515.75 and began cleaning up in preparation for pouring the curb around the air housing base. Ballast placement in the adit was completed in the meantime.

Generator 24 was more than 85% finished by the first week of April. The air housing had been given final leveling and aligning, and was ready for the curb to be poured. All deck plates were in, except those which would be fit around the isolated-phase bussing. The contractor was welding deck beams to the stator support brackets. Cinch anchors had been installed to fasten the air housing to the wall.

Openings for the terminal box "GA" had been cut in the air housing, and doors had been installed. The terminal box was in place. And conduit connections were being made into this box by Close Electric and Westinghouse. Conduit runs were being finished in the generator and air housing as they were required. Channels for the generator switchgear were leveled and aligned, and the switchgear pad had been poured.

The inside of the exciter stub shaft was cleaned and painted before mid-April. Connecting bolts were cleaned, while the fit surface on the rotor (for the shaft) was cleaned and stone-dressed.

The electrical contractor had meanwhile raised the rest of the steel for the take-off structure, as part-welding began. Lightning arresters had been assembled and hung, but they had not been secured in place. The contractor started pulling light circuit wiring, assembling the isolated-phase bus for Unit 24, and placing hangers for the cable trays during April. Three transformers had arrived, and steps were taken to unload and store for fitting (in preparation for filling them with oil).

Final Tests and Checks in Progress

Before the middle of April, the base was poured for the Westinghouse air housing, and the fill-in pour was made at elevation 498.88 for the 11-KV switchgear. Aside from this, Atkinson crews were working at clean-up jobs to close out the contract under Specification 895.

The generator water-cooling system was pressure-tested during the early part of the month (April). Transformer oil lines were tested and flushed. Manual controls for the CO₂ system were hooked up as fire protection for the oil storage room during line-flushing operations.

All deck plates on the generator air housing had been fitted, with nearly half of the felt work completed. The supporting columns and beams had all been installed and bolted, including the wall sections.

Lighting and plug conduits were put inside the air housing. Three-way switches were in place at both air housing doors.

The main bus compartment had been set, and main leads from the generator to the compartment had been installed, taped, and painted.

The high-pot equipment was put in, and the stator and rotor had already been high-potted.

As soon as the electrical contractor took delivery of three transformers, he set to work checking the equipment for nitrogen loss. The conduit for the extension of the duct bank (crossing the railroad bridge) was being worked on, with about 30% of the job accomplished. Steel work for the take-off structure had been completed, and work was started on the isolated-phase busbar for Unit 24.

Powerhouse Construction Work Practically Complete

There was no actual construction activity at the Gorge site during April. The only work performed under Specification 895 was the dismantling of construction-area buildings which had been sold to private individuals.

Regarding mechanical installation (Specification 1035), the Powerhouse had been shut down during the last period of April, while the hemisphere plug in Penstock 24 was removed. The contractor used a crew of eleven men, working continuously from 1:30 p.m. April 28 until 9:30 p.m. on April 29.

Pipefitters had completed the copper tubing for air lines, except for the hook-up to the switchgear. Air piping to the old Powerhouse was near completion. Although it was not connected to the receiving tank, the 25 CFM compressor had been hooked up to the air lines. The rear cooler was in position, but had not yet been connected to the air and water lines. A pair of machinists were working on the turbine bearing.

Work on Generator 24 was progressing satisfactorily. During the first week of May, the thrust bearing was lowered, given a final cleaning, then returned to position. The shaft was centered and blocked with four of the lower guide shoes, while the rest of the guide shoes were put in place and adjusted. The upper guide bearing shoes were being cleaned and fitted, in preparation for assembling. And though not in place,

the lower oil pot seal and cover was assembled.

The braking and jacking pump had been permanently connected by early May, except for connecting the motor. And the motor would be connected as soon as there was a need to use the pump for installation purposes.

Work on Specification 1085 was proceeding well. Two painters had been employed on the take-off structure, touching up welds with red lead, and applying the first coat of aluminum finish paint.

Assembly of the cable tray hangers continued in the cable-spreader room. Transite bottoms were placed in trays in the butterfly valve room.

Wire was pulled to the 25 CFM air compressor and, in the absence of a control panel, a temporary hook-up was made.

Two tank trucks of lubricating oil had been unloaded and stored.

During the first two weeks of May, the only activity on Specification 895 was the day-to-day moving out of material by the Ross Powerhouse Contractors.

However, there was considerable activity in mechanical installation, under Specification 1035. The Sullivan compressor was moved to its permanent location, and would be ready for full operation as soon as the wiring was installed.

Re-pouring of the loose portions around the turbine guide bearing was completed, under the surveillance of a technician from the Allis-Chalmers Company. It was then blued in and installed.

Cover plates were being put in, the oil well and turbine area were being cleaned up, the air and water service cabinets were being installed, and the fire hose had been permanently located.

The Westinghouse Company had completed installation of the oil seal and cover plates on the upper and lower generator bearings. Covers had

been put on the lower bearing bracket supports. But strain gauge readings had not yet been recorded, so covers had not been put on the compression tube. The exciter field and armature had been set in place and wired; connections had been made in the generator terminal box.

The only activity remaining on Specification 895 was the dismantling of the warehouse.

By late May, 1951, the contractor working on mechanical installation had completed his testing of the oil and air lines in the turbine pit. Then he set the guide bearing. The oil well had been cleaned, and the interior of the turbine pit was painted to elevation 504.

The turbine flow meter pedestal had been installed during the last week of May, and piping connections had been made to the piezometer lines. Only the filling of mercury and final adjustments remained to be done.

By the end of the month, air and water line connections to the air compressors were finished. The compressors had already been put in service. Lubricating- and transformer-oil pumps and motors had been aligned in the oil transfer room. The second circuit breaker air compressor was received May 23, 1951.

By this time, work on the generator was going full-bilt. All work on the lower bearing (including the installation of thermocouples), oil and water piping had been completed. The cover of the lower bracket had been put on, and bolted to the pit liner. Name and data plates were put on the air housing.

The electrical-installation contractor had pulled eight runs of cable in the river, crossing the duct bank.

The 4 and 5 panels of the main control board were received, and installed in the operating room. Power Board PA was then connected. Power and control circuits had been pulled to the air compressors and

sump pumps. These units were now in permanent operation.

By the first week of June, there was no activity whatsoever on Specification 895. That phase of the Gorge Powerhouse Extension project had been completed.

The Misco firm had three men on its payroll. To begin the month of June, these men put the second circuit breaker in operation and connected it to the system.

The turbine stuffing box was packed, and drains were installed from the $\frac{1}{2}$ -inch reducing valve strainers. Meanwhile, the pipe sleeves through the transformer deck were re-caulked and covered with mastic.

The device which would be used for lifting the draft tube gates arrived at the site. It was moved to the transformer deck, but was not immediately set up.

Most of the Westinghouse workers employed in work on the generator were engaged in clean-up operations. By this time (early June) the Westinghouse work force was comprised of two men.

The neutral protective screen was completed, strain gauge readings were re-checked, thrust bearing lower screw caps were in place, oil piping to the upper guide bearings was finished, the thrust and upper guide bearing cooling-water return-flow indicators were installed, and miscellaneous oil and temperature gauges were put in.

Wiring work was started on the newly-installed unit control board and the graphic board. The motor-operated rheostat had been set in place. Wiring and connecting the main control, governor cabinet, and generator control leads was in progress by mid-June.

The Casey Electric Company (Close Electric subcontractor) was employing ten men, while the contractor employed thirteen.

During the middle of the month, additional clean-up was done, as the contractor dismantled and removed the batch plant.

The butterfly valve was test-operated under penstock pressure on June 5, 1951.

Generator 24 was started on a mechanical run the next day, as preparations were being made for an early dry-out run of Unit 24. The Donald W. Close Company was busily connecting all power and control cables necessary for the test.

The main control, unit control, field rheostat governor, and lifting, jacking, and breaking controls were pronounced ready for operation, after exhaustive tests were made.

By July 5, little remained of operations under Specification 895. Buildings had been removed and debris had been burned. The concrete foundations for the batch plant, compressor building, and machine shop had been broken up and moved away to provide riprap for road construction.

The temporary track from the contractor's spur switch had been removed, and a new permanent track was being laid from the railroad bridge to the construction adit. This work was completed by late June, and the contractor made arrangements to have a City grader finish the area.

The contractor working on mechanical installation spent the last days of June putting in vent drain pipes leading from the generator air coolers to the floor drains.

Draft tube gates were operated to seal off the draft tubes, allowing personnel to check turbine runner lower seal clearances. Despite persistent efforts, the gates could not be set tight enough to completely unwater the draft tubes.

Early in the morning of June 21, 1951, Unit 24 was placed on the D-1 transmission line to begin its operational test run -- one hour on each .1 gate opening, and thirteen hours on full gate opening. The run was completed the next day, after the contractor had recorded all

operating temperatures as called for by the specifications.

The turbine operational run was followed by governor load dumping tests. They were finished on June 23.

The contractor was employing two men by this time, and for the remainder of June both men were working on cleanup details and removal of construction equipment from the plant.

The crew which had been working on the generator was used during late June to help the Westinghouse test crew on the characteristics tests of Unit 24. These tests were completed June 17, followed by a thorough check of the air housing and upper bracket bolting.

On the 19th of June, the Westinghouse field engineer adjusted the rototrol control. The rest of the month was spent repairing and adjusting minor faults. Nearly 100 pounds of steel weights were welded to the rotor, for balance.

Electrical installation was progressing smoothly during mid-June, with the contractor concentrating his efforts on the installation of 196 KV switches, connections from the transformer to the line to the switchyard, and connecting all control and relay circuits in the switchyard and main control boards. This was done to hurry the operational test of Unit 24. This test began June 21.

The contractor worked on lighting and heating circuits, fixtures for the visitors' gallery, connecting power board "PB", and completing wiring which lead to the pumps in the oil purifier room. These pumps were then tested.

During the last week of June, the contractor worked on the installation of cable trays for 1750 MCH leads to Units 21, 22, and 23.