UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of	)	
	)	
Philadelphia Electric Company	)	Docket Nos. 50-352
	)	50-353
(Limerick Generating Station,	)	
Units 1 and 2)	)	

APPLICANT'S SUPPLEMENTAL RESPONSE TO
INTERROGATORY 12 OF DEL-AWARE UNLIMITED, INC.
ADDRESSED TO APPLICANT PHILADELPHIA ELECTRIC COMPANY

Interrogatory 12: Please identify and describe the contents and conclusions of any reports, studies or other material relating to the phasing of the construction of the Point Pleasant diversion and the timing of the work in the river. In other words, please provide a complete description of and identify all information made available to PECO relating to the need to undertake constructing in the Delaware River during the first winter of project construction (i.e., 1982-83).

Answer: The timing and phasing of the construction at Point Pleasant was discussed fully at depositions on August 6, 1982 (Tr. 46-86) (copy attached). It is estimated that completion of the entire Point Pleasant project as it relates to Limerick will take approximately two years (Tr. 52). Fuel loading for Limerick Unit 1 is currently scheduled to commence between July and October 1984 (Tr. 56). The completion of preoperational testing will require the availability of supplemental cooling water from Point Pleasant at least three months prior to the fuel loading date (Tr. 57). Accordingly, it is deemed necessary to commence construction promptly on December 15, 1982 as scheduled in order to meet existing deadlines.

The final Section 3.8 approval granted by the Delaware River Basin Commission ("DRBC") provides as a condition of the approval the following:

> N. Construction excavation and maintenance dredging in the Delaware River must be performed between November and March to reduce the potential for impact on migrating juvenile and adult shad. [DRBC Docket No. D-65-76 CP (8) (February 18, 1981)]

DRBC has thereby required that Neshaminy Water Resources Authority ("NWRA") undertake work in the river between November and March (Tr. 51). It is necessary to begin the portion of construction in the Delaware River during the winter months of 1982-83 so that river work can be completed during the winter of 1983-84. There is no reasonable assurance that all of the construction work in the river can be completed within a single winter because work cannot be performed during high flow periods, owing to increased river flow velocity (Tr. 53-56). Accordingly, it is necessary that river construction work begin this winter as scheduled.

The letter of September 9, 1981 from E.H. Bourquard to the Corps of Engineers discusses phasing of construction work. Although there is some flexibility in the time for performing the particular work designated for each of these phases, (Tr. 63-66), any delay in starting construction will cause a commensurate delay in its completion (Tr. 73). Regardless of any planned phases of construction work, NWRA must abide by the restrictions imposed by DRBC which limit river excavation to the winter months of November through March.

VERIFICATION

Commonwealth of Pennsylvania)
) ss
County of Philadelphia)

Vincent S. Boyer, being first duly sworn, states that he is Senior Vice President of Philadelphia Electric Company, the Applicant herein; that he has read the contents of "Applicant's Supplemental Response to Interrogatory 12 of Del-Aware Unlimited, Inc. Addressed to Applicant Philadelphia Electric Company" and that the statements and matters set forth therein are true and correct to the best of his knowledge, information and belief.

Vincent S. Boyer

Vincent S. Boyer

Subscribed and sworn to before me this 15th day of September, 1982

Notary Public

Notary Public, Philadelphia, Philadelphia Co.
My Commission Expires

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

In the Matter of	)	
	)	
Philadelphia Electric Company	)	Docket Nos. 50-352
	)	50-353
(Limerick Generating Station,	)	
Units 1 and 2)	)	

CERTIFICATE OF SERVICE

I hereby certify that copies of "Applicant's Supplemental Response to Interrogatory 12 of Del-Aware Unlimited, Inc. Addressed to Applicant Philadelphia Electric Company," dated September 15, 1982 in the captioned matter, have been served upon the following by deposit in the United States mail this 16th day of September, 1982:

Judge Lawrence Brenner (2)
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Judge Richard F. Cole
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Judge Peter A. Morris
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Atomic Safety and Licensing Appeal Panel
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Docketing and Service Section
Office of the Secretary
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Stephen H. Lewis, Esq.
Ann P. Hodgdon, Esq. Elaine I. Chan, Esq. Counsel for NRC Staff Office of the Executive Legal Director
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Atomic Safety and Licensing Board Panel
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Philadelphia Electric Company
ATTN: Edward G. Bauer, Jr.
Vice President & General Counsel
2301 Market Street
Philadelphia, PA 19101

Mr. Frank R. Romano
61 Forest Avenue
Ambler, Pennsylvania 19002

Mr. Robert L. Anthony
Frieds of the Earth of the
Delaware Valley
P.O. Box 186
103 Vernon Lane
Moylan, Pennsylvania 19065

Mr. Marvin I. Lewis
6504 Bradford Terrace
Philadelphia, PA 19149

Judith A. Dorsey, Esq.
1315 Walnut Street
Suite 1632
Philadelphia, PA 19107

Charles W. Elliott, Esq.
123 N. 5th Street
Suite 101
Allentown, PA 18102

Mr. Alan J. Nogee
3700 Chestnut Street
Philadelphia, PA 19104

Robert W. Adler, Esq.
Assistant Counsel
Commonwealth of Pennsylvania
DER
505 Executive House
P.O. Box 2357
Harrisburg, PA 17120

Thomas Gerusky, Director
Bureau of Radiation
Protection
Department of Environmental
Resources
5th Floor, Fulton Bank Bldg.
Third and Locust Streets
Harrisburg, PA 17120

Walter W. Cohen, Esq.
Consumer Advocate Office of
Attorney General 1425
Strawberry Square
Harrisburg, PA 17120

W. Wilson Goode
Managing Director
City of Philadelphia
Philadelphia, PA

Steven P. Hershey, Esq.
Community Legal
Services, Inc.
Law Center
North Central Beury Bldg.
3701 North Broad Street
Philadelphia, PA 19140

Donald S. Bronstein, Esq.
1425 Walnut Street
Philadelphia, PA 19102

Mr. Joseph H. White, III
8 North Warner Avenue
Bryn Mawr, PA 19010

Dr. Judith H. Johnsrud
Co-Director, ECNP
433 Orlando Avenue
State College, PA 16801

Robert J. Sugarman, Esq.
Sugarman & Denworth
Suite 510
North American Building
121 South Broad Street
Philadelphia, PA 19107

James M. Neill, Esq.
Box 217
Plumsteadville, PA 18949

Director
Pennsylvania Emergency
Management Agency Basement,
Transportation
and Safety Building
Harrisburg, PA 17120

Robert M. Rader

Robert M. Rader

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

- - - -

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

- - - -

IN THE MATTER OF PHILADELPHIA ELECTRIC COMPANY (LIMERICK GENERATING STATION UNITS 1 & 2)	: : : : :	DOCKET NOS. 50-352 50-353

- - - -

Depositions of Vincent Boyer, Haines Dickinson, Paul Harmon, and Everett Bourquard, taken on behalf of the Intervenor, at the law offices of Sugarman & Denworth, Suite 510, North American Building, Philadelphia, Pennsylvania, on Friday, August 6, 1982, beginning at 10:10 a.m., before Kathleen S. Seiter, a Registered Professional Reporter and Notary Public.

- - - -

MR. CONNER: Would you give us back the stuff you examined, so it doesn't get mixed up?

MR. SUGARMAN: Oh, yes.

Off the record.

(Discussion off the record.)

BY MR. SUGARMAN:

Q While Mr. Harmon is gone, I will go back onto this -- perhaps we can deal with the timing question at this point.

Mr. Bourquard, if I may ask you, and if some other witness needs to answer, that would be helpful, have you been responsible for specifying the timing aspects of the project? In other words, the construction scheduling.

(Mr. Bourquard responding)

A You mean when construction would start?

Q I mean, the elements of construction, the phasing of the construction by the contractor.

Have you designed that, or have you prepared that material yet?

A Yes.

Q Does it exist, with respect to Point Pleasant, I'm talking about?

A Yes.

Q Is there some reason why that was not produced?

A Well, it was furnished to U.S. Army Corp of Engineers. And I think you have a copy of it.

Q I understand what you're saying. When was that furnished to the Corp of Engineers?

A I think it was September of '81. But I'm guessing now.

Q Have you prepared any documents on construction phasing since that time?

A No. Except there was a -- there was one part that was taken out and submitted to DER, in connection with the canal relocation.

Q One part of it was taken out?

A Well, it was done by phases. And one phase related to the canal, and for the canal crossing permit. And we submitted that part of it.

Q I want to show you a document.

MR. SUGARMAN: I will ask that it be marked as D-4 for identification. It is the letter from E.H. Bourquard to Baldwin, dated September 9, 1981.

(Letter dated September 9, 1981, to Mr. Baldwin from E.H. Bourquard, marked as Exhibit D-4 for identification.)

BY MR. SUGARMAN:

Q I will ask you, Mr. Bourquard, if that's the document you were referring to?

(Mr. Bourquard responding)

A Yes. That's September 9, 1981.

MR. CONNER: Do we have a copy of this?

MR. DICKINSON: I would think so. Yes, I guess.

BY MR. SUGARMAN:

Q Can I understand that these phases, as described in D-4, are sequential? That is, that the first phase will be completed before the second phase starts?

(Mr. Bourquard responding)

A It wouldn't necessarily have to be, no.

Q But was that your plan?

A No, not necessarily. We were given the phases in which the work would be done. But it wouldn't necessarily have to be done in that fashion.

Q But is this the essence -- I'm just trying to say, not is this completed. But as I see it, this document looks to me like it says that this is one way to do it.

The first phase is the installation of the intake conduit under the canal. The second phase is the installation of the remainder of the intake conduit and gate well, et cetera.

MR. CONNER: Mr. Bourquard, do you want to refresh your recollection?

MR. BOURQUARD: Yes, I would like to see it.

A You will note in here, it says the construction procedures for installation of the facilities comprising the Point Pleasant Pumping Station intake, will require the following general activites, the sequence and extent of which may be varied by the contractor within the constraints imposed by the specification and by pertinent permit requirements.

Q And have you prepared the specifications yet?
A We're in the process of doing that now.
Q Will you be specifying any phasing different from that in D-4?
A No. Not generally, no. No. It may go into more detail.
Q How long is it estimated that phase one -- how much time will phase one consume?
A Offhand, I don't know. I would have to check back at the detailed --
Q Just generally, general estimate, engineering judgment, if you like, more or less than six months?
A I would say probably more than six months. The first phase is where we put the intake on the canal, and would probably be somewhere three to six months.
Q Is there a reason why that is phased first?
A No. I think this just happened to be a political part of it. And it looks like we will not do that first.

One of the reasons being, that they probably will do blasting elsewhere, rather than under the canal part of this.

TIMING
PHASING

And another condition would be, depending upon the time of year that we have to start the work. We are required by DRBC to undertake the work in the river between November and March.

Q And when you find out what part of the year you will start, then you will know what the phasing is? Is that what you're saying?

A Yes. The contractor will set up the phasing.

Q What is the constraint in terms of projection completion? What is the limiting element, time-wise?

A I don't quite get what you mean by that.

MR. CONNER: You mean, how soon does the contractor have to be done?

MR. SUGARMAN: No.

BY MR. SUGARMAN:

Q What is the limiting activity? What is the activity which is going to take the longest?

(Mr. Bourquard responding)

A Oh. Well, the construction of pumping station, I would guess. Yes.

Q By the pumping station, you mean the building?

A Yes.

Q And would I be correct in saying that that's about 25 months?

A No. It won't be that long, no.

Q Again, the document is being copied, but I remember seeing a bar chart critical paths, that showed the pump station, your estimate, 22 months, and PECO changed that to 25 months. Or maybe they estimated 22, and you changed it to 25.

A Well, I think the total project will probably take about two years.

Q About three years?

A Two years.

Q Two years.

A And while we may have a bar chart, I'm sure it will be all the parts of the project may be worked on at one -- concurrently.

It won't necessarily be a contract that we will work on a particular area, and just let the rest of it sit there.

If feasible to work on it, I'm sure he will do that.

Q Are there any constraints that require that any of your phases -- you have three phases there -- to be done in any particular sequence, other than what you just described?

A No. No. It will be --

Q There is nothing in the specifications that requires that it be done in any particular sequence?

A No, no. Other than the subject, of course, to the constraints that are imposed by the DRBC, DER, and other regulatory agencies. Yes.

Q And the only one that you know of is the one that you just referred to?

A DRBC's, yes.

Q What would it do to the construction schedule, if anything, to go into and do the river portion of the construction in the winter of '83-'84, as opposed to the winter of '82-'83?

Does it make any difference which November to March period it is done in?

A Yes, I would say very much so. I hope we can get some of the work done during this coming year.

Q What difference would it make to the completion of the project?

A Well, he's limited -- in other words, he is working during the winter months. And he will try to perform this in times when the water is low enough to give him an opportunity to do it.

So he will be taking advantage of low water at every opportunity, I'm sure. So he would start in as soon as possible.

Q Well, is the work in the river going to be completed in one winter or two winters?

A Well, it depends on, I would say, how much high water he gets.

Q Can you go into that in more detail, please?

A Well, he's going to be doing the work from barges. And during a high flow period, he's not going to be able to get much work done.

It is just simply a case that he won't be able to get at it.

Q I beg your pardon?

A He won't be able to get at it when they have high flows in the river.

Q Have you made any projections, in making up your estimated times of completion, as to the likelihood of flows of such levels as would preclude him getting into the river?

A. No. No. We didn't say that above a certain level, he wouldn't be able to get into it, or below a certain level, he would. No, we've done nothing like that.

Q. And what is that certain level?

A. I say we have not done that.

Q. Do you have any idea what level that might be?

A. No.

Q. Do you have any idea whether that level has historically occurred, whatever that level might be? In other words, whether there have ever been flows in the river, in November to March, that would preclude his working?

A. No. I don't know any particular year when it happened. But I'm sure there have been flows in November to March that would have kept him from doing work.

Q. How can you know that without knowing what those flows would be?

A. Well, I have a generalized idea. I haven't gone down in pinpoint as to what flow would stop him, and what flow would not stop him.

Q What is the basis of your generalized idea?

A Well, the fact that, as you get higher flows, you get higher velocities. And you have a problem keeping your equipment anchored in place.

Q At what flow would the velocity be such as to give him a problem?

A This, I don't know.

Q I see. When is Limerick scheduled to first need water from Delaware River Unit One?

(Mr. Boyer responding)

A Summer of 1984.

Q And for what purpose? Is that for operating?

A For preliminary operation, yes. The final check out stage and preliminary operation.

Q And you're estimating the final check out stage and preliminary operation for the summer of '84?

A Fuel load is scheduled between July and October, 1984.

Q And so when would the final preliminary operation take place?

A. Well, we should have the water available at least three months prior to the fuel loading date.

Q. The supplemental water?

A. Yes.

Q. What is the status of construction of the Schuylkill intake?

A. It is basically completed.

Q. What is the status of the permit application for the Schuylkill discharge?

A. The work is completed, so the permit is in hand.

MR. DICKINSON: The Corp of Engineers permit was received for it years ago, and construction started.

BY MR. SUGARMAN:

Q. For construction?

(Mr. Dickinson responding)

A. Yes.

Q. How about for operating discharges?

MR. CONNER: We object now to this line of questioning. Limerick is not an issue here.

He's giving you this time frame. And now this should not be broadened to get a list of all these.

MR. SUGARMAN: I'm not trying to broaden it. I'm just trying to find out -- I'm just trying to check on the time frame.

BY MR. SUGARMAN:

Q Has the permit for discharge into the Schuylkill during operation been applied for yet?

(Mr. Boyer responding)

A I think I can summarize it, by saying, that there are no constraints on the operation of Limerick with regard to Schuylkill River permits.

MR. DICKINSON: We have the DRBC permit for withdraw and discharge.

MR. CONNER: There is a list of permits in the FSAR and the Environmental Report, which state it as of that given date.

MR. SUGARMAN: That's right.

MR. CONNER: If it will save you time, if you just want to go through it again.

MR. SUGARMAN: At that point, it was stated that it had not been applied for yet, I believe.

Is that still the status?

MR. CONNER: That was, of course, two years ago.

MR. DICKINSON: I think yes.

MR. BOYER: It has been applied?

MR. DICKINSON: No, it hasn't.

I think they are working on the application.

BY MR. SUGARMAN:

Q They are working on the application?

(Mr. Dickinson responding)

A As far as I know, yes, for the MDBS permit.

Q Well, Mr. Boyer, if you were to start construction at Point Pleasant today, the water wouldn't be available in two years?

(Mr. Boyer responding)

A Well, it would certainly be available at the earliest possible date. And it could be available in two years, in my view.

Q Well, it wouldn't be available at the time that you want it, which is three months before the fuel loading starts?

A Then we will have to try to make out without it, which would increase total complexity and cost of the job. Delays cost money.

Q Well, is that why you delayed construction of Limerick for three years?

A Delays cost money. We did not want to delay the construction at Limerick. It is costing the customers more money by doing so.

Q As I understand it, your testimony in the PUC, was that you delayed the Limerick voluntarily, because it was part of an overall cost savings to do so. Isn't that correct?

MR. CONNER: We object to this line of questioning. It has nothing to do with the contentions here.

MR. SUGARMAN: The witness volunteered --

MR. CONNER: No. He did not volunteer to get into this in any further depth. I want to limit this to the three issues. And I will ask the witness not to answer.

Your question relating to the time frame for Point Pleasant has been demonstrated as needing the water in the summer of 1984. And that's really as far as you need to go into it for this purpose.

So we object.

BY MR. SUGARMAN:

Q Isn't it true, Mr. Boyer, that delays only cost money if the cost of delay exceeds the cost of saving?

MR. CONNER: We object to the further argument. There is no issue dealing with the philosophy of economics of nuclear power plants.

MR. SUGARMAN: The witness volunteered that delays cost money.

MR. CONNER: I ask the witness not to respond.

MR. SUGARMAN: Do I understand

that -- well, I won't go into it, as you have asked the witness not to answer. I will let it go at that.

BY MR. SUGARMAN:

Q May I have D-4 back, please?

I ask you this, Mr. Bourquard. Were you concerned as to whether the -- when you prepared D-4, were you concerned as to whether the contractor would be able to get into the river for enough of the time during one winter to complete the intake operation?

(Mr. Bourquard responding)

A Was I concerned?

Q Yes.

A Well, it was one of the things we took into account. The fact that he may encounter high water, yes.

Q Why didn't you make that the first phase, to guarantee it would be done in time for the completion of the project, instead of making it the third phase?

A Well, I think you have in there the fact, stated right in the first paragraph there, the fact that the phases, as set up in there, would be subject to certain contstraints.

In other words, we did not try to list that as being one, two, three, in that order. We list them merely as a way of performing work. And we say in there that they would be changed or would be shifted if need be.

Q But you knew about the constraints that you just referred to when you prepared D-4?

A We did not know when the contract would be let.

Q I know that. But what I'm saying is, given your concern that you just expressed this morning, which is not expressed here in D-4, why didn't you locate this third phase first at that time?

A The third phase being what?

Q Installation of river intake screens in the three intake plants.

A If the contract started in other than the winter period, when he could work, he couldn't have worked on there if it had been.

Q Why not put that first, subject to the necessity of changing it, instead of putting it third?

A There was no reason for one or the other. Other than the fact that the Corp was primarily concerned probably with the channel there, the canal. So this was one of the items we started out with.

Q Are you saying that there is no basis for the phasing in D-4?

A Other than --

Q In terms of construction.

A In other words, we stated right in the first paragraph that they can be shifted around as need be, subject to the contract.

Q I understand that. But are you saying that there is no rhyme or reason, in terms of engineering or construction considerations, for the phasing as set forth in D-4?

MR. CONNER: We object to this. This has been asked and answered. The witness explained --

MR. SUGARMAN: What is his answer? There is or there is not a rhyme or reason?

MR. CONNER: He said it depended on the constraints, like when you go in the river. Had the Corp of Engineers issued the permit last summer, and they couldn't work in the river, because of the DOE constraint, they could have gone to a different phase.

That letter was written a year ago.

MR. SUGARMAN: The letter was written in September, 1981.

MR. CONNER: And had the permit been granted in due course, they would have been unable to be in phase three until November. So obviously, they would have gone to one of the other phases.

MR. SUGARMAN: That's your testimony.

MR. CONNER: He already said that.

MR. SUGARMAN: That's not what he testified to.

I'm asking, is there any rhyme or reason for the phasing that is shown in D-4?

MR. CONNER: Answer him one more time.

(Mr. Bourquard responding)

A Well, there is a rhyme or reason to the extent that we were mostly concerned with the work in the canal, and put that as the first phase.

Q Well, why --

A In other words, the understanding that it didn't necessarily have to be the first phase, or that the second phase had to be the second phase, or that the third phase had to be the third phase. That they were interchangeable.

Q By the contractor?

A Yes.

Q Okay. And were you consulted in connection with the Philadelphia Electric's letter to the Corp of Engineers, stating that it was necessary to start construction by December 15th of this year?

MR. CONNER: Will you profess to show the letter to the witness?

MR. SUGARMAN: I'm just asking if he was consulted.

MR. CONNER: About a letter. We would like to see the letter that you are referring to.

MR. SUGARMAN: We will have to take a break for a minute while I get it.

MR. CONNER: Fine.

Do you know the letter that he's talking about?

MR. BOURQUARD: No.

MR. SUGARMAN: I don't think he ever saw the letter. I'm just asking him.

MR. CONNER: Then let's show it to him.

MR. SUGARMAN: I'm not asking if he saw the letter. I'm just asking if he was consulted concerning a representation to the NRC regarding the necessary date of starting construction.

MR. CONNER: You haven't even established then that there is a letter --

MR. SUGARMAN: No, I haven't.

MR. CONNER: -- or that PE sent

such a letter --

MR. SUGARMAN: Not on the record, I haven't, no.

MR. CONNER: -- and you referred to a letter. Well, show him the letter then.

MR. SUGARMAN: Let's take a break for 5 minutes.

(Short recess.)

BY MR. SUGARMAN:

Q Mr. Bourquard, I'm going to advise you that the applicant, through Mr. Conner, advised the NRC of the following:

"NWRA advises the applicant," that's Philadelphia Electric, "that, in order to minimize the adverse affects on the aquatic environment from construction activities, it is required, by DRBC, to conduct the initial phases of its construction work during the winter months."

Now, were you consulted in that representation?

MR. CONNER: I ask the witness

be allowed to examine it, although, I know that's correct, because I wrote it.

I would also note, that I used phase as my word. It has no relation to the things you're talking about, because I had never seen those.

BY MR. SUGARMAN:

Q My question is, were you consulted in making that statement?

(Mr. Bourquard responding)

A December 15th? I set up the schedule, yes.

Q My question is, were you consulted, and were you involved in making the statement, that the NWRA is required by the DRBC to conduct the initial phases of construction in the winter? The emphasis being on initial phases.

Did you participate in making that statement? Were you asked to concur in it? Were you consulted in respect to it?

A I don't know. I might have been indirectly. I wasn't contacted by PECO, as I recall, and have that direct reference.

But we always maintain that the contractor has to get in there right away to finish his job on time. One of his first actions, as soon as he can, depending upon when he starts -- and hopefully we start in December 15th -- he will move right out into the river and start the work.

Q But if the contract were to start in the spring, then he would go into the river the following December; right?

A Yes. He would be allowed to because of the constraints.

Q That wouldn't change the ending date of construction, would it?

A If he --

Q If he went into the river in six months after construction started, instead of as his first activity?

A It would make it six months later.

Q You're saying that the timing -- it would make it six months later to go into the river, but the ending date of the contract would still be the same, wouldn't it? Because the limiting factor is the 25 months for the pump house, or 22 months for the pump house, or whatever it is.

A Well, I think that automatically sets it back. Anytime that date is set back, it automatically delays everything.

Q Anytime what date is set back?

A The December 15th date.

Q But you're talking about the initiation of construction on the project; right?

A Yes.

Q You are not talking about going into the river. That could be done later; right?

MR. BOYER: In our view --

MR. SUGARMAN: I would like to have this from Mr. Bourquard.

A It has to be done as soon as possible.

Q But there is no necessity that that be the first activity; that is, going into the river?

A If the work starts during that period, it does, yes.

Q But if it doesn't start during that period, there is no necessity --

A Well, you can't work on it. So it is not even a factor then.

Q Exactly. But my point is, that doesn't slow down the rest of the work, does it?

A Depending on when it starts, yes.

Q But if the work starts in April, the other phases, or other activities, can go forward at the same pace that they would have gone forward had the work started in December?

A What you are saying is, winter season is different from the other?

Q No, no. What I'm saying is, if he has to plant trees, as part of construction, it doesn't matter whether he plants the trees in month one or month 23. That's an analogy.

He has to go into the river for 90 days, or 120 days, it doesn't matter --

A The analogy, I don't quite go along with, because -- unless it is to the respect that he can only plant trees, say, in September.

Now, if he misses a September, then he's delayed by a year.

Q Exactly. And he plants the trees the following

September?

A Yes. But he's a year later.

Q Right. But the ending date of the overall job is not affected?

A Only to the extent that it set it back whatever that was set back.

Q That's right.

A In other words, if he misses September of '81, say, in planting his trees, then that means it sets everything back from whatever it is after '81.

Q Why does it set everything?

A I mean the final contract.

Q I follow what you're saying. In other words, if there is a three-month delay in starting construction, there will be a three-month delay in finishing?

A Yes.

Q But there won't be a 12-month delay in finishing, simply because he has to wait until the following September to plant his trees?

A He's going to need, probably, the two construction seasons to make sure he completes it.

Q You think he's going to need two construction seasons?

A I don't know. But I think he has to be reasonably sure, to make sure he has that much time available.

Q Well then, why didn't you put that in your phasing here, that that had to be done first, if that's the limiting factor, in D-4?

A Because the phasing, as set up there, as I explained several times --

Q But if this factor is now in your mind, and you knew you wanted to get the thing built, why didn't you think of it at that time, and make that the first phase?

MR. CONNER: Would you let the witness complete the answer he started to give?

A Part of it was, you were talking about September. We didn't anticipate that we would be delayed this long, be it December 15th to get the table to start construction.

That's one of the reasons it probably wasn't put in there at that time.

Q Can you start construction without completing acquisition on the land necessary for the rights-of-way up to Bradshaw Reservoir? Would you plan to do so?

A Well, it is up to the Authority to decide that. But I would see no reason not to.

Q Have they completed construction of the land acquisition up to Bradshaw Reservoir?

A I don't know.

Q You don't know?

A No. I don't know.

Q I will ask Mr. Boyer or Mr. Dickinson if they know whether acquisition of the land up to Bradshaw Reservoir has been completed.

(Mr. Dickinson responding)

A I don't know.

Q Mr. Boyer?

(Mr. Boyer responding)

A I don't know that detail.

Q You say you've been getting monthly reports from NWRA.

A Yes.

MR. CONNER: Before you start,

can I clarify something on the record?

MR. SUGARMAN: Yes.

MR. CONNER: The document that has just been the subject of the colloquy between Mr. Sugarman and Mr. Bourquard, is a letter relating to a hearing schedule, which I sent to the council on June 30th.

But the document that I thought you were referring to, Mr. Sugarman -- and I was referring to earlier -- was the construction schedule that the Board also asked be furnished to it.

And that is a second document, which I am noting, at this point in the record, so there won't be confusion later.

MR. SUGARMAN: Very good.

MR. CONNER: Both of which have the date, December 15th, 1982, as the time for the start of construction for NWRA in it, as I remembered.

MR. SUGARMAN: Very good.

MR. CONNER: Excuse me.

MR. SUGARMAN: That's all right.

BY MR. SUGARMAN:

Q Are the monthly reports that you receive from NWRA part of the file that you have made available to us?

(Mr. Dickinson responding)

A No.

Q Is there some reason for that?

(Mr. Boyer responding)

A I don't see where they were pertinent to these three questions.

Q I thought yesterday you said that you would make them available, and that they were part of the material you brought with you.

A I don't recollect that.

(Mr. Dickinson responding)

A I recall saying they were here.

MR. SUGARMAN: I would ask that they be made available.

MR. CONNER: For what purpose? We want to cooperate. But there is all kinds of reports about this. There are only three contentions. Or perhaps if you would be specific, maybe the witnesses can answer you.

MR. SUGARMAN: Well, I think that if there is nothing in those three reports that relates to any of the three contentions, I would be very surprised.

But I would -- if that's a representation that they are going to make, there is not anything in any of those monthly reports that relates to any of the issues in this proceeding, that are contentions in this proceeding, I would like to have a representation to that effect from you, Mr. Conner.

MR. CONNER: Never seen the reports, I'm afraid I can't do it. But I accept Mr. Boyer's --

MR. SUGARMAN: I don't know Mr. Boyer is prepared to make that representation.

MR. CONNER: I thought he just did.

MR. BOYER: I would have to review

each of those. There is nothing significant in there, in my view, that is not included in the other documents.

MR. SUGARMAN: But I think I'm entitled to see it in those reports, if it is relevant to any of the three issues.

MR. BOYER: We will have to examine them, and see whether they are relevant to the issues then.

MR. SUGARMAN: Okay. I would appreciate that.

Then the next point that I would make is that I'm sure those documents deal with the question of timing. And the question of timing is something that I had reserved.

It did not come up in the contentions, but it comes up in these proceedings.

And, again, Mr. Conner, I think the Board made clear to you that they would want to have that information.

MR. CONNER: I don't think they

said it quite that way. But we have agreed to try to provide that information on the timing, to the extent that we had it.

MR. SUGARMAN: Right. And those reports must relate to that.

MR. CONNER: You can't argue with me. I have never seen them. I don't know.

MR. SUGARMAN: Well, I think it was, really, in all fairness, that -- I understand we're all moving along as fast as we can here. But I really think that that's material that should have been obviously related to those issues.

But I understand --

MR. CONNER: Mr. Sugarman, I can assure you that I have seen hundreds of pages in this case that I know do not relate to any of these contentions.

MR. SUGARMAN: I'm sure you have. But what I don't understand is, how we could get on this business of being so urgent about this without your having even been aware of the existence of those monthly reports, which must have related to timing.

And if you were aware of the existence of those reports, I'm sure you would have produced them.

MR. CONNER: Mr. Sugarman, I repeat, there are hundreds of pieces of paper in this case. I'm not ever going to read them all. And there is no jury here.

MR. SUGARMAN: Well, I would ask that they be produced for that purpose -- for those purposes.

MR. CONNER: We will look at them, and see what was there again. If there is anything relating to these three contentions, we will produce them.

MR. SUGARMAN: That would include the costs and the alternatives and the timing. That's my request.

And I request them on the basis that they are discoverable, according to NRC precedent. They are available, if they may lead to admissible evidence.

MR. CONNER: That's what I was trying to say earlier when you were going on and on. We will make them available if there is anything in there on them. Because I agree with you on that.

MR. SUGARMAN: Okay.

MR. CONNER: I don't agree with the NRC precedence, but you're correct as to what they hold.

BY MR. SUGARMAN:

Q Mr. Boyer, you indicated before that there would be -- and forgive me for not knowing the terminology -- but that there would be some activity between July, the fuel insertion or load up the fuel, in the summer of '84, to the fall of '84, according to the schedule; is that correct?

(Mr. Boyer responding)

A Preoperational tests were being finalized during that time just prior to fuel loading. These will include heat up of the system. There will be some heat to be dissipated. We must check out the overall system of water flow, controls, and whatnot. And you need water available to do that. So that the system will be ready for operation following fuel loading.

Q Ready for operation when?

A Following fuel loading, which means going to power.

Q Well, how do those phases, or how do those activities, relate to construction completion? Are those activities following, or part of construction completion?

A Well, there are different peoples definition of construction completion.

Q I mean by the company's definition of construction completion.

MR. CONNER: Could I try to explain this very quickly?

MR. SUGARMAN: Please.

MR. CONNER: In the NRC practice, you cannot load fuel into a reactor until, quote, construction is completed within the meaning of the Atomic Energy Act.

There are certain preoperational tests, which must be done to demonstrate various things have been constructed within the meaning of the construction permit.

This preoperational testing phase must be completed before you reach that magic moment when construction, in quotes, is complete, and the operating license can be issued.

Until that operating license is issued, no fuel may be inserted into the reactor.

So for purposes of NRC licensing, construction is not completed until all the preoperational testing has been done.

MR. SUGARMAN: Okay.

BY MR. SUGARMAN:

Q Let me ask if that is the meaning that Philadelphia Electric attaches when it provides the NRC with updated construction completion dates, reports?

MR. CONNER: I'm sure it is.

BY MR. SUGARMAN:

Q Quarterly updates.

What does the word construction completion date mean in those reports?

(Mr. Boyer responding)

A Ready for fuel loading.

Q In other words, operating license issued?

A Operating license to be issued, right.

Q And that date is when for Limerick Unit One?

A Between July and October, 1984.

MR. CONNER: Just for the record then, so you will know, and maybe it will save time later, commerical operation is what goes on after you have had your fuel loading and initial testing.

MR. SUGARMAN: Thank you.

MR. BOYER: And consent to full power.

MR. CONNER: And that can be a period of three to six months after fuel loading, roughly.

MR. SUGARMAN: All right.

BY MR. SUGARMAN:

Q Now, has the applicant, Philadelphia Electric, done anything to develop, or to update comparisons of Point Pleasant, with alternative supplemental cooling water sources, since the publication of the environmental report on Bradshaw Reservoir in July, 1979?

(Mr. Boyer responding)

A No.

Q Has the company evaluated, in any way, shape, or form, what the alternatives -- strike that.

Has the company considered how the relative advantages and disadvantages of the previously studied alternatives might be affected by the deletion of unit two of Limerick?

MR. CONNER: Objection; irrelevant to any of the contentions.

MR. SUGARMAN: I think it is exceedingly relevant to the contention with respect to the environmental impacts of the proposed project, and the potential for selection of alternative sources of water.

MR. CONNER: I'm sorry. What contention is that?

E. H. BOURQUARD ASSOCIATES, INC.
WATER RESOURCES ENGINEERING
1400 RANDOLPH STREET
EXIT NO. 24 E. INTERSTATE 83
HARRISBURG, PA.
17104
TELEPHONE (717) 238-9503

WATER SUPPLY
WATER DISPOSAL
WATER RESOURCES
HYDRAULIC STUDIES
FLOOD INSURANCE STUDIES

FLOOD CONTROL PROJECTS
DAMS & RESERVOIRS
DRAINAGE-STORMWATER
HYDROLOGIC STUDIES
ENVIRONMENTAL STUDIES

September 9, 1981

Lt. Col. Roger L. Baldwin,
District Engineer, Philadelphia District,
U. S. Army Corps of Engineers,
Custom House, 2nd and Chestnut Streets,
Philadelphia, PA 19106

Re: Neshaminy Water Resources Authority
Permit Application Nos. NAPOP-R-
80-0534-3 and 80-0813-3

Dear Colonel Baldwin:

Forwarded herewith, in duplicate, are general construction procedures for (1) the installation of stream intake facilities and channel modifications at the North Branch Water Treatment Plant site, and (2) the installation of intake facilities at the Point Pleasant Pumping Station site.

Respectfully submitted,

E. H. Bourquard

EHB/bs
Encl. 2 sets of General Construction Procedures, in duplicate

c.c. J. E. McGettigan, Jr., District Counsel, w/Enclosure
John E. Burnes, Chief Environmental Branch, w/Enclosure
Roy E. Denmark, Jr., Chief Permits Branch, w/Enclosure

SEP 14 1982

NESHAMINY WATER SUPPLY SYSTEM

NESHAMINY WATER RESOURCES AUTHORITY - BUCKS COUNTY

POINT PLEASANT PUMPING STATION

INTAKE FACILITIES

GENERAL CONSTRUCTION PROCEDURES

September 9, 1981

The construction procedures for installation of the facilities comprising the Point Pleasant Pumping Station Intake will require the following general activities, the sequence and extent of which may be varied by the Contractor within the constraints imposed by the specifications and by pertinent permit requirements. The location and general plan of the Station are shown on the accompanying Exhibit No. 1.

Prior to the start of construction, there will be a pre-blasting survey and report, plus submission of blasting plans to the State for approval, which plans will include a test blasting program and provision for monitoring and surveillance during construction blasting. Also, provisions will be made for an archaeologist's services. Additionally, the necessary permits will have been obtained and any required notifications given in compliance with the permit requirements.

The first phase of the construction activities will be installation of sediment and erosion control measures; and the staking of limits of wetlands for protection thereof. This will be followed by the clearing of Station site and intake alignment other than wetlands; and the salvaging of usable timber and chipping of slashings. Selected trees will be preserved and stumps will be disposed of in designated areas. Area No. 1, shown on Exhibit No. 1, will be the equipment and material storage area.

First Phase - Installation of Intake Conduit Under the Canal.

Installation of the intake conduit under the Canal will be accomplished in the dry. The first step will be the installation of a temporary roadway and dike

Attached to EHB letter to COE
dated 9-9-81

across the Canal, where shown on Exhibit No. 1, utilizing materials excavated from the site. There will be two drainage culverts in this dike with slide gates on the downstream ends. Immediately upstream of Lock No. 14 is an overflow weir which will be set to divert all water above a certain elevation to the Delaware River. Temporary pumping facilities will be installed, where shown on Exhibit No. 1, to deliver Delaware River water to the Canal. The slide gates on the culverts through the temporary roadway will be closed and the pumping facilities will be started.

The next step will be to remove the water, and any fish, from the section of the Canal between the Lock No. 14 and the temporary roadway. The water will be pumped to a sedimentation basin and the fish delivered either to the downstream section of the Canal or to the River, per directions from the Fish Commission. Excavation of the trench for installation of the intake conduit between Stations 4+70 and 6+60 can then proceed. The sides of the trench will be supported by the use of contact sheeting and soldier piles tied back into the rock by anchor bars, as shown on the cross section in the upper right-hand corner of Exhibit No. 1. The excavation will be performed by dragline, shovels and/or pans. The trench is to be dewatered as necessary by pumping to the nearby sedimentation basin for containment and filtering of the discharges resulting from the dewatering activities. The rock will be ripped to the extent possible, but some blasting will be required. The rock and soils excavated for the installation will be temporarily stockpiled on the adjoining section of the Station site or in Area No. 2. After a reach of the trench has been excavated to grade, the conduit will be placed and tested, and the trench backfilled using the excavated materials which had been previously stockpiled. The pipe will then continue to be installed and backfilled by reaches until the conduit is in place from Station 4+70 to Station 6+60. The surface of the excavated portion of the Canal will be shaped to original section, and segregated impervious soils from the trench excavation and from the Station site will be used for replacement of the Canal lining.

The next action will be the opening of the slide gates on the culverts in the temporary roadway to fill the Canal with water. The bypass gate of Lock

No. 14 and the upstream overflow weir will then be adjusted to pass water through that section of the Canal, and the temporary pumping facilities will be removed.

Next Phase - Installation of Remainder of Intake Conduit and Gate Well.

After the required clearing, the remainder of the intake conduit between the Canal and the gate well will also be installed in the dry by use of sheeting and the necessary dewatering. Some blasting will be required and the excavated soils and rock will be temporarily stockpiled in Area No. 2 and/or along the pipe alignment and within the limits of the area to be disturbed by the installation. Sediment and erosion control measures will be installed and utilized as necessary to minimize the flow of sediment into the River. Occupancy of the wetlands for all activities will be restricted to that required for the conduit installation.

The gate well and appurtenant facilities will be installed using the same procedures as used in the intake conduit installation, including the excavation and dewatering methods; the temporary stockpiling of excavated materials; disposal of excessive or unsuitable excavated materials; and the protection of the wetlands, together with appropriate sediment and erosion control measures.

Third Phase - Installation of River Intake Screens and the Three Intake Pipes.

The installations of the River intake screens and the three reinforced concrete intake pipes are to be scheduled for a period during the months of November through March to avoid disturbance of aquatic life during the spawning season. These facilities are to be installed by the use of barges and divers. Foundations for the screen units are to consist of cylindrical reinforced concrete units which will be embedded in the River bottom. These will be placed by drilling or by use of caissons. Required excavation for the installation of the foundations will be by use of a barge mounted clamshell or dragline, with materials being temporarily stockpiled on a barge prior to selected use as a backfill for the installation. Most of the rock excavation can be performed by ripping but at the site of the intake screens, the lower two feet of rock excavation is expected to require blasting. Pre-assembled screen units will be set in place on the foundations and connected thereto by divers. The trench for the three intake pipes will also be excavated by barge mounted equipment, and barges will be used for temporary stockpiling of excavated materials. The trench excavation is expected to encounter no rock, except near the screens and between the shoreline and the gate well, and most of the rock appears to be rippable. The intake pipes, which will have sub-aqueous joints, will then be placed and connected by divers. Selected backfill will then be placed from temporary storage on barges. Excess excavation would be used for fill or placed in Area No. 2, the capacity of which is more than adequate for such purpose. Usable rock from rock excavation at the site will be utilized for riprap at the intake screens.

Final Phase - Completion of Construction.

Construction of the intake [illegible]ies under the Canal and out into the River will be completed by removal o[illegible]cess material from the stockpile at Area No. 2; final grading of disturbed areas and permanent access road construction; and permanent seeding and landscaping. The temporary access road across the Canal will be removed and the affected sections of Canal will be restored.

E. H. Bourquard

E. H. Bourquard, P.E.

DOCUMENT/ PAGE PULLED

ANO. 8209200127

NO. OF PAGES 3

REASON

☐ PAGE ILLEGIBLE

☐ HARD COPY FILED AT. PDR CF

OTHER ______________

☐ BETTER COPY REQUESTED ON ___/___/___

☒ PAGE TOO LARGE TO FILM

☒ HARD COPY FILED AT. PDR CF

OTHER ______________

☒ FILMED ON APERTURE CARD NO 8209200127-01

thru

8209200127-03

F. T. KITLINSKI & ASSOCIATES, INC.
CONSULTING GEOTECHNICAL ENGINEERS

FELIX T. KITLINSKI, P. E.
TELEPHONE 717.652.8620

3608 NORTH PROGRESS AVENUE
HARRISBURG, PENNSYLVANIA 17110
(1.2 MILES NORTH OF PROGRESS AVENUE
INTERCHANGE NO. 24 OF I.81)

September 3, 1982

Mr. Robert H. Bourquard
E. H. Bourquard Associates, Inc.
1400 Randolph Street
Harrisburg, Pennsylvania 17104

Re: Bradshaw Reservoir & Pumping Station
Plumstead Township
Bucks County, Pennsylvania

Dear Bob:

As requested during the August 3 meeting in your office, and in accordance with our telephone conversations of yesterday and today, you will find enclosed two (2) copies of a revised "Specification for Off-Site Borrow Soils" for the referenced project.

Very truly yours,

F. T. KITLINSKI & ASSOCIATES, INC.

Felix T. Kitlinski

Felix T. Kitlinski, P.E.

FTK/kp

Enclosures

F. T. KITLINSKI & ASSOCIATES, INC.
CONSULTING GEOTECHNICAL ENGINEERS

FELIX T. KITLINSKI, P. E.
TELEPHONE 717.652.8620

3608 NORTH PROGRESS AVENUE
HARRISBURG, PENNSYLVANIA 17110
(1.2 MILES NORTH OF PROGRESS AVENUE
INTERCHANGE NO. 24 OF I.81)

April 12, 1982

(Revised September 3, 1982)

SPECIFICATIONS FOR OFF-SITE
BORROW SOILS TO BE USED FOR RESERVOIR EMBANKMENT
BRADSHAW RESERVOIR & PUMPING STATION
PLUMSTEAD TOWNSHIP
BUCKS COUNTY, PENNSYLVANIA

For

E. H. BOURQUARD ASSOCIATES, INC.
CONSULTING ENGINEERS
HARRISBURG, PENNSYLVANIA

A. Materials - Impervious Fill

All materials to be hauled from off-site sources to meet the reservoir embankment quantity requirements shall be suitable impervious, inorganic, fill consisting of uniformly-graded silty clays and clayey silts with the amount of friable rock fragments not exceeding more than 20 percent of the total mass, but averaging eight (8) percent or less. Soils classified as impervious fill shall contain at least 65 percent, by weight, of material finer than the No. 200 mesh sieve with the average percent passing the No. 200 mesh sieve being at least 80 percent. All soils shall classify as ML, CL or ML-CL types according to the Unified Soil Classification System (USCS). They shall not have a liquid limit (LL) exceeding 50 and shall have plasticity indices (PI) ranging from at least two (2) to a maximum of 22. No cobbles, boulders or otherwise durable rock fragments having a maximum dimension in excess of four (4) inches shall be included in the impervious fill. In addition, the impervious fill materials, when subjected to the Standard Compaction Test, ASTM Designation 698, latest edition, shall indicate a maximum dry density at the optimum moisture content of at least 107.0 p.c.f. (pounds per cubic foot).

All proposed "off-site" sources of supply shall be first approved by the design consulting engineer or his retained consulting geotechnical engineer prior to being hauled to the site. All fill materials, regardless of type or source shall be free of topsoil, wood, lumber, roots, grass, rubbish, metal, organic content, or other deleterious material.

All "off-site" material proposed for use as impervious fill shall require demonstration of suitability by grain size distribution, plasticity and compaction tests, the results of which must be first approved by the design consulting engineer or his retained consulting geotechnical engineer prior to any hauling to the site.

If during the excavation and hauling of the impervious fill from the approved borrow pit it becomes apparent that the appearance and characteristics of the fill material change to an extent readily noticeable by visual inspection, a complete classification and new compaction control curve will be obtained. If such additional testing indicates the material does not meet the previously approved kind, a new source shall be immediately located by the contractor which shall be tested and approved prior to the material being hauled to the project site.

B. Testing

All required testing of impervious fill materials shall be performed by the owner and/or design consulting engineer at the owner's expense. Proposed sources of impervious borrow materials shall be sampled by the owner's representative; however, the contractor, at his expense, shall make available the necessary excavating equipment and labor to permit the procurement of suitable soil samples considered representative of the borrow material proposed for use.

C. Measurement of Quantities

Approved impervious fill to be hauled to the project site shall be paid for on a cubic yard basis according to the in-place quantity calculated from the cross section(s) of the embankment section to be constructed using the 3-dimensional method, irrespective of shrinkage, consolidation, haul distance, preparatory work or other features associated with establishing the borrow pit. No other payment method, such as truck load measurements, cross sectioning of borrow pit, etc., shall be considered.

--o0o--

E. H. BOURQUARD ASSOCIATES, INC.
WATER RESOURCES ENGINEERING
1400 RANDOLPH STREET
(EXIT NO. 24, INTERSTATE 83)
HARRISBURG, PA.
17104-3497
TELEPHONE (717) 238-9505

WATER SUPPLY
WASTEWATER DISPOSAL
WATER RESOURCES
HYDRAULIC STUDIES
FLOOD INSURANCE STUDIES

FLOOD CONTROL PROJECTS
DAMS & RESERVOIRS
DRAINAGE-STORMWATER
HYDROLOGIC STUDIES
ENVIRONMENTAL STUDIES

~~CHB~~
~~JJP~~
~~TLF~~
~~IAB~~

September 9, 1982

Mr. Rex Wescott,
U. S. Nuclear Regulatory Commission,
7920 Norfolk Ave.,
Bethesda, MD 20014.

Re: Bradshaw Reservoir and Pumping Station

Dear Mr. Westcott:

In accordance with our phone conversation today, enclosed are the following:

1. Bradshaw Reservoir Specification Section 02220, Earth Fill.

2. Soil Testing for Engineers, Lambe, Chapter VI, Permeability Test.

Item 1 specifies the requirements the Contractor must follow in construction of the earthen dam and impervious liner. As we discussed, there will be no specific permeability requirement for the Contractor to meet. However, the material as specified should provide a maximum in place permeability of 0.000005 cm/sec. In the unlikely event the material would exceed this permeability, bentonite would be incorporated into the liner material as necessary to reduce the permeability. Since the need for bentonite is unlikely, it has not been included in the Specification. If needed, the additional work would be carried out under a Contract change order.

Item 2 describes the permeability test procedure. Tests will be conducted at the Contractor's proposed off-site borrow area on the natural undisturbed material and also on the liner after compaction. Undisturbed samples will be taken at both locations. The variable head method will be used.

Sincerely yours,

Robert Bourquard

Robert H. Bourquard

RHB/bs
Encl. As Noted
c.c. Dave Morad, PECO w/encl.

SECTION 02220

EARTH FILL

PART 1 GENERAL

1.01 WORK INCLUDED

A. Construct earth embankments and other earth fills required by the Drawings and Specifications.

1.02 RELATED WORK

A. Section 02210: Salvaging and Spreading Topsoil.

B. Section 02211: Excavation.

C. Section 02265: Water for Construction.

D. Section 02266: Removal of Water

1.03 REFERENCES

A. ASTM D698 - Moisture Density Relations of Soils and Soil-Aggregate Mixtures Using 5.5 lb. (2.49 kg) Rammer and 12-in. (305 mm) Drop.

PART 2 PRODUCTS

2.01 MATERIALS

A. On-site Borrow Areas.
   1. Obtain suitable fill material from required excavations and designated borrow areas.

B. Off-site Borrow Areas.
   1. Locate a suitable off-site borrow area(s), notify the Owner of its location and arrange for entry to the site for testing and sampling. Provide the necessary excavating equipment and labor to permit the procurement of soil samples considered representative of the borrow material proposed for use. The Owner will perform all field and laboratory testing of the material to determine its suitability for construction of the required fills.
   2. If in the judgment of the Owner the material is suitable, the Contractor shall furnish such material from the approved off-site borrow area(s). In the event the material is not suitable, the Contractor shall locate an additional borrow area(s) and the process repeated until an approved borrow area(s) is located.

3. It shall be the Contractor's responsibility to locate the borrow area(s), purchase the material, furnish such material to the site, place and compact such material in accordance with the specifications and meet all governmental requirements.

4. Impervious Material.

   a. Off-site borrow material for reservoir embankment or impervious liner construction shall be suitable impervious, inorganic, fill consisting of uniformly-graded silty clays and clayey silts with the amount of friable rock fragments not exceeding more than 20 percent of the total mass, but averaging eight (8) percent or less. Soils classified as impervious fill shall contain at least 65 percent, by weight, of material finer than the No. 200 mesh sieve with the average percent passing the No. 200 mesh sieve being at least 80 percent. All soils shall be classify as ML, CL or ML-CL types according to the Unified Soil Classification System (USCS). They shall not have a liquid limit (LL) exceeding 50 and shall have plasticity indices (PI) ranging from at least two (2) to a maximum of 22. No cobbles, boulders or otherwise durable rock fragments having a maximum dimension in excess of four (4) inches shall be included in the impervious fill. In addition, the impervious fill materials, when subjected to the Standard Compaction Test, ASTM Designation 698, latest edition, shall indicate a maximum dry density at the optimum moisture content of at least 107.0 p.c.f. (pounds per cubic foot). All fill materials, regardless of type or source shall be free of topsoil, wood, lumber, roots, grass, rubbish, metal, organic content, or other deleterious material.

   b. All "off-site" material proposed for use as impervious fill shall require demonstration of suitability by grain size distribution, plasticity and compaction tests, the results of which must be first approved by the Owner.

   c. If during the excavation and hauling of the impervious fill from the approved borrow pit it becomes apparent that the appearance and characteristics of the fill material change to an extent readily noticeable by visual inspection, a complete classification and new compaction control curve will be obtained. If such additional testing indicates the material does not meet the previously approved kind, a new source shall be immediately located by the Contractor which shall be tested and approved prior to the material being hauled to the project site.

C. Fill Material.
   1. The selection, blending, routing and disposition of materials is subject to the Owner approval.
   2. Material to be free from sod, brush, roots and rock particles larger than 3 inches.

PART 3 EXECUTION

3.01 FOUNDATION PREPARATION

A. Strip foundations to remove vegetation, topsoil and other unsuitable materials.

B. Grade foundation surface to remove irregularities and scarifice parallel to the axis of the fill to a minimum depth of 2 inches. Control the moisture content of the loosened material as specified for the earth fill.

C. Compact and bond the first layer of earth fill with the surface materials of the foundation.

D. Clear loose material from rock foundations by hand or other effective means. Remove standing water from rock foundations before placing fill.

3.02 PLACEMENT OF FILL

A. Complete the required excavation and foundation preparation prior to placement of fill.

B. Do not place fill on a frozen surface nor incorporate snow, ice or frozen material in the fill.

C. Place fill in approximately horizontal layers not more than 8 inches before compaction.

D. Uniformly spread materials in piles or windrows to not more than 8 inches in uncompacted thickness before compaction.

E. Spread material to be hand compacted or compacted by manual directed power tampers in layers not more than 4 inches thick before compaction.

F. Adjacent to structures, place fill in such a manner to prevent damage to the structures and to allow the structures to assume the loads from the fill gradually and uniformly. Increase the height of the fill at the same rate on all sides of the structure. Do not place fill against structures before the time interval listed below.

Structure	Time Interval
1. Retaining walls	14 days
2. Walls backfilled on both sides simultaneously	7 days
3. Conduits and spillway risers, cast in place (with inside forms in place)	7 days
4. Spillway risers (inside forms removed)	14 days
5. Conduits, precast, cradled	2 days
6. Conduits, precast, bedded	1 day
7. Antiseep collars	3 days

G. Place fill for earth fill dams, levees and other structures designed to restrain the movement of water in accordance with the following requirements:

1. Place fill so that the distribution of materials throughout each zone is essentially uniform. Fill to be free from lenses, pockets, streaks, or layers of material differing substantially in texture or gradation from surrounding material.
2. If the surface of any layer becomes too hard and smooth for proper bond with the succeeding layer, scarifice it parallel to the axis of the fill to a depth of not less than 2 inches before the next layer is placed.
3. Maintain the top surface of embankments approximately level during construction. Provide a crown or cross-slope of not less than 2 percent to insure effective drainage. If the Drawings or Specifications require or the Owner directs that fill be placed at a higher level in one part of an embankment than another, maintain the top surface of each part as specified above.
4. Construct dam embankments in continuous layers the entire length. Openings may be provided to facilitate construction or to allow the passage of stream flow.
5. If an embankment is built at different levels, provide a maximum slope of 3 to 1 at their junction. °Strip the bonding surface of the higher embankment of all loose material and scarifice, moisten the soil and recompact when new fill is placed against it to insure a good bond between the two fills and to obtain the specified moisture content and density in the junction.

3.03 CONTROL OF MOISTURE CONTENT

A. Moisture content of the material at the time of compaction to be not more than 3 percentage points above or one percent below the optimum moisture content. Soils containing free water or soils having moisture contents greater than a moisture content midway between the liquid and plastic limits for the material are considered too wet for placement in the embankment. If they are used, dry prior to placement. Accelerate drying action by discing, harrowing, or manipulating to the extent necessary to reduce the moisture content to within the specified limits. When the material is more than one percentage point below optimum, wet the material by sprinkling uniformly, and disc or harrow to obtain uniform distribution of the moisture content to within the specified limits.

B. Scarifice and dry or moisten the previously placed layers when necessary to produce a suitable bond for the succeeding layer.

3.04 COMPACTION

A. When the moisture content and condition of the layer is satisfactory, compact by tamping rollers to a density of at least 95% of the maximum density as determined by ASTM D698.

B. Tamping rollers to consist of one or more heavy duty double drum units with a drum diameter of not less than 60 inches. The drums to be capable of being ballasted. Each drum to have staggered feet uniformly spaced over the cylindrical surface such as to provide approximately three tamping feet for each two square feet of drum surface with the distance between the feet equal to or greater than 9 inches. The tamping feet to be 8 to 10 inches in clear projection from the cylindrical surface of the roller and to have a face area of not less than 6 nor more than 10 square inches. The roller to be equipped with cleaning fingers, so designed and attached as to prevent the accumulation of material between the tamping feet. The weight of the roller to be not less than 4,000 pounds per foot of linear drum length ballasted, and not more than 3,250 pounds per foot of drum length empty. The loading to be such as to obtain the specified compaction. The roller to be pulled by a crawler-type tractor of sufficient power to operate the roller at a speed of approximately 3½ mph.

C. Use power driven hand tampers, vibratory or other satisfactory tampers to tamp around structures or other locations where larger rollers cannot satisfactorily compact the material.

D. Compaction rollers of other designs may be used after approval by the Owner provided the requirements for compaction and other specified requirements are met.

3.05 REMOVAL AND PLACEMENT OF DEFECTIVE FILL

A. Remove or rework fill placed at densities lower than the specified minimum density or at moisture contents outside the specified acceptable range.

3.06 TESTING

A. During the course of the work, the Owner will perform such tests as are required to identify materials, to determine compaction characteristics, to determine moisture content, to determine permeability and to determine density of fill in place. These tests performed by the Owner will be used to verify that the fills conform to the requirements of the Specifications. Such tests are not intended to provide the Contractor with the information required by him for the proper execution of the work and their performance shall not relieve the Contractor of the necessity to perform tests for that purpose.

END OF SECTION

SOIL TESTING

for Engineers

T. WILLIAM LAMBE

The Massachusetts Institute of Technology

NEW YORK · JOHN WILEY & SONS, INC.

LONDON · CHAPMAN & HALL, LIMITED

FIFTH PRINTING, FEBRUARY, 1958

PRINTED IN THE UNITED STATES OF AMERICA

CHAPTER VI

Permeability Test

Introduction

A hundred years ago, Darcy showed experimentally that the rate of water q flowing through soil of cross-sectional area A was proportional to the imposed gradient i or

$$\frac{q}{A} \sim i \qquad q = kiA$$

The coefficient of proportionality k has been called "Darcy's coefficient of permeability" or "coefficient of permeability" or "permeability."[1] Thus permeability is a soil property which indicates the ease with which water[2] will flow through the soil.

Permeability enters all problems involving flow of water through soils, such as seepage under dams, the squeezing out of water from a soil by the application of a load, and drainage of subgrades, dams, and backfills. As will be discussed in later chapters, the effective strength of a soil is often indirectly controlled by its permeability.

Permeability depends on a number of factors. The main ones are:

1. *The size of the soil grains.* As pointed out on page 30, permeability appears to be proportional to the square of an effective grain size. This proportionality is due to the fact that the pore size, which is the primary variable, is related to particle size.

2. *The properties of the pore fluid.* The only important variable of water is viscosity, which in turn is sensitive to changes in temperature. Equation VI-3 expresses the relationship between viscosity and permeability.

3. *The void ratio of the soil.* The major influence of void ratio on permeability is discussed later in this chapter.

4. *The shapes and arrangement of pores.* Although permeability depends on the shapes and arrangement of pores, this dependency is difficult to express mathematically.

5. *The degree of saturation.* An increase in the degree of saturation of a soil causes an increase in permeability. This effect is illustrated by Fig. VI-1.

For testing sands and silts, the normal procedure is first to determine, by laboratory tests on disturbed samples, the relationship of void ratio to permeability. After obtaining the in situ void ratio of the soil, we can predict the in situ permeability by using the void ratio–permeability curve determined in the laboratory. This procedure is the most feasible one because of the difficulty of obtaining undisturbed samples of cohesionless soils. It should be remembered, however, that many soils have widely different[3] permeabilities along the stratification and perpendicular to it, and, therefore, the results obtained on disturbed samples may be of little real significance. The permeability of an undisturbed sample of clay can be determined directly at several different void ratios while running a consolidation test, as described in Chapter IX.

At least four laboratory methods of measuring the permeability of a soil are available. The variable

[1] The three terms are used interchangeably, even though the use here of "coefficient" may be questioned. The coefficient is not dimensionless, but has the units of velocity.

[2] The soil engineer rarely deals with pore fluids other than water. However, the permeability of a soil can also be obtained for fluids such as oil.

[3] Very frequently the permeability along the stratification is five to fifty times as large as that across it.

head and constant head tests are presented in this chapter. The capillarity method is presented in Chapter VIII; the use of consolidation test data to compute permeability is discussed in Chapter IX. The variable head test is normally more convenient for cohesionless soils than the constant head test because of the simpler instrumentation. There are conditions, however, under which the constant head test is preferable: for example, for the tests on partially

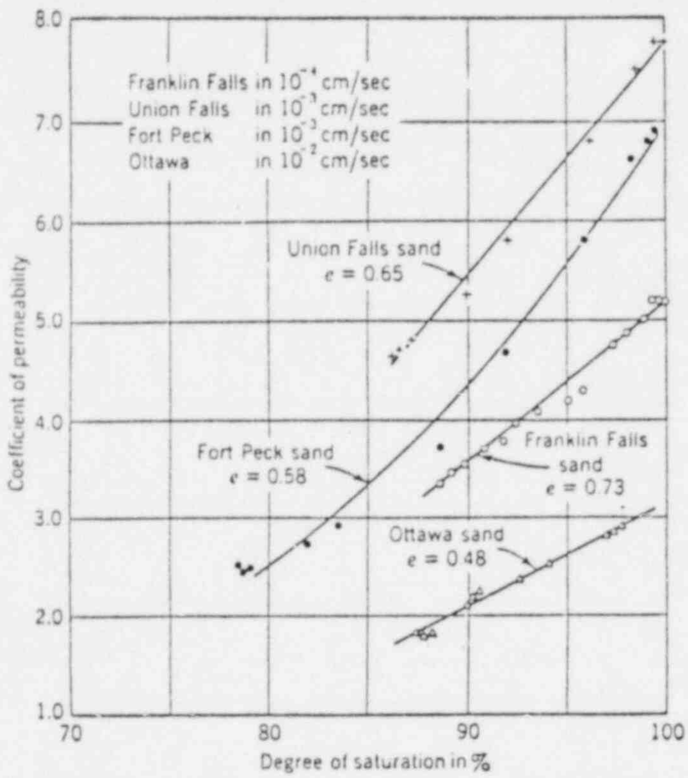

FIGURE VI-1. Permeability versus degree of saturation for various sands. (Data from reference VI-6.)

saturated soils (discussed in Chapter VIII) and for direct permeability determinations in conjuncton with consolidation tests (discussed in Chapter IX) on certain soils.

Apparatus and Supplies [4]

Variable Head Test

Special

1. Permeameter tube [5]
   - (*a*) Two screens
   - (*b*) Two rubber stoppers
   - (*c*) Spring
2. Standpipe
3. Deairing and saturating device
4. Support frame and clamps

General

1. Wooden hammer
2. Bell jar for constant head chamber
3. Supply of distilled, deaired water
4. Vacuum supply
5. Balance (0.1 g sensitivity)
6. Drying oven
7. Desiccator [6]
8. Scale
9. Thermometer (0.1° sensitivity)
10. Stop clock
11. Rubber tubing
12. Evaporating dish
13. Funnel
14. Pinch clamps

Figure VI-2 is a diagrammatic sketch of a variable head test setup which has proved satisfactory. In the laboratory, the parts can be permanently mounted to a panel or simply held to a support frame by clamps. The use of a transparent material, such as lucite, for the permeameter and water chamber is highly desirable, because it facilitates the measurement of the length of soil sample, L, and aids the detection of any air bubbles or movement of soil fines during the test. Likewise the water level in a transparent water chamber can be observed. The measuring of the soil length can be further facilitated by the cementing of graph paper strips, with units of length marked on them, to the outside of the permeameter. It is good policy to number each permeameter and standpipe, and mark on each its cross-sectional area. The bottom screen in the permeameter should be attached by some type of inside wedge and not screws, since screw holes are a possible source of leaks when the permeameter is evacuated.

The tubing should be either metal, high-pressure rubber (see Fig. VI-2), or some other material which can resist the applied vacuum. If low-pressure tubing is used between the standpipe and the permeameter, it will decrease in diameter as the hydrostatic pressure decreases because of a lowering of the water level in the standpipe. To prevent errors from such volume changes, the amount of tubing in this connection should be kept to a minimum. Water traps in the line preceding the manometers are desirable to prevent water from flowing into the manometers during the saturating process.

[4] The apparatus for this test is described in more detail than for some of the other tests because it is more often constructed in the soils laboratory from stock materials.

[5] The desirable size of a permeameter depends on the soil to be tested. Permeameters in the neighborhood of 4 cm in diameter and 30 cm long have been found satisfactory for many soils. See page 58.

[6] A desiccator may not be needed. See page 10.

The choice of standpipe size should be made with regard to the soil to be tested. For a coarse sand, a standpipe whose diameter is approximately equal to that of the permeameter is usually satisfactory. On the other hand, fine silts may necessitate a standpipe whose diameter is one-tenth or less of the permeameter diameter.

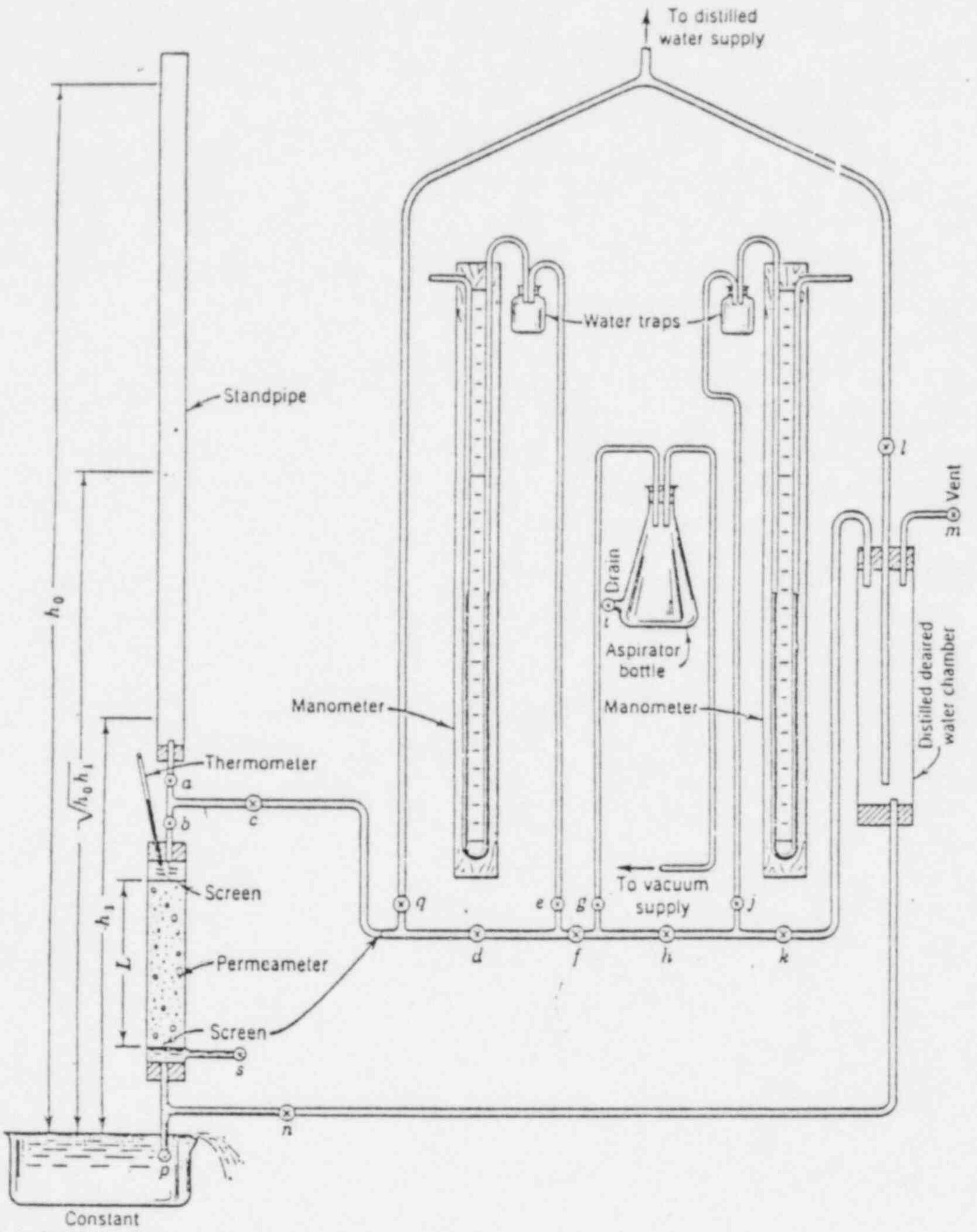

FIGURE VI-2. Setup for variable head permeability test.

Constant Head Test. There are several items needed for the constant head test in addition to those listed for the variable head test. The additional items depend on the type of setup used.

In Fig. VI-3 are shown diagrammatically two test setups for running the constant head test. Although the one on the left is simpler, it should be used only for soils of high permeability. This limitation is due to the fact that, if the soil is relatively impermeable, the rate of flow is low, and thus the loss of water by evaporation can become an important consideration.

The balloons (Fig. VI-3b) furnish a convenient means of preventing evaporation. If the air inside them is allowed to become saturated with water vapor prior to testing, no evaporation will occur during the test (unless the atmospheric pressure or temperature changes). The balloons should be kept very loose so that the pressure in them will be essentially atmospheric.

If the diameter of the water supply bottle (Fig. VI-3b) is large relative to the diameter of the permeameter, the value of h can usually be considered

be applied to the water to obtain the additional head sometimes needed for testing impermeable soils.

Recommended Procedure [7]

The detailed procedures described below are for soils which are cohesionless; permeability determinations on fine-grained soils are discussed in Chapter IX.

Variable Head Test

1. Measure the inside diameter of the standpipe and permeameter.

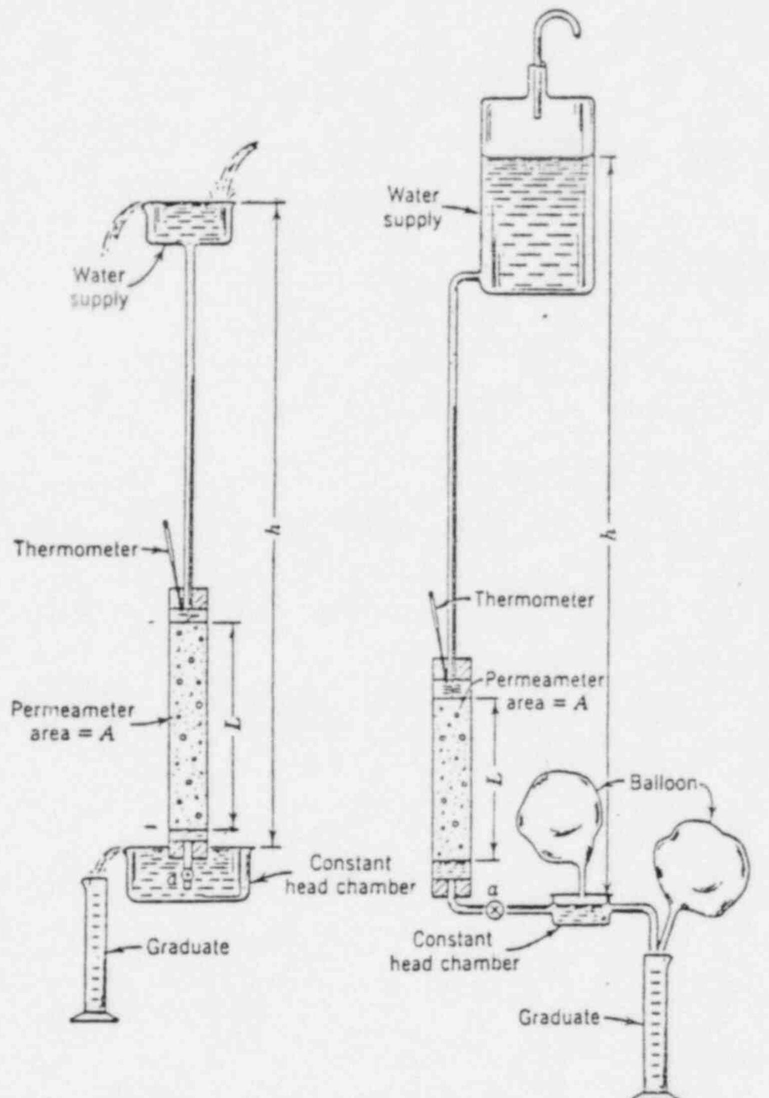

FIGURE VI-3. Setup for constant head permeability test.

constant for a test. The water level in the bottle should be recorded at the start and completion of the test to check the degree of validity of this assumption. The use of a bottle for the water supply has two advantages; it is a convenient means of storing water between tests, and it easily permits pressure to

2. Obtain to 0.1 g the weight of the empty permeameter plus screens, stoppers, and spring.

[7] A student doing this test for the first time should be able to test a cohesionless soil at three or four void ratios in 2 to 3 hours and do the computations in about an hour. He probably will need supervision for the first part of the test.

3. Load the permeameter with dry soil[8] to a loose, uniform density by pouring the soil in.[9]

4. Place the top screen, spring, and two stoppers in the tube. The spring should be compressed so that it will apply a pressure to the soil and help keep it in place when it is saturated.

5. Weigh the filled permeameter; the difference between the two weights is the amount of soil used.

6. Place the filled permeameter in position for testing as shown in Fig. VI–2.

7. Evacuate the sample to an absolute pressure of only a few centimeters of Hg by the following method:

(a) Close all valves shown in Fig. VI–2.

(b) Open valves g, h, j, k, f, e, d, c, and b.

8. After waiting some 10 to 15 minutes for the removal of air, saturate the soil by the following method:

(a) Close valves f, g, and h.

(b) Open valve n. The water will enter the soil because of the capillary attraction aided by the difference in elevation between water chamber and permeameter. If more head difference is needed, it can be obtained by slightly opening vent m. The difference in readings of the two manometers will indicate the additional pressure head that is thus obtained.

(c) Allow the water to saturate the sample and rise up to valve b, then close n.

(d) Release the vacuum on the sample by first closing k and d, and then slowly opening q and m.

(e) Any air bubble in the permeameter above the soil should be removed by slightly opening the upper stopper while applying water through q, with d closed. Any bubble in the bottom should be removed through s, while applying water through n with m open.

9. Measure the length of sample L and locate and measure the heads h_0 and h_1. The top limit of h_0 is selected at the upper end of the standpipe; h_1 a few centimeters above the lower end of the standpipe; the head $\sqrt{h_0 h_1}$ should be marked on the standpipe.

10. With valves n and d closed, fill the standpipe with distilled, deaired water to an elevation which is a few centimeters above h_0 by opening valves q, c, and a. Close valve c; leave a open.

11. Check to see that there is no air in the line between the standpipe and permeameter up to valve c, as well as in the line from the permeameter into the constand head chamber.

12. Begin the test by opening valve p; start the timer as the water level falls to h_0 and record the elapsed times when the water level reaches $\sqrt{h_0 h_1}$ and h_1. Stop the flow after the level passes h_1 by closing p.

13. Obtain temperature readings at the head water end of the sample and in the constant head chamber.

14. Compare the elapsed time required for fall from h_0 to $\sqrt{h_0 h_1}$ with that for $\sqrt{h_0 h_1}$ to h_1.[10] If these times do not agree within 2% or 3%, refill and rerun.[11]

15. When a good run has been obtained, decrease the void ratio by tapping the side of the permeameter with the wooden hammer.

16. Remeasure the sample length and obtain time observations for the falling head in the standpipe as was done for the previous void ratio.

Constant Head Test

1. Place the soil in a measured permeameter, weigh, and saturate as in the variable head test (steps 1–8).

2. Measure the value of the head, h, and specimen length, L.

3. Start flow by opening valve a (see Fig. VI–3).

4. After allowing a few minutes for equilibrium conditions to be reached, obtain graduate and time readings.

5. After a sufficient amount of water has collected in the graduate for a satisfactory measure of its volume, take graduate and time observations. Subtract the graduate and time readings obtained in step 4 from the respective values obtained in this step to give Q and t for Eq. VI–2.

6. Record the temperature of the water every few minutes.

7. Change the void ratio of the soil as was done in the variable head test, and take another series of graduate and time readings. Measure the specimen length at each void ratio.

Discussion of Procedure

Degree of Saturation. In the preceding procedure, an attempt was made to get the soil completely satu-

[8] See page 58 for a discussion of the maximum grain size which should be used.

[9] Pouring the soil into the permeameter tends to cause segregation. Segregation can be minimized by placing the soil with a small can tied to strings in such a way that it can be lowered into the permeameter and then emptied.

[10] Since

$$\frac{h_0}{\sqrt{h_0 h_1}} = \frac{\sqrt{h_0 h_1}}{h_1}$$

the elapsed times should be equal because the other terms in Eq. VI-1 are constant for any given run. A lack of agreement here could be due to leaks, incomplete saturation, movement of fines, foreign matter in water, or water not sufficiently deaired.

[11] Even though the times for the two decrements are in agreement, it is a good policy to make a check run (see Numerical Example).

rated because the permeability of an "almost saturated" soil may be considerably different from its saturated[12] value. Figure VI-1 illustrates this point. To obtain a high degree of saturation, use a vacuum approaching absolute zero. For example, Fig. VI-4 shows the relationship between the degree of vacuum for evacuating a certain fine sand and the resulting degree of saturation. In this case an applied vacuum of at least 27 or 28 in. of mercury was necessary to get a high degree of saturation.

The water used for saturating the soil should be almost completely deaired, because if there is much

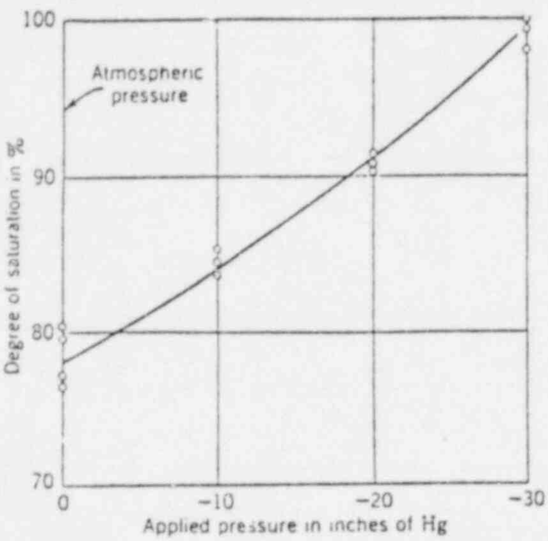

Figure VI-4. (From reference VI-4.)

air dissolved in the water, most of it will be brought out of solution by the high vacuum used for the saturating process of step 7 (see page 56). The deairing of the saturating water, however, presents no problems in the apparatus shown in Fig. VI-2. In fact, the procedure described in step 7 applies a vacuum to the water in the "distilled deaired water chamber" from which the saturating water is drawn. A vacuum can be kept on the water in this chamber when the apparatus is not in use.

Air dissolved in the water used for the actual permeability test causes no trouble in normal testing as long as it does not come out of solution to collect in the tubing or to collect in the soil, thus decreasing its degree of saturation. If water saturated with air were used, a rise in temperature or a decrease in pressure in the water would have to be prevented as it flowed from its storage supply through the soil. This is because the solubility of air is proportional to the pressure of the air above the water for small pressures (Henry's law, VI-3) and decreases with temperature as shown by Fig. VI-5. The solubility of air in water may be altered by other changes in the water as it flows through the soil; for example, the dissolving of any soluble salts from the soil.

To prevent any air from coming out of solution, two procedures are recommended. First, keep the temperature of the water a few degrees warmer than the soil and tubing. If this is done, the water will cool as it flows, thus slightly increasing its capacity for dissolving air. This procedure is known as "maintaining a favorable temperature gradient." Second, use water which has less than its capacity of air dissolved in it; such water is commonly called "deaired" water.

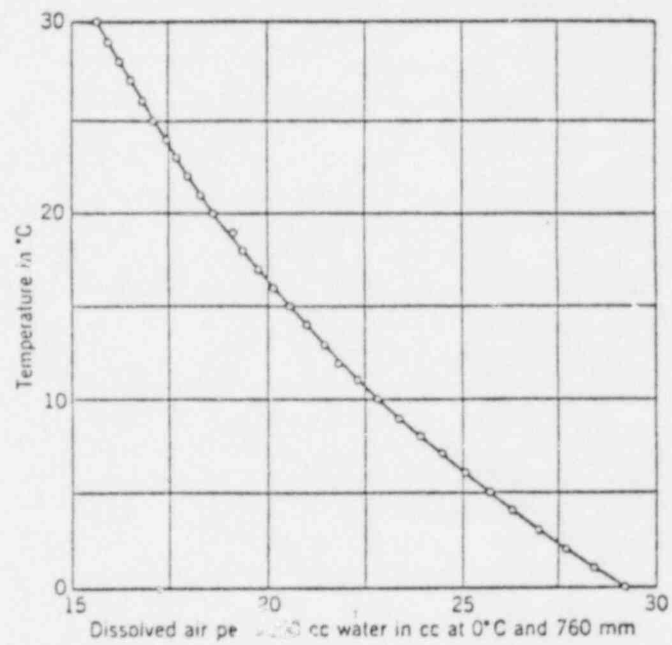

Figure VI-5. Solub[illegible] air in water. *Note:* Air free of CO_2 and NH_3. ([illegible] from *International Critical Tables*, Vol. III.)

Deaired Water. The air dissolved in water can be removed by increasing the temperature or decreasing the pressure. Boiling can reduce the dissolved air in water to about 0.75 ppm of oxygen or 1.5 cc of air.[13] Water which has been deaired is slow in regaining its air, as evidenced by Fig. VI-6, which is a plot[14] of

[12] As discussed in Chapter VIII, natural soils do not necessarily exist in a saturated state. Careful control of the degree of saturation, however, is required in order to obtain test data which can be reproduced. Also, the permeability of a soil when saturated is a limiting value and, therefore, is of importance (see Chapter VIII). Unfortunately, there are permeability test procedures in use which do not control, or even measure, the degree of saturation.

[13] One ppm of oxygen in air dissolved in water corresponds approximately to 2.0 cc of air at 760 mm pressure and 0° C per 1000 cc of water.

[14] This is a plot of data from a research project in the Hydraulics Laboratory at M.I.T. The data were obtained by the mercury-dropping electrode system; the readings were taken at

oxygen pick-up against elapsed time for a vessel of deaired water whose surface was exposed to the air. Figure VI-6 shows that at the end of 13 days the water was only 60% saturated. More elaborate methods for deairing and storing water are available (VI-2), but they are not thought necessary for normal permeability testing. Boiled distilled water is satisfactory for most permeability testing for some time after

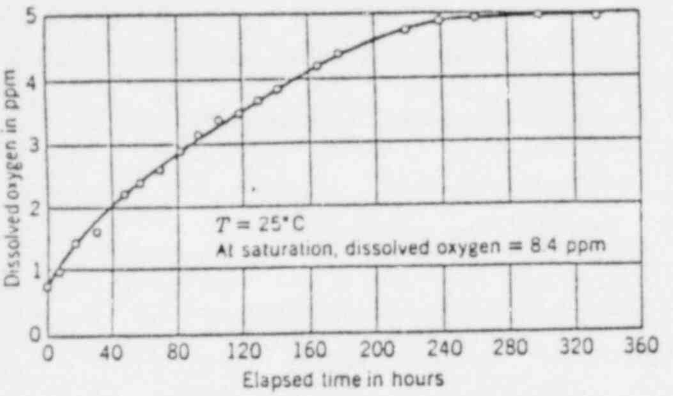

FIGURE VI-6. Pick-up of oxygen by water.

boiling. The water should not be agitated and should be covered to prevent the collection of foreign matter from the atmosphere. Water can easily be covered by stoppering the storage vessel and venting it with a tube whose end is pointing downward, as illustrated in Fig. VI-7. Figure VI-7 also shows the recommended manner to tap the water supply; the water at the bottom of the vessel tends to contain less dissolved air than that at the top.

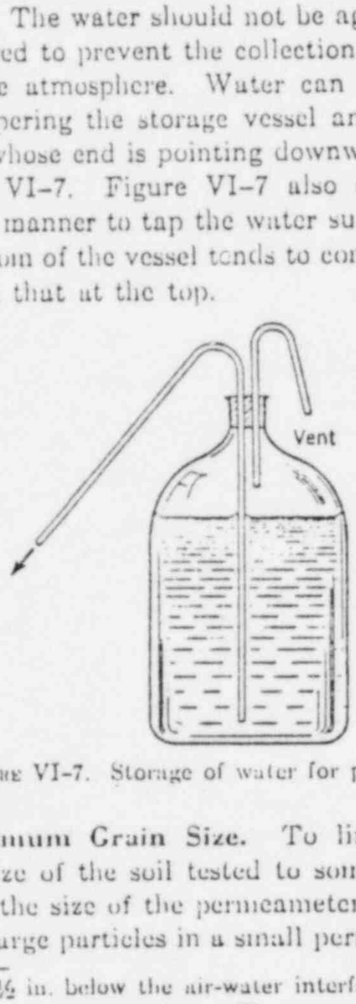

FIGURE VI-7. Storage of water for permeability tests.

Maximum Grain Size. To limit the maximum grain size of the soil tested to some reasonable fraction of the size of the permeameter is desirable. The use of large particles in a small permeameter increases the chance of large voids forming where the particles touch the wall of the permeameter. Keeping the ratio of the permeameter diameter to the diameter of the largest soil particle greater than about 15 or 20 has been found satisfactory. This limits the soil tested in the 4-cm permeameter suggested on page 53 to that passing a No. 8 or No. 10 sieve. A larger permeameter should be used to test a coarser soil.

If the soil tested is too coarse, the flow will be turbulent rather than laminar. Laminar flow is assumed in Darcy's law, by which Eqs. VI-1 and VI-2 are derived. For the normal test setup, laminar flow exists only in soils finer than coarse sands. The error appears small, however, in using Darcy's law on soils whose particles are a little larger than coarse sand.

Gradient Increase by Gas Pressure. To increase the rate of flow in the constant head testing of soils of low permeability, a gas pressure can be applied to the surface of the water supply. (When a pressure is used, it is advisable to cover the surface of the water supply with a membrane of some sort to reduce the amount of gas going into solution.) The head lost is then h (Fig. VI-3) plus the applied pressure changed to units of water head. Pressure is often employed for permeability determinations on consolidation specimens (Chapter IX).

a point ½ in. below the air-water interface in a vessel 5½ in. in diameter and 48 in. deep. The rate of air pick-up is related to the ratio of exposed surface area over volume of the water.

Calculations

Variable Head Test

The coefficient of permeability k can be computed from

$$k = 2.3 \frac{aL}{A(t_1 - t_0)} \log_{10} \frac{h_0}{h_1} \qquad \text{(VI-1)}$$

in which a = cross-sectional area of the standpipe,
L = length of soil sample in permeameter,
A = cross-sectional area of the permeameter,
t_0 = time[15] when water in standpipe is at h_0,
t_1 = time when water in standpipe is at h_1,
h_0, h_1 = the heads between which the permeability is determined (see Fig. VI-2).

Constant Head Test

The coefficient of permeability k can be computed from

$$k = \frac{QL}{thA} \qquad \text{(VI-2)}$$

in which Q = total quantity of water which flowed through in elapsed time, t,
h = total head lost (see Fig. VI-3).

[15] If the time is started at zero when the water in the standpipe is at h_0, then t_0 is equal to zero.

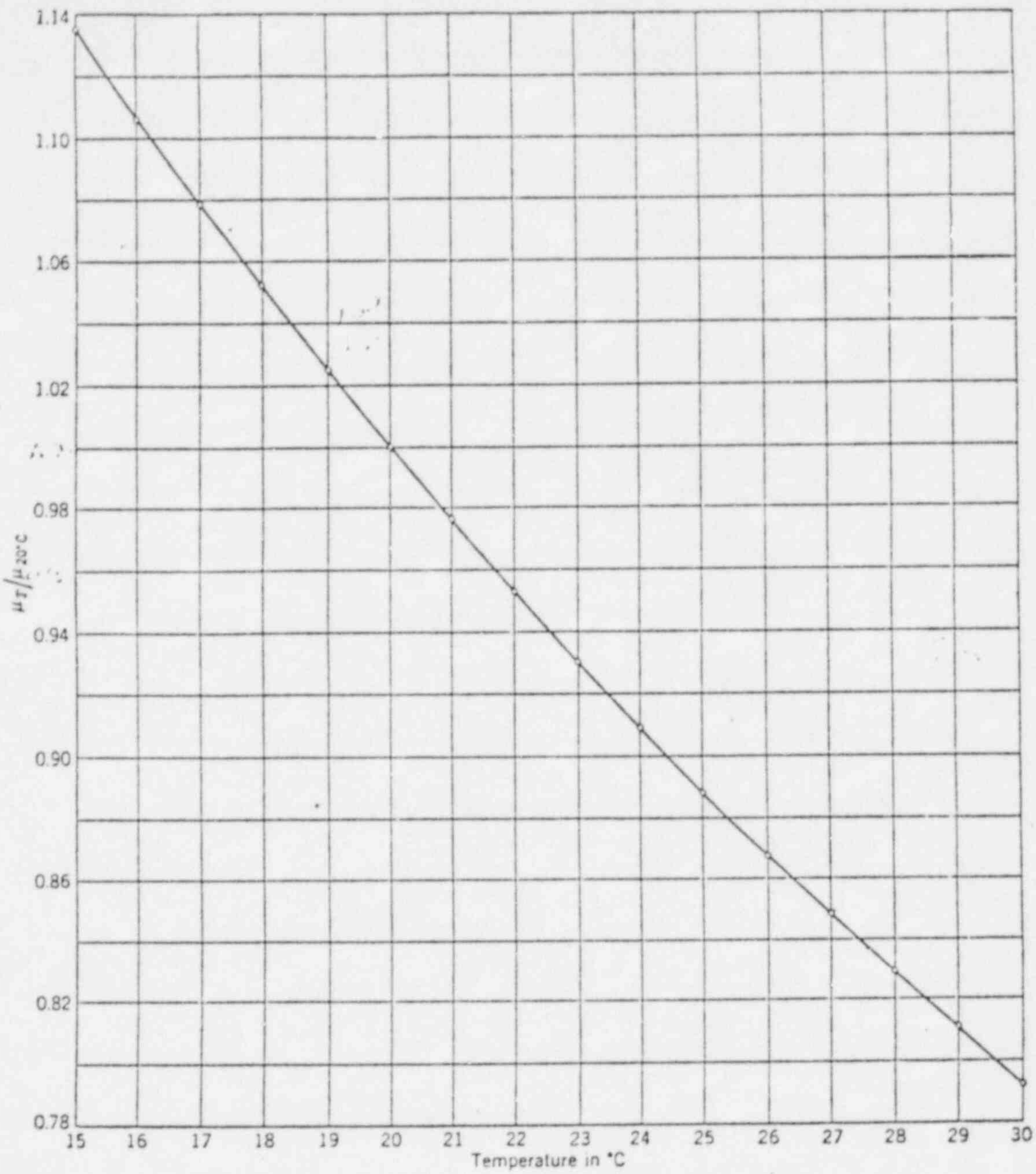

FIGURE VI-8. (Data from *International Critical Tables*, Vol. V.)

The permeability at temperature T, k_T, can be reduced to that at 20° C, $k_{20°C}$, by using

$$k_{20°C} = k_T \frac{\mu_T}{\mu_{20°C}} \qquad \text{(VI-3)}$$

in which $k_{20°C}$ = permeability at temperature 20° C,
k_T = permeability at temperature T,
μ_T = viscosity of water at temperature T (see Table A-3, p. 148),
$\mu_{20°C}$ = viscosity of water at temperature 20° C (see Table A-3, p. 148).

A plot of $\mu_T/\mu_{20°C}$ against temperature is given in Fig. VI-8.

Results

Method of Presentation. The results of a permeability test are usually presented in the form of a plot of some function of void ratio, e, against some function of permeability, $k_{20°C}$. Often two plots are made: k vs. $e^3/(1+e)$, $e^2/(1+e)$, and e^2 on one sheet and e vs. $\log k$. The best relationship of the above four is then used to present the results of the test (see discussion below).

Typical Values. The permeabilities of several soils are given in Fig. VI-1. A better indication of typical permeabilities can be obtained from the classification of soils based on their permeabilities which is given below (VI-5).

Degree of Permeability	k in Centimeters per Second
High	Over 10^{-1}
Medium	10^{-1} to 10^{-3}
Low	10^{-3} to 10^{-5}
Very low	10^{-5} to 10^{-7}
Practically impermeable	Less than 10^{-7}

A permeability of 1 μ per second (10^{-4} cm per second) is frequently used as the borderline between pervious and impervious soils. Thus a soil with a permeability less than 1 μ per second might be considered for a dam core or impervious blanket, whereas one with a permeability greater than 1 μ per second might be considered for a dam shell or pervious backfill.

Discussion. Both theoretically and experimentally there is more justification for $e^3/(1 + e)$ to be proportional to k than for either $e^2/(1 + e)$ or e^2 in the case of cohesionless soils. Laboratory tests on all types of soils have shown that a plot of void ratio versus log of permeability is usually close to a straight line.

Numerical Example

In the example on pages 61 and 62 are presented the results of a variable head permeability test on a well-graded, coarse sand, which was used for the shell of an earth dam. The plots of data in Fig. VI-9 show that $e^3/(1 + e)$ is almost proportional to k and that the e vs. log k curve is almost a straight line. According to the classification given under Typical Values, this soil would be called one of medium permeability.

REFERENCES

1. American Society for Testing Materials, "Procedures for Testing Soils," Philadelphia, Pa., July, 1950.
2. Bertram, G. E., "An Experimental Investigation of Protective Filters," *Harvard University Publication* No. 267, 1939–1940.
3. Millard, E. B., *Physical Chemistry for Colleges*, McGraw-Hill Book Co., New York and London, 1946.
4. Parfitt, H. R., and N. E. Pehrson, "Experimental Investigation of the Degree of Saturation in Sands," Master of Science Thesis, Department of Civil Engineering, Massachusetts Institute of Technology, 1948.
5. Terzaghi, K., and R. B. Peck, *Soil Mechanics in Engineering Practice*, John Wiley and Sons, New York, 1948.
6. Wallace, M. I., "Experimental Investigation of the Effect of Degree of Saturation on the Permeability of Sand," Master of Science Thesis, Department of Civil Engineering, Massachusetts Institute of Technology, 1948.

E. H. Bourquard Associates, Ir
1400 Randolph Street
HARRISBURG, PENNSYLVANIA 17104

Phone 717-238-9505

LETTER OF TRANSMITTAL

DATE Sept. 9, 1982
JOB NO.
ATTENTION Mr. David L. Morad
RE: Bradshaw Reservoir & Pumping Station

TO Philadelphia Electric Company,
2301 Market Street, 2N-1,
Philadelphia, PA 19101

WE ARE SENDING YOU ☒ Attached ☐ Under separate cover via ______ the following items:

☐ Shop drawings ☐ Prints ☐ Plans ☐ Sa ☐ Specifications
☐ Copy of letter ☐ Change order ☐ ______

COPIES	DATE	NO.	DESCRIPTION
1			"General Provisions and Specifications Regulating Occupancy
			of Township Highway Right-of-Way"
1			"Schedule of Fees for Highway Occupancy Permits . . . ."

THESE ARE TRANSMITTED as checked below:

☐ For approval ☐ Approved as submitted ☐ Resubmit ____ copies for approval
☐ For your use ☐ Approved as noted ☐ Submit ____ copies for distribution
☒ As requested ☐ Returned for corrections ☐ Return ____ corrected prints
☐ For review and comment ☐ ______
☐ FOR BIDS DUE ______ 19 ____ ☐ PRINTS RETURNED AFTER LOAN TO US

REMARKS It is my understanding that the Township has already approved NBTM & EBTM Moyer Road crossing, thinking that NWRA had applied for this permit. They have requested prints of the crossing. We will inform the Township that Moyer Road crossing will be submitted separately by PECO.

COPY TO ______

SIGNED: ______

If enclosures are not as noted, kindly notify us at once. Robert H. Bourquard

GENERAL PROVISIONS AND SPECIFICATIONS

Regulating Occupancy of Township Highway Right-of-Way

GENERAL PROVISIONS

1. The work authorized by this permit shall be done at such time and in such a manner as shall be consistent with the safety of the public and shall conform to all requirements and standards of the township, designated herein as the township. If any time it shall be found by the township that the work is not being done or has not been properly performed the permittee and/or its contractor upon being notified in writing by the township, shall immediately take the necessary steps, at its own expense, toward placing the work in condition to conform to said requirements or standards.

2. In the event of willful failure or neglect by said permittee and/or its contractor or their employes to perform and comply with the conditions, restrictions, and provisions of this permit, the township may revoke and annul this permit and order and direct said permittee and/or its contractor to remove any or all structures or property belonging to said permittee and/or its contractor from the legal limits of the highway right-of-way and to restore the highway right-of-way to its former condition.

3. If work is stopped on a project for any reason, and any ditch or trench, in the opinion of the Township, remains open for an unreasonable period, the permittee and/or its contractor, if so directed, shall refill the ditch or trench and work shall not be resumed thereon until the permittee and/or its contractor is prepared to proceed with the work until completion. In the event that the permittee and/or its contractor fails to refill the ditch or trench or proceed until completion of the work upon notice from the township to do so, the township may perform the necessary and required work subject to reimbursement by the permittee and/or its contractor.

4. The permittee shall pay all costs and expenses incident to or growing out of the project including the prescribed fees for the same, the cost of making and maintaining the temporary restoration of the disturbed areas and making permanent restoration, and further shall reimburse the township for any inspection costs which the township may deem it necessary to incur, and the permittee shall reimburse the township for said costs within thirty (30) days after receipt of the statement setting forth sums expended therefor by the township.

5. If the permittee and/or its contractor, after making an opening in the highway to place or repair pipe or for any other purpose, fails to restore any portion of highway right-of-way to conform with specifications of the township, the township reserves the right to do the work and bill the permittee for the cost of the restoration.

6. The permittee will submit to the township, certificate or certificates of insurance for public liability and property damage, in sufficient amounts to cover any loss, that may be incurred for or on account of any matter, cause or thing arising out of the construction, reconstruction, repair, relocation or installation of the permitted facilities, except in those instances where the township by prior arrangement has authorized the permittee to provide other means of protecting the township and its employes.

7. The permission herein granted does not relieve the permittee and/or its contractor from obtaining any consent otherwise required from the owner or owners of the abutting property and does not confer upon the permittee and/or its contractor the right to cut, remove or destroy trees or shrubbery within the legal limits of the highway except under such conditions, restrictions and regulations as the township may prescribe.

8. If at any time the structure or facility shall become a hazard from any cause whatsoever, the permittee and/or its contractor shall have the same removed or repaired within 48 hours after receipt of written notification, except at times of extraordinary happenings when extension of such time limit may be given by the township.

9. After each and every excavation made by the permittee and/or its contractor in any road or highway right-of-way covered by this permit incident to the erection, repair, resetting or removal of any poles, manholes, conduits, water, steam, oil, gas pipes, sewers or any other obstructions or construction, said permittee and/or its contractor shall, under the supervision and direction of the township, restore the road to a condition conforming to requirements and/or specifications of the township. So long as said permittee and/or its contractor operates and leaves in place such structures and appliances, in, upon or along said highway right-of-way, the permittee and/or its contractor shall maintain and keep in good order and repair the said structures and appliances. The permittee covenants and agrees to fully indemnify and save harmless the township of and from all liability for damages or injury occurring to any person or persons or property at or on said roads through or in consequence of any act or ommission of any contractor, agent, servant, employe or person engaged or employed in, about, or upon the said work, by, at the instance, or with the approval or consent of the permittee, or from the failure of the permittee and/or its contractor to comply with the provisions set forth herein.

10. If at any time in the future the highway is widened or the alignment or grades are changed, the permittee further agrees to change or relocate, any part of the structures covered by this permit which interferes with the improvement of the highway, at its own expense, to the extent now or hereafter required by law.

11. During the time when the highway right-of-way covered by this permit is under process of construction and/or until said road or highway is accepted by the township, no permittee and/or its contractor will be authorized to enter upon said highway right-of-way for the purpose of erecting poles, laying conduits, water, steam, oil or gas pipes or sewers, or doing any other work whatsoever which might interfere with the construction of the road or highway, unless said permittee and/or its contractor shall first file with the township a duly attested certificate, signed by the contractor or other authority constructing said road or highway, containing the full consent to such proposed work of said permittee and/or its contractor within the lines of the said highway right-of-way, together with a satisfactory waiver, release and quit-claim to the township, of all damages and all defenses whatsoever for delays by reason of such work and occupation of said roadway by said permittee and/or its contractor, or from any cause whatsoever resulting by reason of such work and occupation, provided that the provisions of this paragraph shall not apply in case of emergency; in such case the permittee and/or its contractor shall procure the written consent of the township to do such work as may be deemed necessary to correct the existing emergency conditions.

12. Any work done under this permit shall be subject to the conditions, restrictions, and provisions of this permit which shall govern all excavations, openings and trenches for the purpose of making repairs to any poles, conduits, water, steam, oil, gas pipes or sewers, or other structures, or property and appurtenances thereto belonging, erected on or in the highway right-of-way.

13. This permit is issued subject to any additional rights which the township in which the work is to be done may have in such matters.

14. After a permit is granted by the township it shall not be assigned nor transferred without prior written approval from the township.

15. To protect the highway surface or pavement on said projects, all equipment used by the permittee and/or its contractor shall be approved by the township. Such equipment shall have rubber runners or wheels. In the event that other than rubber equipped machinery is used, the pavement shall be protected by the use of heavy rubber or similar matting which shall be a minimum of four (4) inches wider on each side than the tracks or wheels of the equipment used.

16. Information as to the date and character of construction or reconstruction of the township road or street may be obtained by contacting the township.

17. If, in the construction work the permittee will be required to use certain blasting operations in the excavation the permittee agrees to make, execute and deliver to the township, a bond in the sum stipulated by the township with surety in the form of a surety company, duly registered and authorized to do business in Pennsylvania, conditioned that the permittee will save harmless the township, from any damages whatsoever to its subgrade, subbase, modified subbase, drainage facilities, road metal, and any other installations or matters in, under or upon the highway right-of-way for a period of two (2) years from the date of the completion of the last work covered by this permit.

18. Maintenance and protection of traffic for work authorized by this occupancy permit must be carried out in accordance with the requirements of the township. In this connection, the permittee shall provide and maintain all necessary precautions to prevent injury or damage to persons and property from operations covered by this permit. A traffic control plan may be required as directed by the township.

(a) Warning signs shall be placed beyond each end of the actual operation in such a manner as to be visible to the traveling public and meet the requirements of the township. These signs shall display the name of the permittee and/or its contractor on the back of the sign. Special employes shall be assigned by the permittee and/or its contractor to direct traffic when it becomes necessary to limit it to one way. Advance permission must be obtained from township, or its authorized representative before directing traffic through one lane. Substantial barricades with adequate illumination shall be provided and maintained for any open trench or hole in the highway right-of-way in a manner approved by the township.

(b) Flagman will be provided as specified and in accordance with the requirements of PennDOT.