ORIGINAL

IN THE SUPREME COURT OF OHIO

STATE OF OHIO EX REL. WAYNE T. DONER, ET AL.	:	
Relators,	:	
v.	:	Case No.: 2009-1292
SEAN D. LOGAN, DIRECTOR OHIO DEPARTMENT OF NATURAL RESOURCES, ET AL.	:	
Respondents.	:	

JOINT EXHIBITS - VOLUME THIRTEEN

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The parties to this action, by and through their respective attorneys, hereby jointly submit, for purposes of this action only, that each of the exhibits listed below are authentic for all purposes in this action:

Tab	**Description**
76	Deposition Transcript with Exhibits of Pressley L. Campbell taken April 28, 2010

Dated: June 1st, 2010 Joint Exhibits Approved and Respectfully Submitted By:

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Tab 76

1 SUPREME COURT OF OHIO

2 - - -

3 State Ex Rel. Wayne T. Doner, et al., :
4 Relators, :
5 vs. : Case No. 2009-1292
6 Sean D. Logan, Director, Ohio Department of Natural Resources, et al., :
7 :
8 Respondents. :
9 - - -
10 DEPOSITION
11
12 of Pressley L. Campbell, taken before me, Julieanna
13 Hennebert, a Notary Public in and for the State of
14 Ohio, at the offices of Richard Cordray, Ohio
15 Attorney General, 30 East Broad Street, Floor 26,
16 Columbus, Ohio, on Wednesday, April 28, 2010, at 8:30
17 a.m.
18 - - -
19
20
21
22 ARMSTRONG & OKEY, INC.
222 East Town Street, 2nd Floor
23 Columbus, Ohio 43215
(614) 224-9481 - (800) 223-9481
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11 On behalf of the Respondents.

12 ALSO PRESENT:

13 Mr. Tadd Henson
Mr. Jay Dorsey
14

- - -

15

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Wednesday Morning Session,

April 28, 2010.

- - -

STIPULATIONS

It is stipulated by and among counsel for the respective parties that the deposition of Pressley L. Campbell, a witness called by the Respondents under the applicable Rules of Civil Procedure, may be reduced to writing in stenotypy by the Notary, whose notes thereafter may be transcribed out of the presence of the witness; and that proof of the official character and qualification of the Notary is waived.

- - -

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- - -

PRESSLEY L. CAMPBELL

being by me first duly sworn, as hereinafter certified, deposes and says as follows:

CROSS-EXAMINATION

By Mr. Cole:

Q. Dr. Campbell my name is William Cole and along with Mindy Worly we're representing the Department of Natural Resources in this litigation.

Based on your resumé I assume you've been deposed before.

A. I have.

Q. I'm just going to go over a few ground rules just to keep things going and clear at this deposition.

If you have any questions, let me know. I would ask you please give verbal answers because it is being transcribed. Please wait for me to finish asking my question before you begin answering. You may anticipate the answer, but I may change it at the last or do something. On the same token, I'll do my best not to ask another question till you're finished answering.

If I ask you something, it's not clear, you don't understand, let me know, I'll try to rephrase. I'm not trying to trick you, I'll break it

1 down.

2 If there's any objections or the

3 attorneys start talking, go ahead and wait and unless

4 you're instructed not to answer if there's an

5 objection, please go ahead and answer.

6 And certainly I don't know how long we're

7 going to be here, you're welcome to take a break

8 whenever you feel like. The only condition is if

9 there's a question pending, please go ahead and

10 answer that before you take a break.

11 A. Thank you.

12 Q. Any problems with those conditions?

13 A. No, none.

14 Q. Do you have any questions before we

15 begin?

16 A. No, sir.

17 Q. One question I do want to ask you,

18 Dr. Campbell, are you taking any medication or do you

19 have any condition that would impact your ability to

20 understand my questions or answer my questions

21 truthfully?

22 A. No.

23 Q. Let's go ahead, I would like to mark

24 this.

25 MR. COLE: Counsel, are we going -- we

1 decided we're doing numbers or letters? I forget how
2 we did it with the relators.
3 MR. FUSONIE: I know with the relators we
4 did it each deposition.
5 Off the record.
6 (Off the record.)
7 (EXHIBIT MARKED FOR IDENTIFICATION.)
8 Q. Dr. Campbell, why don't you go ahead and
9 take a look at that exhibit. I think it's going to
10 be familiar so you don't need to meticulously go
11 through it, but just skim over and make sure
12 everything's there.
13 MR. FUSONIE: Make sure everything's
14 there.
15 Q. As you're looking, Dr. Campbell, I'll
16 note that the exhibit labels and the Bates stamps at
17 the bottom were marked when we received them, so
18 we -- I do not believe that our office has done
19 anything.
20 MR. FUSONIE: Exhibit B is a -- or was a
21 legal size document that has been -- the copy has
22 been --
23 A. The photo reduced.
24 MR. FUSONIE: It didn't get folded over.
25 A. You call these Bates numbers? Yeah,

there's no Bates number between ending in 1180 and 1182. So 1181.

Q. I do have the original and later on we'll get that admitted as the full one. Thank you for pointing that out.

MR. FUSONIE: So the record's clear, Exhibit B to what has been marked as Exhibit 1 is a -- should be a legal size document that in the copying a portion of it was not copied because it was folded over.

MR. COLE: Right. And again, we'll come back and get that corrected. I'm not going to do it now though.

A. Yes, I'm familiar with it.

Q. All right. That appears to have been signed by you, if you want to look on page 7, September 29th, and what I'd like to ask you, Dr. Campbell, is are you aware if any of the statements in your affidavit, any of your allegations or any of the information there has changed between then and now?

Is there anything that while it may have been accurate or true at the time, may not be the case because of subsequent events?

A. I'm not aware of anything.

Q. I want to ask you some questions first about your qualifications and experience, and you may just want to look at Exhibit A, which is your, I believe it's your curriculum vitae there.

When did you receive your Ohio engineer's license?

A. I don't recall.

Q. Roughly?

A. It would be probably after '76.

Q. The first engineer's license you got, what state was that?

A. Pennsylvania.

Q. Do you recall when that was?

A. No.

Q. I see --

A. Probably '76, '78, '79. Let me think if I can get my brain to course through it.

Probably in the '75-'76 period of time.

Q. And have you, as far as your Ohio license gone have you held that continuously? Have there been any breaks where you may not have been licensed for whatever reason?

A. No, it's been continuous since I obtained it.

Q. Was your license ever suspended or was

1 any professional action taken against your license,
2 your Ohio license?
3 A. No.
4 Q. How about any of your engineering
5 licenses in the other states?
6 A. No.
7 Q. How do you -- tell me what you did to
8 obtain your Ohio license.
9 A. I made application to the state licensing
10 system.
11 Q. How many -- do you recall how many
12 licenses you had when you applied for the Ohio
13 license?
14 A. No, sir.
15 Q. But you had other licenses. Ohio wasn't
16 your first.
17 A. Yes, sir, that's correct.
18 Q. Did you have to take -- you say an
19 application. Did you have to take any written tests
20 or anything like that to get your Ohio license?
21 A. My recollection is that Ohio relied upon
22 the exam that I took in the state of Pennsylvania.
23 Q. So would it be fair to say you got the
24 Ohio license through reciprocity?
25 A. Well, some states don't like to use that

1 term, "reciprocity." I don't know, but it certainly
2 is through qualification through another similar
3 system.
4 Q. And as far as your license, and I'm not
5 an engineer, do you have any special engineering
6 designations? I see your degree's in civil
7 engineering. Anything beyond that? Do you have any
8 special certifications or designations?
9 MR. FUSONIE: Objection as to form.
10 A. I have I mean several. Certainly I'm a
11 civil engineer but I do practice in some aspects of
12 structural engineering and in geotechnical
13 engineering.
14 Q. Is there a separate formal designation or
15 certification that goes with particular types of
16 engineering?
17 A. That depends upon the state. So most of
18 the states have their own independent designations
19 and licensing systems. So it would depend upon the
20 state.
21 Q. What about Ohio?
22 A. I don't recall the details of Ohio.
23 Q. Did you do any engineering work either as
24 an apprentice or otherwise or any assistance with
25 engineers in Ohio before you got your Ohio license?

1 MR. FUSONIE: Objection as to form.
2 A. I don't recall the precise date that I
3 obtained the license, so it's virtually impossible
4 for me to answer that. I know I did a lot of work in
5 Ohio certainly when I was in -- working in the
6 Pittsburgh office. So we did a lot of projects in
7 Ohio. Whether that was before, during, or after my
8 supposed apprenticeship or my licensure, I don't
9 recall.
10 Q. You said "supposed apprenticeship." what
11 do you mean by that?
12 A. You used the word "apprenticeship."
13 Q. Was there an apprenticeship?
14 A. I don't believe -- there's no such word
15 as an "apprenticeship" as far as I know with Ohio
16 professional engineering licensure. I think at that
17 time I believe that we were called engineers in
18 training. But I don't think I was ever an
19 apprentice.
20 Q. Can you briefly tell me what the minimum
21 requirements are to take -- to get an Ohio license?
22 MR. FUSONIE: Objection.
23 Q. If you know.
24 A. Based on my recollection I can tell you,
25 surely. I believe Ohio is similar to most states

1 that it requires that you have a minimum of a
2 Bachelor's degree or a Master's degree in a certain
3 engineering curriculum followed with a minimum of
4 four years of training.
5 (Interruption.)
6 Q. Dr. Campbell, were you finished answering
7 my question?
8 A. I don't recall exactly.
9 Q. I believe, Dr. Campbell, you had pointed
10 out that I may have mischaracterized your experience
11 prior to getting your licensure as an apprenticeship
12 and I believe I followed up with what did you need to
13 do to get licensed as an engineer. I think it was
14 something like that.
15 A. Right. And my recollection is I was
16 explaining that I believe the State of Ohio requires
17 that you are registered with that state as an
18 engineer in training and there are minimum
19 requirements with that and I met that and that you
20 work as an engineer in training under the supervision
21 of a registered or licensed engineer for a minimum of
22 four years, at which time you are then qualified to
23 be able to take the professional engineer's
24 examination.
25 You take the examination then and if you

1 successfully pass that and are still found in good
2 standing, then you receive your registration or
3 licensure.
4 Q. And based on your earlier answer about
5 being able to get licensed in other states without
6 taking a full test, I presume that the test you do
7 take is multi-state, it would be -- the same test
8 would be in different states? Do you know?
9 A. Well, I mean I do know. I know that some
10 states accept the tests of another state and some
11 states don't. And I don't recall Ohio, but the
12 record would speak for itself, but my recollection is
13 that Ohio accepted my examination and testing from
14 the state of Pennsylvania.
15 Q. How would you -- how in your words would
16 you characterize your expertise, your engineering
17 expertise?
18 A. I would characterize that I'm qualified
19 in civil engineering, some areas of structural
20 engineering, some areas of geotechnical engineering.
21 I do have many other designations but I don't know
22 that it's appropriate for me to name them.
23 I mean, the CV speaks for itself. So
24 certainly civil engineering and the related branches
25 of civil.

Q. Do you have any designations having to do with either hydrology or hydraulic engineering?

A. Per se specifically, not that I know of. Not sure that there are any.

Q. It seems from your CV that most of your training and the projects that you worked on were in the environmental engineering field, remediation, and solid and hazardous waste management. Is that a fair characterization?

MR. FUSONIE: Objection.

A. I'm not sure that I would agree to characterize it that way. Certainly I mean in terms if you span the beginning of my career to date, that would be a dominant area of expertise, yes.

Q. What percentage of your time in, say, the last five years have you devoted to hydrologic and hydraulic modeling?

A. My estimate would be between 25 and 50 percent.

Q. And in the past five years what percentage of your work have you done in Ohio?

A. I'd say it's probably less than that. Would probably be 10 to 20 percent.

Q. And that would include your work on this case as well as the Case Leasing case?

A. Yes, and other projects, surely. I've had a number of projects in the state of Ohio.

Q. Have you ever been retained as an expert witness in an eminent domain or property taking case other than this case which is we call it the Doner case or the Case Leasing? Have you been an expert witness in cases like these two before? Other than these two?

MR. FUSONIE: Objection as to form.

THE WITNESS: I should answer though, yes?

MR. FUSONIE: If you understand the question.

A. I think I understand the question. And the answer would be yes, I have.

Q. Can you tell me about that?

A. I've provided technical support for a law firm in Lafayette, Louisiana that's called Oats & Hudson law firm. And a number of projects related to property, property impairment that I don't understand the legal significance of the term "taking" but certainly related to property impairment and compensation and damage related to that.

That's certainly one of a series I participated for with the law firm in the city of

1 Philadelphia for a very large flood event which was
2 taking an insurance litigation, the Delaware River.
3 And certainly you can tell it's my PhD thesis
4 dissertation is in flooding on the Allegheny River in
5 Western Pennsylvania.
6 And both my Master's and my Bachelor's
7 thesis are in hydraulic engineering. So I certainly
8 came into this entire civil engineering discipline
9 majoring in hydrology and hydraulics. And it still
10 remains a dominant role. And many of those
11 situations where I provided expertise involve
12 property damage and impairment and/or taking and/or
13 whatever the damage would be related to it.
14 So I don't understand exactly all the
15 background of the question but I've been involved in
16 many cases like that.
17 Q. Well, and I don't want to go over all the
18 legal implications, but as you're probably aware in
19 this country and in the States, if the government
20 either deliberately or through its actions
21 substantially destroys the value of property or
22 physically invades it, the owners are entitled to
23 compensation. I assume you understand that basic
24 approach.
25 A. That's what my response was related to,

1 that approach. Some impairment which could be
2 compensation.
3 Q. In those cases that you have been a
4 witness, on those types of cases have you ever been
5 an expert for the government agency involved or if it
6 was a utility company or whatever, that the agency
7 that or the entity that is being sued or is the one
8 who's taking the property?
9 MR. FUSONIE: Objection as to form.
10 A. Yes.
11 Q. When was that? Or tell me about that
12 situation.
13 A. Well, I mean, that's dominantly the law
14 firm of Oats & Hudson represents in the state of
15 Louisiana the Department of Transportation and
16 Development. So we can look in the details of my CV
17 but certainly there's three, four, or five of those
18 particular I call them projects or litigations that
19 that was the -- they were the sole source.
20 The State of Louisiana felt that
21 something happened and they needed to take legal
22 action in order to either not pay an accused amount
23 or an asserted amount, pay less, or have no damage
24 caused by the State of Louisiana.
25 Q. Were there any eminent domain claims or

1 takings claims associated with Hurricane Katrina that
2 you worked on?
3 A. Yes.
4 Q. Tell me about those.
5 A. Well, I believe those are also identified
6 in the CV. But I evaluated over 900 homes as a
7 result of Hurricane Katrina and a certain percentage
8 of those damages were litigated because of a
9 disagreement between the owner and the insurer with
10 regards to the valuation.
11 So I did a number of hydrology and
12 hydraulic evaluation, flooding studies and water
13 impairment, the cause of damage assessments and
14 testimony either in deposition or in trial.
15 Q. Were the Katrina cases that you talked
16 about, were those you mentioned insurance? Those
17 were -- those weren't eminent domain cases though,
18 were they?
19 MR. FUSONIE: Objection.
20 A. Not to my recall, no.
21 Q. Anything with Katrina where you were an
22 expert on behalf of the State of Louisiana or any
23 political entity?
24 A. Not that I recall.
25 Q. On page 2 of your resumé you have I

1 believe you list six hydrology and hydraulic
2 projects.
3 A. I do.
4 Q. I'm going to ask you some questions about
5 those and the first one I can't pronounce what that
6 name is.
7 A. Atchafalaya Basin.
8 Q. Atchafalaya Basin, thank you.
9 When did you work on that project?
10 A. Would be certainly within five years. I
11 don't remember the precise year.
12 Q. And what models were used on that
13 project?
14 A. The same whatever the -- depending upon
15 the year, the HEC models. Hydrology Engineering
16 Center models.
17 Q. Can you break that down even further? Do
18 you know if it's the HEC HMS, HEC-1, HEC-2?
19 A. It has to do with the year, so those are
20 just terms related to whenever when those terms were
21 whatever designated. Before that the same models
22 were there, they were just different versions. They
23 were different names. So again the same hydrologic
24 models.
25 Q. What can you -- what were the models you

1 used? Can you describe them?
2 A. I believe I just did. But basically I
3 don't remember the precise year of that. So I would
4 have to look at the record to answer your question.
5 Q. Well, do you know if it involved steady
6 or unsteady flow?
7 A. Surely.
8 Q. Which was it?
9 A. It involved both steady and unsteady
10 flow.
11 Q. Was there a hydrology component to that
12 model that you used in the Atchafayala Basin?
13 A. Yes.
14 Q. What about hydraulics, was there an
15 element to that?
16 A. Yes.
17 Q. Can you elaborate on those at all? Just
18 based on your resumé and your recollection?
19 A. Well, that was a thorough evaluation of
20 some proposed levying and channelization in the
21 Atchafalaya Basin. And there were many different
22 jurisdictions involved.
23 There's situations called levy districts,
24 and then of course there's in Louisiana are parishes,
25 in Ohio you have counties, as well as municipalities.

1 And the evaluation was very thorough related to
2 rainfall runoff and diversion of water as to protect
3 properties from certain storm events, so.
4 So rainfall runoff and stream flow
5 modeling were all an integral part of that
6 evaluation.
7 Q. Were you the -- were there any other
8 engineers or engineering firms that worked on this
9 project or were you the only one?
10 A. No, there were several engineering firms
11 that worked on that project.
12 Q. Were you coordinated in your efforts?
13 A. I acted as a reviewer on behalf of the
14 law firm Oats & Hudson which acted on behalf of
15 either the State of Louisiana or one of the levy
16 boards or levy districts.
17 Q. So when you say "review," correct me, did
18 another engineering firm do the legwork and then you
19 reviewed that for accuracy and correctness?
20 A. And/or several firms evaluated from
21 different viewpoints. Again, you have multiple
22 entities evaluating levy controls and channelization
23 projects, and so one levy board may have hired one
24 firm, a parish may have hired another firm.
25 So there were multiple hydrology and

1 hydraulic evaluations of the situation and I acted on
2 behalf of my client Oats & Hudson to review each and
3 every one of those.
4 Q. So you were re -- you weren't reviewing
5 other engineers' work.
6 A. Yes, I was.
7 Q. You were, all right.
8 Was it strictly limited to review though,
9 or did you do your own modeling and studying of the
10 situation, or were you just simply reviewing what
11 others had done?
12 A. My recollection is that I only reviewed.
13 I did not do any hands-on modeling.
14 Q. The next project listed is the Baraboo,
15 Wisconsin for the industrial facility there. Can you
16 tell me when that project was done? When you worked
17 on that one?
18 A. That one I would think would be between
19 2000 and 2005. Might go back to '97 or something
20 like that but it's in that frame.
21 Q. Do you recall what models were used on
22 that project?
23 A. No, I don't.
24 Q. Do you recall what -- were there
25 hydrological and hydraulic components to that, do you

recall?

A. Yes, most definitely.

Q. And steady and unsteady flow, do you recall?

MR. FUSONIE: Objection; vague.

A. Dominantly steady flow were the assumptions in that project.

Q. Was that a situation where you were reviewing as in the Atchafalaya or were you doing hands on?

A. I reviewed and did hands on. I believe I was the -- my recollection is that I was deposed or close to being deposed in the litigation before there was a settlement.

Q. What -- do you know what percentage of your engineering work is involved with cases in litigation?

MR. FUSONIE: Objection; vague as to time frame.

A. Probably about a quarter of them.

Q. Within the last five years?

A. Uh-huh.

Q. Yes?

A. Yes.

Q. Okay.

A. Didn't mean to mumble, I apologize.

Q. That's all right.

And again, you don't recall for the Baraboo project what models for hydrology or hydraulics were used on that?

A. What I recall is again it was the HEC models were used. What terms, whether they are HEC-1, HEC-2, HEC RAS, HEC HMS, depending upon the year that it was, the same HEC models were used.

Q. And just so the record's clear, can you tell me what does "HEC" mean? It's an abbreviation.

A. Standards for the Hydrologic Engineering Center. It's an entity of the United States Army Corps. of Engineers.

Q. And is it the standard to use for hydrology and hydraulic modeling?

A. It's a standard that's readily accepted.

Q. Is it one that you frequently use and accept?

A. Frequently use and accept it, yes.

Q. Are there other ones that can be used that you've used?

A. Most definitely.

Q. Can you briefly tell me about those?

A. Yes, I can. There are several. They're

1 readily used and readily accepted. And what really
2 amounts to, it amounts to there has to be a certain
3 dollar value at stake or at risk because to use one
4 of the HEC models requires a substantial amount of
5 energy and setup and problem definition.
6 And so I will often use more simple, more
7 straightforward models or engineering calculation
8 techniques whenever it's not warranted to spend days,
9 weeks, and months preparing a model.
10 So many models are accepted and you use
11 the right model for the right project.
12 Q. Then would the HEC models, are they
13 generally more complicated and time consuming, is
14 that why you don't always use them?
15 A. That's a characterization that I would
16 really not rather agree to.
17 Q. Okay.
18 A. That it requires certainly much more data
19 or information about the watershed characteristics,
20 the extreme characteristics, requires a lot more
21 input data to run one of those models.
22 Q. And so because of that, cost is a factor
23 also in deciding whether to use it?
24 A. The cost and the amount of, well, there's
25 many factors. But certainly it relates to how much

information do you have of the watershed and of the streams. What are the -- what's the -- what is at risk or what's the potential damage and impairment --

How much time do you have to obtain an answer or complete an evaluation and what kind of precision do you need in your evaluation?

Q. -- are there in your experience accepted, professionally accepted or industry standard models that are more precise than the HEC models?

MR. FUSONIE: Objection.

A. No.

Q. The next project you have listed there is the Ashville, North Carolina. Can you tell me when you worked on that project?

A. Since 1997. And probably before 2005.

Q. Okay. That's just somewhere in between there? That's as good as you can recall?

A. As good as I can recall.

Q. Do you recall what models were used on that project?

A. Yes, I believe.

Q. And what were those?

A. Used what's called a PC Swim, which is a stormwater model developed by the EPA, and then I used another model. I don't remember the name but it

1 was related to erosion. Related to rainfall runoff
2 and then stream erosion.
3 Q. I'm not familiar with PC Swim. Does that
4 model have a hydrology component to it?
5 A. Yes, it does.
6 Q. Does it have a hydraulics components?
7 A. Yes, it does.
8 Q. Are both of those involved -- in that
9 project were both of those at issue in the project?
10 A. I used both of those.
11 Q. Were any of the -- do you recall whether
12 you used the HEC models for that project?
13 A. I recall I did not.
14 Q. Why not?
15 MR. FUSONIE: We seem to be -- I know you
16 have to ask these questions. I also -- I'm not
17 counsel obviously for Conestoga but we're wandering
18 in areas where this is consulting work versus
19 testifying work and I don't want him to breach any
20 duty he has to other clients by disclosing reasons
21 for not using certain models versus using other
22 models.
23 So with that said, if you are afraid that
24 you're going to be disclosing attorney work product
25 between you and some other client because you were

1 working in a consulting versus testifying capacity,
2 I'm not instructing you not to answer but I'm giving
3 you that -- I'm making that comment on the record.
4 A. I believe I'm able to answer that
5 question. I did consulting work and testimony in the
6 state of North Carolina in that particular project.
7 And I used a model that I thought was appropriate for
8 the watershed at hand.
9 Q. And again, why didn't you use any of the
10 HEC modeling in that?
11 A. Because it would have cost either ten
12 times more or a hundred times more. And the data was
13 not available. It would have cost an immense amount
14 of money to collect the data that would have been
15 needed to put into a HEC model.
16 Q. If you had used a HEC model, do you think
17 you would have -- that would have given you a better
18 result than the PC Swim model and the other model you
19 used?
20 MR. FUSONIE: Objection; calls for
21 speculation.
22 A. No. I specifically did not use the HEC
23 model because I did not believe it was appropriate.
24 Q. Were there any other reasons besides cost
25 that was inappropriate to use?

A. Yes. My engineering evaluation, it was not appropriate.

Q. Tell me about that. Why not?

A. Because the HEC model was not the model that was appropriate for the application in that watershed.

Q. Can you tell me why it was not the appropriate model? Why would it --

A. The data was not available.

Q. All right. To input in the model.

A. That's correct.

Q. Anything else?

A. Sir, yes. There are many things involved. Many things went into my decision. That was one of them.

Q. What were the other reasons?

A. I can't sit here today and tell you the ten reasons. But I didn't make a decision for one of them. I'm giving you my best recollection of that project.

But the HEC model is not the best model in the world and I used the best model that I see for a project at hand. That's my expertise; to evaluate the watershed at hand, the project objectives at hand, and use the appropriate model.

Q. So the other reasons you don't recall, you're not refusing to answer, you just don't recall the other reasons why you didn't use the HEC modeling in that?

A. I believe I answered your question.

Q. Well --

A. The HEC model was not the appropriate model for that watershed.

Q. And you said there were a number of reasons and you said you can't give it. I'm just asking you is it because you don't recall all the reasons?

A. I recall all the reasons.

Q. All right. Then why can't you tell me all those reasons?

A. I told you those reasons. The watershed was small, the project was a project where the party felt that they were impaired by an action taken by the North Carolina Department of Transportation.

The North Carolina Department of Transportation had completed an analysis. I reviewed the analysis they had completed. And I believe that their analysis was not appropriate for the watershed at hand.

So I selected from the watershed at hand

1 what models might be appropriate to be used. As a
2 matter of fact, I did two or three of them and I
3 applied those and I got answers which were in
4 conflict with the answers provided by the Department
5 of Transportation.
6 I wrote a report, went to trial, and the
7 outcome was in the favor of the client that I
8 represented.
9 Q. The Department of Transportation in that
10 case, did they have an expert? An engineering
11 expert?
12 A. They had at least one, maybe two or three
13 as I recall.
14 Q. Do you recall what modeling those experts
15 used on this case?
16 A. No, I don't.
17 Q. Did the Ashville project involve steady
18 or unsteady flow modeling?
19 MR. FUSONIE: Objection; vague.
20 A. I believe it was appropriate. All the
21 parties used steady flow modeling.
22 Q. The next one you have listed there just
23 down the line is the Missouri River at Omaha,
24 Nebraska. When did you work on that project?
25 A. In the '70s.

Q. How long has HEC modeling been around, do you know?

A. I'm sure we can look it up. I don't recall.

Q. All right.

A. Again, different versions of it have been worked on for many years.

Q. Do you recall what models were used in that project? I know it's been some time.

A. I can't recall that much about what models I used at that project. Apologize.

Q. That's all right. I was very young at the time too.

Do you recall whether that was a steady or unsteady flow situation?

A. That was definitely an unsteady -- because it was very -- the Missouri River at Omaha was -- the subject of all that work was quite a large watershed with many major dams and reservoirs and releases and records, so clearly had a steady and an unsteady characteristics in its evaluation.

And if you can tie that back very closely, you can see that that was the topic of my PhD thesis was the steady and unsteady flow and the characteristics of that.

1 So this was really my first major
2 application of a lot of my PhD work in the practical
3 world for the client and that particular project was
4 the Omaha Public Power District for a facility in
5 Omaha.
6 Q. Did that project involve both hydrology
7 and hydraulics components to it?
8 A. Yes.
9 Q. Then the next one you have listed is the
10 valuation of the Delaware River near Philadelphia.
11 When was that project? When did you work on that
12 project?
13 A. That would be in the '80s.
14 Q. Do you recall what models were used on
15 that project?
16 A. Yes. I referred to that earlier in the
17 deposition when I referred to Philadelphia and
18 Delaware River. There were a number of models what
19 were involved in that. That was -- the models that
20 were reviewed on that were the models that were used
21 by the flood insurance program. So that would have
22 been all the standard HEC models.
23 Q. Okay, so they were -- and did you use the
24 HEC models in that case?
25 A. Again, what I did in that particular

1 situation was I evaluated the modeling done by others
2 and provided recommendations with regards to the
3 boundary conditions that were assumed in those
4 models.
5 Q. Did you --
6 A. And again that one also had a favorable
7 outcome for the client where after review, the
8 company that had completed the flood study, because
9 those are all done under contract, agreed that my
10 suggestion on the boundary conditions were an
11 improvement over what they had in the flood study,
12 and the flood map was changed as a result of my
13 evaluation on that.
14 Q. Did, when you were reviewing or
15 evaluating, did you -- was it your conclusion that
16 the HEC modeling, use of HEC modeling was appropriate
17 for that project?
18 A. Yes, it was.
19 Q. You say there were -- do you know if it
20 was entirely HEC modeling or if there was other
21 modeling involved?
22 A. There was a rainfall and runoff component
23 as well as a stream flow component.
24 Q. And was the Delaware River a steady or
25 unsteady or both modeling?

1 MR. FUSONIE: Objection; vague.
2 A. In the flooding scenario it was -- would
3 have been modeled for the supposed hundred year flood
4 flow, a steady flow situation.
5 Q. And so just -- that was just a steady
6 flow?
7 A. In terms of the, again, the -- I think
8 you're going to see as we proceed through the day is
9 that the flood insurance program designates that it's
10 one steady flow modeling is its rule of thumb. And
11 in that case it stipulated that. So I didn't dispute
12 that.
13 Q. Does that mean that -- you say it was
14 stipulated, you didn't dispute. It was stipulated in
15 the litigation that that's what would be done?
16 A. Well, it was part of the project.
17 Q. All right.
18 A. The client of the law firm that retained
19 me felt that the flood study caused much of their
20 property to be designated within the hundred year
21 flood plane. Which causes an economic impact to the
22 value of that property.
23 Q. That would be a negative impact.
24 A. It would be an adverse, that's correct.
25 It would devalue or lower the value of their

1 property. And so they contracted and I completed an
2 evaluation of that study.
3 Part of the ingredients of that study was
4 to make a model of a hundred year flood event and so
5 I took that as a given that I was working on an
6 evaluation of a hundred year flood event. Which is
7 what the insurance program prefers. So I didn't
8 dispute that point because I was able to have it
9 changed by evaluation of that point in and of itself.
10 Had that not been successful, I may have
11 looked at whether or not there needed to be other
12 points such as whether it would be steady flow or
13 unsteady flow.
14 In other words, we won. We won with that
15 as the point. So you don't need to go to another
16 point. Whenever they got -- we got the flood study
17 changed, their property was no longer as much in the
18 hundred year flood plane, and so they -- instead of
19 them losing property value, that property value was
20 restored.
21 Q. The final one you have listed on page 2
22 is the four dam sites in Pennsylvania and West
23 Virginia. When did you -- it says you evaluated.
24 Again based on that I presume you were reviewing
25 other work?

A. I don't think on those --

Q. Make I shouldn't.

A. No, in those ones we actually did probable maximum flood evaluations.

Q. When did you work on that project?

A. This would either be in the late '70s or early '80s.

Q. And do you recall what models were used on that project?

A. Actually I don't.

Q. Both hydrology and hydrological components?

A. Surely.

Q. Flow modeling steady, unsteady?

MR. FUSONIE: Objection; vague.

A. Mostly steady.

Q. The six that I've just covered, how many of those -- you've referred to some of them. How many of those were involved in litigation? And which ones? Maybe that's a better question. Which ones of those was there litigation?

A. Baraboo involved litigation, Ashville, North Carolina involved litigation. Those really are the only ones that had litigation. It was impaired property in the one in Philadelphia I've identified.

Q. In those that were in litigation were you representing -- you were working with law firms that represented property owners; is that correct?

A. Certainly in Baraboo. In Baraboo it was not a property owner, I believe it was a tenant in Baraboo. And in North Carolina it was a property owner.

Q. If you could go to page 8 on your resumé, sir.

A. Yes, sir.

Q. The first full bullet point there is you refer to hydrology and hydraulic design of spillways, channels and appurtenances for 15 coal facilities in various states including Ohio. Do you see that?

A. Yes, sir.

Q. When did you work on that project?

A. I would say one of them continues on to today, but certainly the dominant part of that work that I'm referring to would be in the '70s and the '80s.

Q. What is the one that you say is still going on, is that in a particular state?

A. Well, I believe I have it identified in another -- I believe I have it in another -- such a large project, I broke it out from that one somewhere

1 else in my CV.

2 But basically there was a failure in West

3 Virginia that -- actually there was a failure in

4 Kentucky that then coursed in the river between the

5 state of Kentucky and West Virginia, and then on into

6 the Ohio River.

7 Q. Do you --

8 A. So that was related to a coal refuse

9 facility that failed.

10 Q. Do you recall what models were used on

11 that project or those cases?

12 A. In these particular ones here most of

13 these did not use the HEC models.

14 Q. Why is that?

15 A. It's not appropriate for those

16 watersheds.

17 Q. Why wasn't it appropriate?

18 A. Coal refuse embankments there was Mine

19 Safety Health Administration promulgated requirement

20 that the coal refuse facilities be designed for

21 either probable maximum flood or percentage of

22 probable maximum flood.

23 So the dominant part of these projects

24 were related to the determination of the rainfall

25 runoff from a selected design storm. Most of those

1 watersheds were small watersheds. Most coal refuse
2 facilities are constructed near the headwaters of a
3 watershed. So the use of the HEC models is just not
4 appropriate.
5 Q. Is use of HEC modeling usually
6 inappropriate when you're looking at rainfall runoff?
7 A. Again, the key that I tried to put on
8 there, sir, was when you're near the head of the
9 watershed, then much use of the HEC models is just
10 not appropriate.
11 Q. That's a general rule?
12 A. Yeah, because again, it's the HEC again
13 but goes back to my previous answer is it relates to
14 the amount of information and data that is needed to
15 input into a model that is such degree of
16 sophistication of the HEC set of models. And when
17 you're at a very small watershed, the headwater.
18 Watershed, it's just not appropriate to
19 use that model. There's nothing wrong with the
20 model, it's just not the right model for that
21 particular watershed. Beginning and end, that's it.
22 It's not the right, you know, it's not the right
23 model for those watersheds.
24 Q. Was steady or unsteady flow modeling used
25 in these coal cases here? The coal refuse disposal

1 facilities?

2 MR. FUSONIE: Objection; vague.

3 A. Yeah, again, Mine Safety Health

4 Administration designated that each and every coal

5 refuse facility had to be designed and/or verified to

6 be designed to be able to withstand a certain

7 percentage of the probable maximum flood event. And

8 so those are spillway evaluations.

9 So what you're trying to do there is to

10 determine the peak runoff so that you then have a

11 spillway that is designed adequately to protect the

12 facility from the peak runoff.

13 So your analysis is you use an

14 instantaneous peak, you assume it's a steady flow,

15 and you do the evaluation to make certain that your

16 appurtenance or spillway will withstand that flow.

17 And by the way, the one that I talked

18 about is the very next bullet on that page 8 where

19 there was a surface impoundment related to a coal

20 refuse disposal facility where the 250 million

21 gallons of coal slurry was released into the

22 environment, and that work continues today.

23 Q. That's the second full bullet point on

24 page 8?

25 A. Yes.

Q. The Appalachia one?

A. Yes, sir.

Q. Tell me a little bit about -- you led into it, let me ask you, you say that "continues," when did that start? When did you start working on that?

A. I would have to look that up. About ten years.

Q. Ten years ago approximately?

A. About ten years ago.

Q. And you say it's ongoing. Are you actively involved with that project still?

A. I'm not actively involved but the project still has an active element in it.

Q. What did you do in that project? And strike that. Let me ask you this, did you use any hydrological or hydraulic models in that project?

A. Yes, I did.

Q. Can you tell me about those? Did you use HEC modeling?

A. Actually did not use HEC modeling, no, sir.

Q. And why not?

A. Because I didn't believe it was appropriate.

Q. Why was it not appropriate?

A. Again, where the situation was it was in the upstream part of the watershed.

Q. Was it similar to the prior one we discussed?

A. In a way it was similar to that. Certainly the dominant impediment in that particular project was the coal slurry. So it was a -- it was not as much hydraulics but the movement of the sediment, that was the dominant issue.

So I did very sophisticated sediment transport analyses in that project. And actually had to create my own models for that because the available software was not adequate to address the situation that I was addressing.

Q. I do have a couple more questions, I do want to go back for a second to the six that we discussed on page 2. You made a reference I think on the, I think it was the sixth one, the Pennsylvania/West Virginia dam sites or possibly the Delaware River about the hundred year flood event. Which one of those was that?

A. That was the Delaware River in Philadelphia.

Q. What is a hundred year flood event?

A. That depends on the context. If you ask it in terms of a hydrologist, it has one answer, but if it's related to the insurance program, then there's a very prescribed definition by the United States government that designates and stipulates what "hundred year event" is.

Q. Let's -- give me the definition or what you understand in the general, not what the government requires.

A. Right, what we would understand as hydrologists, a hundred year event or a ten year event or a 50 year event is what we would perceive or evaluate using engineering tools as some event that would occur with that recurrence interval.

Q. So the --

A. So what we usually do to do that is we usually use precipitations that whether we could prove it or not may have more reliability with regards to the recurrence interval frequency.

And then we use that to calculate the corresponding runoff. And then that would be what we would do as a hydrologist. That would be the way I would say X recurrence interval five years, ten years, 25 years, hundred years or whatever. Then I would -- that's what I would do as a hydrologist.

Q. So in the Delaware River case, correct me if I'm wrong, you ran -- you did your analysis on a hundred year flood event recurrence.

A. Not by my definition at all. Not by the definition I just articulated. That was a flood study. So that was a hundred year event as stipulated by the federal government through the insurance program.

Q. So you were constrained by that.

A. Or that was stipulated. That was part of the situation.

Q. Okay. What about -- do you recall what -- were there recurrence, flooding recurrence issues in the other projects we went over, we discussed on page 2? The hydrology and hydraulic projects.

A. I believe each one would have its own characteristics with regards to it.

Q. Do you recall what recurrence events you looked at or ran for those projects specifically?

A. I pretty much do, yes.

Q. Go ahead.

A. Well, the work in the Atchafalaya Basin was an entire myriad of different hydrologic events. Because the very jurisdictional entities, i.e., a

1 parish or a levy district or a municipality may have
2 jurisdiction over certain recurrence interval events
3 and not another one.
4 Q. All right.
5 A. So that project was an analysis of
6 multiple recurrence interval events. The flood
7 events at Baraboo was, again, under the jurisdiction
8 of the Flood Insurance Administration and the related
9 flood maps, so that was the government designated
10 valuation of the hundred year flood.
11 The Ashville, North Carolina was an
12 evaluation by the North Carolina Department of
13 Transportation, and they used multiple recurrence
14 interval events in their design.
15 The Omaha Public Power District, because
16 it was on the Missouri River, had to be designed for
17 the probable maximum flood. That was the -- that
18 facility was under the jurisdiction of the Nuclear
19 Regulatory Commission and, therefore, that facility
20 had to be able to -- had to be designed to withstand
21 the probable maximum flood.
22 Q. Do you recall what that -- what the
23 probable maximum flood is? Do you recall the
24 particulars of that?
25 A. I surely do. Immense recall.

Q. What was that?

A. Well, the probable maximum flood is the maximum flood as the result of a runoff from a probable maximum precipitation. So it's actually an optimization.

And this watershed was many over a hundred square miles, so a given storm event, let's say a storm event that has an impact area of ten square miles, you have a probable maximum precipitation for a ten-square-mile watershed.

You have a 10,000-square-mile watershed, so you attempt to evaluate where that storm may occur anywhere within that watershed to produce the maximum flood at your point of interest.

So that's one point for one size of a storm. You then hypothesize a 1,000-square-mile storm event, a probable maximum precipitation, you then model it throughout your watershed to determine the resulting flood.

And so do you this for a series of them and then you evaluate what is the maximum of the maximum. And that is by definition the probable maximum flood.

Q. All right. How about, I think you told me about Delaware River.

A. Delaware was an insurance program. And the dam sites in state of Pennsylvania, again, they were designated I believe by the, at that time the Bureau of Reclamation stipulation, law, whatever you want to call it, that the -- all the dams had to be evaluated to withstand probable maximum flood.

Q. Could you go to page 13?

A. Yes, sir.

Q. And if you go down to the -- go to the fourth bullet point.

A. Yes, sir.

Q. Can you tell me a little -- where was -- this is what you have under "Other Projects and Experience." Is this multiple events, multiple projects, or a specific one you're talking about there?

A. Yes, sir.

Q. Which? I'm sorry, multiple or a single event?

A. No, these are multiple. What I'm trying to do here, sir, is having already articulated a number of projects for 14 pages of my resumé, I'm trying -- but certainly not in any way designating each and every one of them, I'm trying to create a bullet which will allow the reader to understand that

1 I've worked on many other projects that would include
2 those disciplines.
3 Q. Do you recall in the past five years how
4 many times you used HEC modeling?
5 A. No, I surely don't.
6 Q. The past three years, past two years?
7 MR. FUSONIE: Objection. Which question?
8 Q. Past three years?
9 A. No, I certainly don't.
10 Q. Do you know in the past five years how
11 many flood studies you've completed?
12 A. I could probably go through my resumé and
13 calculate probably a half a dozen. Probably one or
14 two a year. Might be somewhere between five and ten.
15 Q. For the past five years?
16 A. Surely. What I'm doing is by my memory.
17 Q. Sure.
18 A. I'm telling you about one or two a year.
19 Q. Do you know how many flood studies you've
20 completed in Ohio in the past, say, five years?
21 A. Probably one a year.
22 Q. Did you do a flood study in the Case
23 Leasing case?
24 A. I would call that a flood study, yes.
25 Q. Do you recall the most recent time that

you used HEC modeling for steady or unsteady flow analysis?

MR. FUSONIE: Objection.

A. Other than the particular case that's at hand?

Q. Okay, so you've used it in this case, correct?

A. Sure. I mean this was part of the work at hand here.

Q. Right. How about before that?

A. Half a dozen.

Q. Can you tell me a little bit about those projects? Or those, yeah, those projects that you worked on that you used HEC modeling the most recent times?

A. Those projects involved rainfall runoff and frequently they have at issue flood studies by -- some completed within the jurisdiction of the Flood Insurance Administration, and it's not uncommon that when you review those studies they involve implementation of the HEC models.

Q. What sort of projects or what type of projects is the steady flow analysis most appropriate?

MR. FUSONIE: Are you asking him in his

1 professional expertise, FEMA's definition?
2 Q. In your opinion.
3 A. Could you repeat the question?
4 Q. In your professional opinion what type of
5 projects is the steady flow analysis or modeling most
6 appropriate?
7 A. Well, I will almost always complete a
8 steady flow analysis of every project as a starting
9 point. And then again depending upon the project,
10 evaluate the situation and the circumstances and make
11 a project-by-project determination if something other
12 than steady needs to be incorporated.
13 Q. And why do you do that? Why do you
14 almost always start off using a steady flow?
15 A. It has to do with the previous answers
16 that I've already given: It's a good starting point
17 and it's, generally speaking, even if we know we need
18 to do an unsteady evaluation, we are still going to
19 begin with the steady evaluation and then compare the
20 unsteady evaluation to the steady evaluation.
21 Q. Is that an industry standard that other
22 engineers like yourself would use?
23 A. I don't really want to speak to an
24 industry standard. That's the way I would do it.
25 Q. What sort of project is the unsteady flow

analysis most appropriate?

MR. FUSONIE: Objection.

Q. In your opinion.

A. If the unsteady flow peak causes substantially more impairment to a watershed or a property, then it is usually -- one could argue that it would be most appropriate to use an unsteady evaluation.

Q. Tell me what you mean by "substantially more impairment."

A. Higher stage, higher velocity. More water. More damage.

Q. Does the type of land you're looking at, is that a factor whether you use a steady flow or unsteady flow, the geography of the property?

A. Surely. Again it's probably five, ten, 20, key parameters. Type of land is certainly one of them.

Q. What are the most important factors that you consider?

A. Size of the watershed is very important, size and character of the stream is very important. Whether there's control structure or not a control structure is very important. Time of the year. And seed moisture condition. Vegetation cover. Slope.

1 Again, that's everything that's involved in
2 hydrology.
3 Q. In this case, in the Doner case did you
4 use a steady flow analysis?
5 A. In this case I evaluated --
6 MR. FUSONIE: Hold on. The only thing
7 I'm going to --
8 MR. COLE: I'll rephrase the question.
9 I'll rephrase it.
10 MR. FUSONIE: All I'm going to say is
11 if -- you are here as a testifying expert. I'm not
12 sure -- and that's it. That's what is discoverable
13 in this action is what you are here for as a
14 testifying expert.
15 With that instruction, you can answer
16 questions.
17 MR. COLE: Counsel, I don't understand
18 your comment. Can you -- you certainly can --
19 MR. FUSONIE: Rule 26 is pretty clear
20 Rules of Civil Procedure. So I'm just standing by a
21 Rule of Civil Procedure 26 that the scope of
22 discovery is the scope of his testifying -- him as a
23 testifying witness.
24 MR. COLE: Okay.
25 MR. FUSONIE: With that instruction, you

1 can answer.

2 MR. COLE: Are you objecting to the -- I

3 presume you're objecting to the scope of my last

4 question?

5 MR. FUSONIE: I'm objecting to it to the

6 extent it is somehow going to stray into attorney

7 work product because there is, under the Ohio Rules

8 of Procedure, Rule 26, what is discoverable is what

9 he is testifying -- he is a testifying witness about.

10 I'm just making sure, I'm only one of

11 five attorneys on our side. I want to make sure he's

12 not straying --

13 MR. COLE: As I am I.

14 MR. FUSONIE: -- he's not straying into

15 something that is not Rule 26 as a testifying expert.

16 MR. COLE: I presume you're not

17 begrudging me the ability to inquire as to his work

18 on this case.

19 MR. FUSONIE: His work on this case as a

20 testifying expert, correct. I'm not begrudging you

21 that. I'm simply staying within the scope of Rule 26

22 and commenting for the benefit of Dr. Campbell as to

23 that as well.

24 MR. COLE: I do have a few important

25 questions, you can certainly discuss with him at a

1 break, I'd like to take a break and feel free to talk
2 with him on that.
3 MR. FUSONIE: Sure.
4 Q. (By Mr. Cole) I'm going to withdraw my
5 last question and ask you broader, your work on this
6 case, you've rendered an opinion through an affidavit
7 and you've done some analyses, correct?
8 A. That is correct.
9 Q. What flow analyses have you done in this
10 case?
11 A. The record reflects what analyses I did.
12 Q. Would you tell me anyway?
13 A. I can read it. I mean, I evaluated the
14 impact of the replacement spillway.
15 Q. Did you -- I'm sorry, go ahead.
16 A. I mean we can read the report. Evaluated
17 the precipitation data. I looked at the records of
18 NOAA, ODNR, Mercer County. That was what I did. I
19 reported on the analysis I did.
20 Q. Did you conduct a steady flow analysis on
21 the hydrological and hydraulic aspects of this
22 litigation?
23 A. I completed an analysis of stream flow
24 records. I completed analysis of the ODNR model. I
25 completed analysis of the Corps. of Engineers' work.

1 I did not make an independent model of Grand Lake
2 St. Marys or the Beaver Creek or the Wabash River.
3 Q. So you reviewed what others --
4 A. Period. I didn't. I mean the record
5 reflects I did what I did.
6 Q. And just to make it clear then, you
7 looked at what others had done in this case.
8 A. That's exactly what I -- that's exactly
9 what's articulated throughout the Grand Lake
10 St. Marys' evaluation.
11 Q. And is that also what you did in the Case
12 Leasing case?
13 A. Yes. The Case Leasing case record is
14 there and it reflects what did I in the Case Leasing
15 case.
16 Q. When did you do this review and
17 evaluation in the Doner case?
18 A. That's ongoing.
19 Q. All right, well, when did you do your
20 analysis that formed the basis of the opinions you
21 set forth in your affidavit?
22 A. Well, I did that evaluation on or before
23 September 29.
24 Q. Well, do you recall exactly when?
25 A. On or before September 29.

Q. Let me ask you this, what -- is it fair to say the first time you looked at water movement from Grand Lake St. Marys, would be fair to say the first time you looked at it was when you were retained in the Case Leasing case?

A. That's fair to say.

Q. That is true.

A. That's fair to say.

Q. And you did an analysis, you testified in the Case Leasing case, correct?

A. Except I'm going to correct, I actually had looked at some flooding along the Wabash River for other evaluations before the Case Leasing case. But whatever, as you know, for this project Grand Lake St. Marys and the Wabash River to the Linn Grove Station, that really became to my attention as a result of the Case Leasing case.

Q. Do you -- as far as looking at Grand Lake St. Marys before Case Leasing do you recall when you did that?

A. No, I didn't say -- what I said was I looked at the Wabash River. The Wabash River runs through much of the state of Indiana in a circuitous path and I did do some work along the Wabash.

Q. When did you do that?

A. In the '80s. Maybe even in the '90s.

Q. Tell me a little bit about that. What were you doing when you were looking at the Wabash in the '80s and maybe the '90s?

A. Again, clients make inquiries and I do projects in that related. All I'm recalling is that I did some evaluation when I was in the Chicago office because they had clients who were affected in the state of Indiana.

Q. Do you recall --

A. And so there was a number of large flood events along the Wabash River for many years. I mean it's a very famous and well-documented river that has a large history of flooding.

MR. FUSONIE: In the state of Indiana.

A. In the state of Indiana, uh-huh.

Q. What about the state of Ohio?

A. I'm answering what my recollection is.

Q. All right, so when you were looking at the Wabash in the '80s and '90s, you were only looking at that river in Indiana, you weren't looking at it in Ohio?

A. Again, mostly related to inquiries of clients in the state of Indiana, yeah.

Q. Did you deal with any clients or any

1 situations in Ohio?
2 A. Not that I recall. Not that I recall.
3 Q. What was the cause of the -- what's the
4 cause of flooding of the Wabash in Indiana? What
5 causes it to flood?
6 A. Rainfall and runoff.
7 Q. Is that what you were determining while
8 you were doing this work in the '80s and the '90s, is
9 that what you were looking at?
10 A. Yes. And property impairment resulting
11 thereof.
12 Q. Were you involved in any litigation as an
13 expert related to the Wabash before these cases?
14 A. Not that I --
15 Q. Before Case Leasing?
16 A. Not in the Wabash, not that I recall.
17 Q. Did you -- Case Leasing was, if I recall,
18 it was tried in the Court of Claims, what, in 2005?
19 Does that sound right?
20 A. Perhaps.
21 Q. You testified as a witness.
22 A. Sort of sounds right.
23 Q. All right.
24 A. I did testify twice, yes, sir.
25 Q. Did you review any updated data on Grand

1 Lake St. Marys, the spillway, Beaver Creek, or the
2 Wabash River subsequent to that litigation, the Case
3 Leasing litigation?
4 A. Yes.
5 Q. When did you do that?
6 A. I did a review within the last 30 days.
7 Q. What about before then? Let me strike
8 that.
9 When was the last time you reviewed water
10 data, hydraulic, hydrological, on the spillway or the
11 Beaver Creek prior to September of 2009 when you
12 signed your affidavit?
13 MR. FUSONIE: Objection as to form.
14 A. Sir, that's quite a vague question. I
15 certainly testified in 2006 and have been involved in
16 this litigation that's been on an ongoing basis. I
17 don't have any way that I would precisely be able to
18 recall when I did an evaluation. But obviously it's
19 been an ongoing project. Often.
20 Q. Tell me what you have done since Case
21 Leasing, since the Case Leasing case ended and this
22 case was filed, what did you do if anything with
23 regard to Grand Lake St. Marys, the spillway or water
24 movement?
25 A. I've had inquiries from counsel.

Q. Which counsel?

A. Counsel in the Case Leasing case. I'm not sure that I would be able to be at liberty to reveal those.

Q. That's all right. I'm not asking.

A. But those happened periodically, sporadically, and when an inquiry is made, it causes me an opportunity to go and look at the record. So periodically from time to time I go into the, I believe it's called the Linn Grove, go into the USGS database, pull down the stream flow record at Linn Grove.

Q. What else?

A. Then when this litigation came up, it caused it to bring it up again and review it again.

Q. When were you first contacted by anyone about this litigation?

A. I'm going to say it was sometime in 2009 but I don't know that date precisely.

Q. And was that from the Vorys law firm?

A. It was.

Q. What did you review? What did you look at?

MR. FUSONIE: Again, just my limitation on that you're here as a testifying expert on what

1 you reviewed and in order to prepare yourself for
2 being a testifying expert in this case.
3 Q. Consistent with your role as an expert
4 witness and your retention as an expert witness, what
5 did you review? What did you look at?
6 MR. FUSONIE: As a testifying expert.
7 A. I reviewed a lot of material but three
8 things that I specifically recall that I reviewed
9 were the two Case Leasing reports that I prepared,
10 and the stream flow record at Linn Grove. And there
11 were other things but sitting right here I can't
12 recall specifically what all they were and when they
13 were.
14 Q. Since 2006 when -- since Case Leasing did
15 you look at any or did you review any ODNR or State
16 documents in connection with being an expert in this
17 case?
18 MR. FUSONIE: Up to and through today?
19 MR. COLE: I'm not asking for future.
20 MR. FUSONIE: Well, since 2006 up through
21 today is the question.
22 MR. COLE: Well, actually, no, counsel,
23 thank you.
24 Q. Up to the filing of this lawsuit. Which
25 was in I think it was in July -- June/July of last

1 year.
2 A. I don't recall looking at any ODNR
3 records.
4 Q. Do you recall looking at any other
5 records related to Grand Lake St. Marys, Beaver
6 Creek, the spillway, between the end of the Case
7 Leasing case and the filing of the lawsuit in the
8 Doner case?
9 MR. FUSONIE: Objection as to form.
10 A. Yes.
11 Q. What were those?
12 A. Mercer County records.
13 Q. Mercer County what kind of records?
14 A. Any record I could find.
15 Q. Well, can you be a little more specific?
16 A. I really can't. I mean looking for
17 records, you dig for records. I certainly recall
18 going back and finding the 2003 "survey," if you
19 would call it a survey, that Mercer County did. I
20 considered it a reasonable sophisticated or detailed
21 evaluation to log and survey in highwater marks from
22 the 2003 event.
23 Q. Up to the filing of this lawsuit you said
24 you did not look at any ODNR records?
25 A. I don't know when this lawsuit was filed.

1 Q. Well, it was, I believe it was filed in
2 the summer of last year. So between 2005-2006, and I
3 might be getting the appeal --
4 MR. FUSONIE: It's July of 2009.
5 Q. July.
6 A. Okay. So between July 2009 and --
7 Q. And going back.
8 A. Going back to middle of 2006?
9 Q. Fair enough.
10 A. Do I -- the question is do I, in that
11 period, recall whether I looked at ODNR records?
12 Q. Yes.
13 MR. FUSONIE: I want to make sure that
14 the record's clear. I believe the Case Leasing,
15 there was one trial that started in August of '06, it
16 was continued so that further discovery can be
17 conducted, and the continuation of the trial finished
18 up in November or December of 2006. So I don't want
19 there to be confusion because he said go back to
20 middle.
21 MR. COLE: I appreciate the
22 clarification, Counsel.
23 Q. Let me put it this way, Dr. Campbell,
24 when your work -- when you were done testifying in
25 the Case Leasing case, let's say it was sometime in

1 2006.
2 A. Yes.
3 Q. We have about three years before the
4 lawsuit was filed in this case. You were obviously
5 contacted by the relators' law firm about being an
6 expert, correct?
7 A. Yes. In 2009.
8 Q. Once you were contacted or anytime in
9 between those two events, did you ever look at any
10 ODNR records?
11 A. As I believe I just said, I don't recall
12 that I did.
13 Q. Okay. You may have --
14 A. That's what I said, I don't recall that I
15 did.
16 Q. Okay, I thought you said you had not.
17 A. You can have the record and whatever the
18 record is. I don't recall that I did.
19 Q. Do you believe that you would have looked
20 at ODNR records before you signed the affidavit?
21 A. If they were available, I might have.
22 But I don't recall.
23 Q. Do you recall contacting anyone at ODNR
24 to obtain records to look at?
25 A. No, I do not recall.

MR. COLE: Let's take a short break, if that's all right.

MR. FUSONIE: Yeah.

(Recess taken.)

Q. Let's go back on.

A. Now if I could, while I was in the restroom I have two questions that I answered that I really realized that my answers are not accurate depiction.

Q. By all means, go ahead.

A. First of all, it's probably a very large mischaracterization that I'm only doing one or two flood studies a year. I'm probably doing more like four and ten. I just may not, you know, they may not be highly sophisticated but I still am doing a lot of flood evaluations. So that's a mischaracterization on my part.

And the second thing is the inquiry about have I looked at any ODNR records. I have certainly looked at lake level records and those are ODNR records. So I certainly have looked at ODNR -- looked at lake level records which would be ODNR records.

Q. Thank you for clarifying.

A. Thank you for allowing me to.

1 Q. Sure.
2 When did you -- do you recall when you
3 looked at those records?
4 A. I'm pretty sure I've looked at them
5 within the last month. I certainly can't recall
6 where between December 2006 and July of 2009 when I
7 looked at them. That's lost in my memory cells.
8 Q. But did you look at them between Case
9 Leasing and the Doner case being filed?
10 A. Again, for inquiry from counsel in the
11 Case Leasing case periodically, sporadically, yes.
12 Q. Did you look at ODNR records prior to
13 drafting your affidavit and report in this case?
14 A. Yes. And I would even think that it
15 might behoove us to be better that it would be lake
16 level records rather than a generalization of ODNR
17 records.
18 Q. Can you quantify percentage of your time
19 when you're working on a project, are you usually
20 reviewing what someone else has done, what another
21 engineer or somebody has done as far as model or
22 analysis, or are you usually doing the work yourself?
23 MR. FUSONIE: Objection as to form.
24 A. Well, within the last five years, because
25 I have now a reasonable size staff that work under my

1 direction, in the last five years I'm not doing a lot
2 of hands on myself, although I'm doing some hands on,
3 not nearly the amount that I did in the previous part
4 of my career.
5 Q. About what percent would you say you're
6 doing hands on?
7 A. That's a mixed bag. Probably somewhere
8 between 10 and 20 percent are hands on. That's a
9 mischaracterization because I spent last week three
10 days in the field drilling holes in the ground.
11 So, you know, you would try to
12 mischaracterize my thing that I'm an office person
13 directing people out in the field where there I was
14 basically three days in a three-day field effort in
15 the trenches. So I will work specific when specific
16 is needed and I will work general when general is
17 needed.
18 Q. Well, that's fine. I'm not trying -- I
19 don't want you to -- I'm not trying to trick you in
20 anything. If I ask you a question and you think I'm
21 trying to lead you to a conclusion, let me know.
22 It's not my goal. I don't know. I don't work with
23 you.
24 A. Right.
25 Q. So when I ask you what percent of time,

1 you know, I've got to take your best estimation of
2 that.
3 A. And what I'm trying to say is that that's
4 a mischaracterization because a percent of the time
5 doesn't really matter. I work on a project
6 specific-by-project specific basis. So I'm -- while
7 I do have corporate functions, I am a
8 project-by-project person.
9 Q. But as you said before, in the last five
10 years is it fair to say more often than not you are
11 reviewing work of others?
12 A. Yes.
13 Q. Have you, let's say in the last five
14 years or -- well, strike that.
15 Have you ever personally built an
16 unsteady flow model using HEC, HEC RAS or any of the
17 others?
18 MR. FUSONIE: Objection; vague.
19 A. Yes.
20 Q. When was that?
21 A. '70s or '80s. Might be some in the '90s
22 too. Surely, I have.
23 Q. Any time in the last five years?
24 A. Not that I recall.
25 Q. Don't you think you'd remember something

like that?

MR. FUSONIE: Argumentative.

A. Not really.

Q. Do you recall when you did build, personally build those flow models, the unsteady flow models what you were doing there?

A. Surely. Doing analyses where after doing a steady analysis I determined that it might be appropriate to do an unsteady analysis.

Q. Did you build an unsteady flow analysis model in Case Leasing?

MR. FUSONIE: Objection; vague.

A. As I already identified, I didn't build any of my own models in Case Leasing case. I used work done by others.

MR. FUSONIE: What do you mean by "others"?

A. Well, I used the Ohio DNR model was the dominant thing I used in the Case Leasing case. Merely used that identical model without modification so that I couldn't be accused of adjusting the parameters so I'd get a preferred outcome.

Q. Did you establish the frequency -- let me ask you this, just so there's no confusion with anyone here, can you tell me what is a steady flow

model? What is that?

A. Surely. A steady flow in terms of a hydraulic engineer means steady as a function of time.

Q. All right.

A. So for -- in order to do a steady flow model, you select or you're giving a discharge X some value, for example, in hundreds of cubic feet per second which is a volumetric flow basis, and then you model what happens to that flow as that moves along a stream.

Q. That's a --

A. That's a steady flow model.

Q. According to what, a hydrological engineer?

A. That's what I would define it.

Q. In your professional designation.

A. Right.

Q. What about can you give me a professional engineer's -- your definition, professional definition of what an unsteady flow model is?

MR. FUSONIE: Objection; imprecise, vague.

A. Well, it is vague in the sense that I would rather answer the question in an analysis or

evaluation rather than a model. I mean because a model is any representation of the real world or whatever.

So an unsteady flow, what you're allowing is that as one moves to a different location along the stream or river, the discharge quantity changes as a function of time.

Q. All right.

A. So at the -- to be very specific, at the spillway at Grand Lake St. Marys a steady flow model would assume X cubic feet per second, comes across the spillway for many hours, maybe ten hours, maybe a hundred hours.

In an unsteady flow model it might start at ten cubic feet per second, build up to a thousand cubic feet per second, and then decrease to a hundred cubic feet per second as a function of two hours, ten hours, 24 hours, a hundred hours.

So unsteady is time, and hydraulic engineering we usually also imply that unsteady also means with space. In other words, with distance along the river. So we usually imply time and space.

Q. That's the distinction between steady and unsteady?

A. Steady and unsteady, yes, sir.

Q. One other thing, you had testified previously you used the term "control structure"? Can you tell me what you meant by that?

A. Surely. A "control structure," again, in hydraulic engineering terms a control structure is a point in which the evaluator knows the parameters of the stream. The spillway is the most obvious control structure because we know that for a given point in time so many cubic feet per second are flowing over the spillway.

And we then, based upon knowing the thickness of the overflow, we can calculate the velocity. So we -- that's a control structure. A control structure to a hydraulic engineer the use of the term in part explains the term, it's a control structure, it's a structure where there is control. So you know --

Q. "Control" being?

A. "Control" meaning that when I know the stage in Grand Lake St. Marys, I can calculate and know, and I can control by controlling the stage, I know what the flow is over the structure. Therefore, I know what the flow is in the stream.

Q. You have not personally -- and I apologize if you've answered this. But you have not

1 personally done any modeling water hydrologic or
2 hydraulic modeling since the Case Leasing case; is
3 that correct?
4 MR. FUSONIE: Objection; form.
5 A. I think that's accurate, I have not.
6 Q. Did you establish the frequency,
7 duration, and/or the depth and aerial extent of
8 flooding along Beaver Creek?
9 A. To the degree that I reported it in my
10 affidavit.
11 Q. All right.
12 A. As reported in the record at the ODNR
13 record at the lake and at the Linn gauge stage.
14 Stream gauge.
15 Q. You did that by reviewing then?
16 A. The Linn gauge record. And the ODNR
17 record at the Grand Lake St. Marys.
18 Q. Which studies did you use? Did you use
19 any studies?
20 A. Not sure "studies" is appropriate. Just
21 record.
22 Q. Do you know what models were used for
23 those?
24 A. Again, I'm not -- I'm talking about
25 record data. Data.

1 Q. So you didn't look at any HEC models in
2 forming -- did you look at any HEC models in forming
3 your opinions that are set forth in your affidavit?
4 A. I believe the answer is no, I did not.
5 Q. I'm going to mark this is Exhibit 2.
6 (EXHIBIT MARKED FOR IDENTIFICATION.)
7 Q. Go ahead and take a look at that. And,
8 Dr. Campbell, while you're doing that I will tell you
9 at the very end you had an addendum attached to this.
10 But go ahead and take a look. Obviously there's a
11 lot of pages so you don't have to look at everything
12 but kind of procedurally look at that.
13 MR. FUSONIE: I think we're going to have
14 the same problem with legal size documents being cut
15 off. It looks -- maybe not.
16 MR. COLE: Might have been the same one.
17 MR. FUSONIE: Well, no, I think -- I'm
18 sorry. I apologize.
19 MR. COLE: Let me know if you see any,
20 Tom.
21 A. When you refer to "addendum," did you
22 mean the addendum report? Because there was an
23 addendum report.
24 Q. I have one I think it's the last, about
25 the last 20 pages approximately.

A. Okay. My recall is that the November '06 was substantially longer than this.

MR. FUSONIE: It's substantially longer than this. Has all sorts of figures and tables attached to it.

A. I believe I'm looking at maybe six or eight pages. I believe it was substantially longer.

Q. Let's take a minute off the record.

(Off the record.)

Q. Let's keep going.

You said that your addendum was November of 2006, correct?

A. Yes.

Q. All right.

A. And the submittal that you gave me has the cover page of that addendum, the table of contents, and seven pages of text. But it did not have --

Q. The data.

A. -- the attached tables and figures and there's probably many other pages, so it's just this is an inaccurate record of what it is.

Q. Do you recall the flood level, the elevation of water on the Case property, the sports complex, as a result of the July 2003 storm?

A. No, I don't, but I'm sure I can look it up.

Q. How would you characterize the July 2003 storm?

A. Severe event.

Q. Anything else? What about would that be -- do you have a duration or occurrence level on that kind of storm, do you recall?

A. Sitting here today I would not want to characterize it as some recurrence interval level storm.

Q. Why not?

A. Because it's not fresh in my mind.

Q. Figure 3 on the exhibit I gave you, I need to find it too so give me a minute.

Did you find that?

A. I found figure 3, yes, sir.

Q. Now, that shows no flooding on the Case property from 1927 to 1978; is that correct?

MR. FUSONIE: I'm going to object.

A. I don't think it says that, no. Figure 3 doesn't say that. My interpretation of figure 3 is not that it says that.

Q. On page 9.

A. Yes.

Q. And if you could go down to the fourth paragraph.

A. Yes, sir.

Q. Starts with "The historical storms of record."

You're discussing hundred year storms of various durations. Do you see that?

A. I do.

Q. How did you determine that the 96-hour storm results in the most severe flooding?

A. I evaluated these alternatives, 24, 48, 72, 96, and 120, and it had the most flooding of those events.

Q. When you say you "evaluated," what did you do?

A. Looked at the rainfall and the runoff.

Q. Why would a 96-hour storm be a more severe than a 120-hour storm?

A. Because of the characteristics of the watershed.

Q. Tell me about that.

A. Well, characteristics of the watershed such that that would cause the maximum storm. Maximum outflow.

Q. Can you elaborate on that at all?

1 A. Well, the discipline of hydrology has to
2 do with the evaluation of when precipitation falls
3 from the sky to the land surface and when that water
4 manifests itself at a point of outfall. So the
5 reason it took a 96-hour duration for it to be the
6 maximum outfall was a characteristic of the
7 watershed.
8 In other words, the water was retained in
9 the watershed. Again we're looking at in terms of
10 all of your questioning so far about steady and
11 unsteady and what one does when one studies a
12 different duration storm event times zero, it's not
13 raining, and then it starts to rain and it rains for
14 some duration.
15 And we actually, there are algorithms
16 which are really models or preconceived evaluations
17 as to how the precipitation then is distributed
18 across that duration of a storm event. And then one
19 thing calculates or maps or charts the flow of the
20 rain from in the watershed to a common point of
21 outfall.
22 So you get what we call an inflow
23 hydrograph and an outflow hydrograph. And what the
24 outflow hydrograph is showing is that the 96-hour
25 storm causes the most significant, the largest

1 outflow for a hundred year rain.
2 So in other words, if you -- when one
3 looks up a storm event, one looks up on charts, there
4 are charts, NOAA charts that says for a hundred year
5 recurrence interval for a 24-hour duration event, the
6 precipitation is X, for a 48-hour duration, the
7 precipitation is Y. And so much and so much and so
8 much.
9 And so what that's -- what did I here is
10 I used 24, 48, 72, 96, 120 hour event and found out
11 what the discharge was. And the discharge is the
12 larger for the 96-hour event.
13 Q. How did you find that out? What did you
14 run to determine that?
15 A. I don't recall sitting here what I used.
16 Q. Do you recall whether it was something
17 that you or your office created or did you review
18 something that someone else had done?
19 A. I don't recall.
20 Q. What is a hydrograph?
21 A. It's what I just described. Hydrograph
22 is discharge as a function of time. And again
23 hydrograph is usually, hydrologists, we talk about
24 hydrograph usually as a function of a start of, in
25 this particular case, where we're talking about

1 hypothetical event.
2 If the hypothetical event occurs at time
3 T equals zero, then what is the discharge for 24
4 hours, 48 hours, 72 hours, 96 hours, 120 hours after
5 the beginning of the rain?
6 Q. Do you know how the hydrograph for -- in
7 the Case Leasing was developed?
8 A. Yes.
9 Q. How was that?
10 A. The hydrograph in the Case Leasing in the
11 analysis was -- I used the ODNR model to evaluate the
12 hydrograph.
13 Q. All right. Did you run an unsteady flow
14 analysis to route the storm hydrographs with these
15 various durations through the lake in Beaver Creek?
16 MR. FUSONIE: Objection; vague.
17 A. No, I used the ODNR model which did not
18 have any unsteady feature in it.
19 Q. Why did you use the ODNR model?
20 A. Because I was trying to duplicate what
21 ODNR did.
22 Q. Do you -- did you feel it gave you an
23 accurate indication?
24 A. Counsel determined, and I didn't
25 disagree, that we needed to use the ODNR model.

Q. Counsel for Case Leasing?

A. The Case Leasing case. We're in the Case Leasing report.

Q. So --

A. So there was a decision was made that in order to be able to evaluate whether ODNR designed or did not adequately design their spillway, we used the ODNR model. I used ODNR model in that evaluation in the Case Leasing case.

Q. That was the only one you used?

A. Yes.

Q. And that was because counsel instructed you to do that.

A. That was the strategy that we used in the litigation.

Q. If you would go to page 7 please. You have some discussion there on HEC modeling. Did you model the flow in Beaver Creek downstream from Grand Lake St. Marys?

MR. FUSONIE: Objection.

A. No, I used the ODNR model and it did not have that.

Q. Did the model you used, did the ODNR model that you used model the flow in the Wabash River, the water flow in the Wabash River?

A. My recollection is that it did not.

Q. In rendering your report did you take into account the backwater affects of the Wabash River?

A. As I articulated in my affidavit, to the degree that it was reflected in the record, yes.

Q. So you looked at what was in the ODNR record as far as backwater; is that what you're saying?

A. What was in the ODNR model. I used the ODNR model. This Case Leasing report uses the ODNR model.

Q. All right. Did you review, did you read the 1981 Army Corps. of Engineers report for Grand Lake St. Marys?

A. I did.

Q. I have a portion of it. Let's go ahead and mark this as 3.

(EXHIBIT MARKED FOR IDENTIFICATION.)

Q. I will represent to you this is Volume 1 which is the main report. It is not all the technical data.

A. Thank you. I have it.

MR. FUSONIE: Just so the record's clear, I'm still flipping through the pages, but this

1 document is a front-and-back exhibit.
2 MR. COLE: Yes, it is a two-sided
3 document, thank you.
4 A. Until you get to the exhibits. It's
5 front and back until you get to the exhibits. And
6 the exhibits are on the front side.
7 Q. If you would look at page 15 --
8 MR. FUSONIE: Before answering any
9 questions give me a chance to finish flipping
10 through.
11 MR. COLE: Sure, that's fine.
12 A. Your reference was to page 15 of
13 Respondent 3?
14 Q. Yes, sir. If you would go ahead and look
15 at the last paragraph on that page. That indicates
16 in that report that local residents and farmers
17 reported significant flood events at various times;
18 January of 1949, '57, '58. It's in there. The '64,
19 '65, and '72. Do you see that?
20 A. I do.
21 Q. Do you have any reason to doubt the
22 accuracy of this information?
23 A. No.
24 Q. Do you recall what you concluded or what
25 you learned about the backwater affects on flooding

on the Wabash River from Case Leasing?

A. Yes.

Q. What was that?

A. Didn't evaluate it very much. Case Leasing property is very close to the spillway, so didn't do a lot of evaluation of the backwater affect.

Q. Did you consider the backwater affects on the Wabash River in your analysis of the properties in the Doner case?

A. Yes.

Q. What did you conclude? What did you find?

A. Well, you find that the backwater does have affects certainly at the further downstream portions of the reach.

Q. I apologize if I asked this before. When were you first contacted about working on this case, the Doner case?

MR. FUSONIE: Objection; asked and answered.

A. I believe it was in 2009.

Q. Do you recall what month?

A. No, I don't.

Q. What were your -- what was the scope of

1 your work on this case?
2 A. The scope was to look at the affects of
3 the spillway and/or the change in the spillway in the
4 Beaver Creek, in the area downstream from the Case
5 Leasing property downstream to the state line,
6 approximately.
7 Q. Were you given any instructions by
8 counsel in proceeding?
9 A. Not that I recall, no.
10 Q. How did you proceed? What have you done
11 in this case?
12 A. Again, I looked at -- what I recall here
13 today what I did was I relooked at the Mercer County
14 record from the 2003 event, because the Mercer County
15 record from the 2003 event had measurements of the
16 measured stage at several points within Mercer County
17 but downstream from the Case Leasing property. So
18 that was important.
19 I certainly looked at the stage records
20 in Grand Lake St. Marys, and as I already indicated,
21 I looked at the USGS record at the Linn Grove Station
22 which is five or six miles in the state of Indiana.
23 But very close to the state line.
24 The point in this particular case I
25 specifically paid attention to the disparity between

1 the City of Celina flood study and flood map and the
2 Mercer County flood study and flood map. Because
3 they do not match at their point where they have a
4 common point of intersection, which is almost on the
5 Case Leasing property, by the way.
6 I believe I did pull down and look also
7 at the precipitation records between, again, between
8 the -- whatever the -- let's just say for
9 generalities let's say 2003 and 2010, looked at the
10 precipitation records, the near precipitation
11 records, and the Linn Grove record. Whatever.
12 I mean I think that's basically -- I'm
13 trying to refresh my recollection of what was done.
14 I do recall that I read, perhaps not in great detail,
15 these two reports that you just provided. I would
16 call the Case Leasing reports the May report and the
17 November report.
18 Q. Did you talk with any other experts? And
19 I should say any other engineering experts.
20 A. Outside of CRA people?
21 Q. Yes.
22 A. Not that I recall.
23 Q. How about inside CRA?
24 A. Sure.
25 Q. Who did you talk with?

1 A. Well, Charles Munce and I were the
2 dominant preparers of the Celina May and November
3 reports. That work was supported by Jim Moir.
4 That's spelled M-o-i-r. And Juraj Cunderlik.
5 C-u-n-d-e-r-l-i-c-k, or n-k. I don't remember right
6 off the bat, I'm embarrassed by that but I think it's
7 i-n-k.
8 Q. What was his first name?
9 A. Juraj.
10 And several other engineers that do
11 perform hydraulic calculations within Jim's staff
12 because he is in Waterloo office of CRA. And my
13 staff in the Baton Rouge office.
14 So we have a handful of other staff that
15 we routinely use on these -- on flooding and flow
16 indications and evaluations probably, there would
17 probably be six or eight other people in our staffs
18 that we use.
19 Q. Where is Mr. Munce located?
20 A. He's in the Baton Rouge office.
21 Q. And Mr. Moir, you say is in Waterloo
22 office?
23 A. Mr. Moir is in Waterloo, Mr. Cunderlik is
24 in Waterloo.
25 Q. Did you ever meet or discuss this case

with Richard Vannatta?

A. No, sir.

Q. Jay Gould?

A. That name is vaguely familiar but not to my recollection.

Q. Keith Early?

A. Keith Early? I would -- I never discussed the Doner case but I certainly, well, and I'm not sure I ever discussed any case with Mr. Early. But I certainly did discuss the work that Mr. Early did when he was the engineer with Mercer County with him on phone interviews. I was never able to go and visit him.

(Interruption.)

(Off the record.)

Q. Back on.

Have you talked with any of the relators in this case? Any of the property owners who were involved in this litigation?

A. No, sir.

Q. Have you visited any of the their parcels personally?

A. No, sir.

Q. Have, as far as you know has anyone at your company CRA done so?

A. Not to my knowledge.

Q. Any witnesses, non-experts in this matter who told you about flooding in the area?

A. Not to my recollection.

Q. Have you ever personally visited the spillway, the Grand Lake St. Marys?

A. I have.

Q. When was the last time you were there?

A. I wouldn't recall. I'm going to estimate 2006. Maybe 2007 early.

Q. That was -- what were you -- why were you visiting at that time?

A. My visit was related to the Case Leasing case.

Q. How many times did you visit the Grand Lake St. Marys, personally visit them during that case?

A. Sitting here today I recall three visits.

Q. All in connection with that litigation?

A. Yes, all related to that. That project.

Q. Had you ever visited the lake before getting involved in Case Leasing?

A. No, sir.

Q. Had anyone else from your company CRA visited Grand Lake St. Marys at your direction?

A. No, sir.

Q. Or anyone with your company visit Grand Lake St. Marys in connection with Case Leasing or the Doner litigation that you know of?

A. That's a compound question. I'm not sure I can answer that accurately.

Q. Let me break it down. Fair enough.

Do you know of anyone in CRA, anyone else at CRA ever visiting Grand Lake St. Marys?

A. Yes.

Q. Who was that and when?

A. We had a survey crew survey in the highwater marks that I designated. I don't recall the precise date of when they did.

Q. Approximately?

A. It was during the Case Leasing case. So my best guess sitting here today that would have been in 2006. And I believe that Mr. Moir has visited it on one or more occasions. I believe he visited on one occasion related to the Case Leasing case and on one occasion related to the Doner case.

Q. Do you know when he last, approximately when he last visited?

A. My best guess is within the last 60 days.

Q. Do you know if he visited before then?

1 MR. FUSONIE: He's already testified he
2 visited at Case Leasing.
3 Q. Good point.
4 Do you know if he visited it before --
5 after the suit was filed? Between that and the last
6 60 days?
7 A. My guess is that it was not. He was also
8 accompanied in his recent visit by Mr. Cunderlik.
9 And there the last three letters are l-i-k.
10 Q. So from what I'm getting then, correct me
11 if I'm wrong, it sounds like as far as the Doner case
12 litigation goes, Mr. Moir and Mr. Cunderlik visited
13 Grand Lake St. Marys, the spillway one time
14 approximately in the last 60 days.
15 MR. FUSONIE: Objection.
16 Q. Is that fair?
17 MR. FUSONIE: You're mischaracterizing
18 what he said.
19 Q. To your knowledge.
20 A. To my knowledge. To my knowledge they
21 did, yes. And the surrounding area. And they spent
22 a day there.
23 Q. Do you know if they visited before or
24 after March 1st?
25 A. My recall is that it was after March 1.

Q. Why did they visit?

A. They visited with regards to this litigation.

Q. In rendering your -- in giving the information and rendering your affidavit did you review any pictures of any of the Doner properties? When I say "Doner," I mean properties in the Doner case.

A. I recall that I did.

Q. Do you know where those pictures came from?

A. They were provided to me by counsel.

Q. Were they -- do you recall, were they taken by the owners themselves or people from that area?

A. We would have to learn that from counsel. They were provided by counsel.

Q. Were the pictures labeled?

A. I don't recall.

Q. Do you recall whether Mr. Moir and Mr. Cunderlik took any pictures on their recent visit to Mercer County?

MR. FUSONIE: To the extent you know.

A. To the extent I know, they did.

Q. All these --

A. To the extent I know, they did. They showed me photographs, yes.

Q. One thing I noticed in your report, you talk about the spillway before 1997 and afterward. And I believe you refer in your affidavit to -- I say report, it's affidavit and attachments but I think you understand what I mean by that.

You refer to the pre-'97 spillway as a 39.4-inch spillway.

A. 39.4-foot, yes.

Q. Foot, excuse me.

A. Yes.

Q. And then the current spillway, the post -- the new spillway you refer to a 500-foot spillway, correct?

A. Yes. As a general characterization of a pre and a post, yes, sir.

Q. Yeah, why do you -- I mean you're not -- when you're looking at 39.4 and 500, you're not comparing apples and apples; is that correct?

A. You're comparing two spillways.

Q. All right. But is the -- was the opening at 39 -- what -- let me ask you this and just keep it very simple. 39.4-inch spillway, what are you referring to? What does that number refer to?

A. That's the pre-'97 spillway.

Q. And what was 39.4 feet?

A. Its overflow area was 39.4 feet long in length. That's how we talk about spillways, sir. We talking about the overflow length. So that's the -- to the hydraulic engineers, whatever, the hydrologist, that has great meaning, the length of the overflow area.

Q. And what about the 500? What is that?

A. That refers to the 500-foot is the overflow area.

Q. So those -- so the ODNR increased that more than ten times.

A. They did.

Q. Does the larger spillway have any safety benefits to the dam that you know of?

A. Larger spillway was constructed in order to assure safety of the dam. If you don't recall that --

Q. I'm just asking you.

A. The Corps. of Engineers wrote the report that said that the 39.4-foot spillway was inadequate to withstand the designed storm event as they determined the designed storm event to be. And so that was the cause that the ODNR then completed the

redesign.

Q. Do you --

A. Or the design of the 500-foot spillway.

Q. Do you question that finding?

A. No, I don't question that finding.

Q. Throughout your affidavit I believe you refer to a flooding event. What is a flooding event in your words?

A. The Press Campbell determination of a flood event is when a stream exceeds the channel banks. Now, a flooding event might be a flooding event at the Case Leasing property because it would exceed the channel banks at the Case Leasing property or it may not.

It might still be a flooding event to a, you know, the adjacent property owner downstream where the channel bank was in a lower elevation. So it could be a flooding event for their property. But to me a flooding event is when it exceeds the channel banks.

Q. Is there a standardized definition of "flooding event" in engineering?

A. Yes, there is. We call it the bank full stage. So in other words, when the river or a stream gets so that its bank is filled, then that is its

capacity. It has a certain discharge that it's carrying a volumetric flow cubic feet per second is the rate that its carrying and when it's at bank full stage, then it's at capacity.

When the flow is greater than that, then it flows over the banks. So that's my definition of a flow. Flood.

Q. So is that the sole criterion then is overflow? I'm trying to understand.

A. It's my number one standard.

Q. Are there other factors you consider?

A. Well, surely. Because if I have a piece of property and the flood could come up to that property but it still could impair my property even behind a dike, then I could call that a flood event. Even though I would be impaired behind it.

I mean, we certainly saw that very dramatically at Katrina where there were levies constructed at a certain elevation and so the levy retained the water but there was a boil where the water then, if you want, channelized through the levy and was causing property damage.

Then that property owner could have easily called that a flood event. Even though I may not call it a flood event because it was still within

1 the channel banks.
2 Q. All right.
3 A. So I can understand how a property owner
4 could call flooding even though the river was still
5 in the bank full stage.
6 Q. You indicated the Press Campbell
7 definition of flooding event.
8 A. Yes, that's what I believe when I made my
9 affidavit that's what I had in mind.
10 Q. When you refer and use the term "flooding
11 event," are there any other considerations other than
12 embankment that you've indicated that you consider?
13 A. Not that I recall.
14 Q. If you could go back to Exhibit 1, which
15 is your affidavit and attachments. Please go to your
16 affidavit paragraph 7. It's on page 2.
17 A. Thank you.
18 Q. Off the record.
19 (Off the record.)
20 Q. Let's go back on.
21 Dr. Campbell, do you know if the Linn
22 Grove gauge that you've referred to is still active?
23 A. Yes. Was active as of last week.
24 Q. You looked at the data?
25 A. I looked at the record I believe midweek

1 last week. So about one week ago.
2 Q. I'm going to ask you some follow-up
3 questions. We were talking about backwater. If the
4 ODNR models that you looked at did not include it,
5 how did you evaluate the impact of backwater on the
6 Wabash?
7 A. Mostly by understanding the hydraulics of
8 Beaver Creek and by understanding the analysis by the
9 Corps. of Engineers, and Burgess & Niple also did a
10 hydraulic study.
11 There were other studies, certainly
12 Mercer County did some hydraulic studies. There's
13 the flood studies that were done. You know, the
14 Mercer County flood study, so that certainly does
15 that.
16 And the Linn Grove gauge being downstream
17 a priori, that is by its location where it is, is
18 including what we would say backwater affect, that is
19 it's reflecting its condition. Which would include
20 backwater.
21 Q. Let me ask you broadly. What have you
22 found the impact of backwater in the Wabash has on
23 flooding in the properties in its vicinity?
24 A. I don't think that that -- I don't think
25 that question -- that's certainly not simple.

Q. All right.

A. Before we answer that we really have to define what do we mean by "backwater". Okay? Because I mean --

Q. What do we mean by "backwater"? Thank you, I appreciate that.

A. Really what happens is the dominant flow along Beaver Creek is the closer you are to the spillway, it's more dominantly affected by the spillway. And the further you get away from the spillway, the less it's affected by the spillway and the more it's affected by backwater.

So the effect of backwater as we're talking about it has to be somewhat precise as to where along that reach are we talking about the affects of backwater. But certainly the further you are from the spillway, the more important is the backwater effect. And the closer you are to the spillway, the less importance of the backwater affects.

So backwater has more affect closer to the state line than it does closer to the spillway. So it's -- it can only be evaluated in the context of the spillway and in the context of the record at Linn Grove, all other things being considered.

1 So I mean, you know, I mean, it does have
2 an effect. There's no question it has an effect.
3 Q. And just my next question would be so
4 then parcels, properties, that are further downstream
5 closer to the Indiana line along the Wabash, the
6 impact of backwater would be greater than on
7 properties closer to the spillway.
8 A. Correct.
9 Q. Did you look at --
10 MR. FUSONIE: Assuming that their
11 elevation is the same.
12 A. Well, there's a whole bunch of other
13 assumptions. The fact of the matter is that for any
14 individual storm event, you know, that has a role in
15 it too. So again, to characterize what backwater
16 effect is, it's really a misnomer and a
17 mischaracterization.
18 Backwater, hydraulic engineers, we know
19 backwater is an important parameter, we have to
20 evaluate it, we have to include it, and we evaluate
21 it. That's the, you know.
22 Did the backwater cause flooding in this
23 particular -- on any of these individual properties?
24 I'm not sure that any of us can make with a hundred
25 percent certainty a determination whether backwater

1 caused the flooding or not.
2 Q. So it's possible.
3 A. It's possible. I'm very certain that
4 spillway caused a lot of flooding. So again, it's
5 more in a gray area.
6 Q. Did you consider what impacts backwater
7 had on properties before the new spillway was built?
8 A. Can you clarify that a little bit?
9 Q. Yeah. I did eminent domain for five
10 years, I don't mean to sound like an appraiser. So
11 we're talking pre-1997. Did you study the impact
12 that backwater had on flooding of properties along
13 the Wabash along Beaver Creek?
14 Again, this is all before the new
15 spill -- the spillway was changed in '97.
16 MR. FUSONIE: Objection as to form.
17 Q. Do you understand my question?
18 A. I believe I understand the question. Did
19 I study it? I mean certainly there are records, for
20 example, the Corps. of Engineers records, the Burgess
21 & Niple had records. There are records of the
22 condition of the downstream Beaver Creek and then
23 into the Wabash.
24 Did I study that? I guess I did my best
25 to try to incorporate that but I don't know whether I

1 would say I "studied" that. I don't think that I
2 would characterize my work as "studied."
3 Q. Have you ever tried to quantify the
4 backwater affects on any of the Doner properties?
5 A. The closest I could answer that to the
6 affirmative is I certainly have considered what I
7 might do to study the backwater affects.
8 Q. And what's that?
9 A. Well, it would take a pretty good
10 sophisticated study to do that.
11 Q. All right. Which you haven't done in
12 this case.
13 A. Haven't really done that, no, sir.
14 Q. What is local inflow?
15 A. In terms of this case and in terms of
16 hydrology?
17 Q. Yes.
18 A. Local inflow would mean that that is
19 between the spillway and some point downstream
20 there's a local tributary which if it's raining on
21 top of that tributary will bring water flowing down
22 the tributary, and we would call that local inflow.
23 Q. Did you consider local inflow in this
24 case? In evaluating the parcels here?
25 A. Generically we do, yes. But in terms of

1 did we make a precision or make any modeling effort
2 to model any local tributaries? Certainly in the
3 Case Leasing case did not because the Case Leasing
4 case is very close --
5 Q. Right.
6 A. -- to the spillway, so not there. Nor
7 did the ODNR. So the answer is with a very limited
8 degree.
9 Q. What about in Doner?
10 A. In Doner to a very limited degree also.
11 Q. Even though we're obviously talking about
12 a lot more properties here.
13 A. Right. Except when you look at the Linn
14 Grove record, you are looking at all of backwater.
15 So you have all of that included in your evaluation
16 when you look at the Linn Grove record.
17 Q. Does the Linn Grove record, would it give
18 you a complete data on local inflow?
19 A. Well, it would give you the total. So
20 you have what's coming out the spillway plus local
21 inflow plus backwater from the Wabash, that's what
22 Linn Grove would reflect. So you have -- there are
23 elements that would add up to reflect it.
24 Q. But if you take any parcel halfway in
25 between, just, for instance, between Case Leasing

which is practically right up against the lake and the Indiana line, there might be a creek or a tributary along the way, you wouldn't be able to get a -- you wouldn't be able to determine the complete impact of that inflow by looking either at Case Leasing property or by looking at the Linn Grove gauge, could you?

A. No, you wouldn't. Again, that all relates to how sophisticated of an evaluation are you going to complete. How thoroughly you're going to look at it. What are the available topographic records.

And quite honestly, you don't have available precipitation records. So to me it's not really possible to do it accurately and thoroughly because you don't have the data.

Q. I suppose one way you could do it would be to literally go and look at every parcel physically and do it. I mean, it might be very demanding.

A. Yeah, but you could never get a rain record there that anybody would necessarily agree is an accurate precipitation record. So again, the topography means a lot but I need a rain record and I don't have a rain record.

Q. All right. Now, is the new spillway, the one that's currently there built in 1997, is it a compound structure?

A. Can you define "compound"? I mean it has a notch in it. Is that what you're trying to ask?

Q. Right.

A. It certainly does have a notch in it.

Q. Can you characterize the elevations and links of the wears and notches there?

A. Surely. It's clearly documented in all the reports. Sitting here today I don't have that recall, but it has a notch.

MR. COLE: Let's go ahead and break.

(Lunch recess taken.)

- - -

1 Wednesday Afternoon Session,
2 April 28, 2010.
3 - - -
4 (EXHIBIT MARKED FOR IDENTIFICATION.)
5 - - -
6 PRESSLEY L. CAMPBELL
7 CROSS-EXAMINATION CONTINUED
8 By Mr. Cole:
9 Q. Let's go back on.
10 Dr. Campbell, I've handed you what I have
11 marked as Exhibit 4, Respondent's Exhibit 4. Have
12 you ever seen this before?
13 A. Not sure that I have.
14 Q. Do you recall seeing any maps where the
15 relators or the landowners in this litigation's
16 properties are designated and highlighted?
17 A. Not sure. I believe that counsel gave me
18 their parcels and I had a draftsman do something
19 similar to this. But I don't know that this is that
20 map.
21 Q. Have you ever looked at a map showing the
22 parcels in relation to each other, relation to the
23 Indiana line and the Great Lake St. Marys?
24 A. I've looked at a map similar to this that
25 counsel gave me. I don't recall the number of

1 parcels, and I had the Drafting Department prepare.
2 Q. When did you first see that?
3 A. 2009.
4 Q. Do you know if it was before or after
5 you -- do you know if you saw a map before or after
6 you did your affidavit?
7 A. I don't recall the detail on that.
8 Q. Do you know if you saw the map before or
9 after the lawsuit was filed, or do you not recall
10 that either?
11 A. No, again, I prepared a map for
12 Mr. Fusonie, for counsel. He provided the parcels
13 and I provided a draftsman to plot them.
14 Q. And if you'll look there right below
15 "Celina" on the far right side, and it's kind of in
16 orange there, that is the Case Leasing parcels. Does
17 that appear to be accurate to you?
18 A. That appears to be accurate.
19 Q. In fact, if I'm not mistaken, and I will
20 let you know that the Doner case parcels are all in
21 yellow. Do you see that?
22 MR. FUSONIE: Just so the record's
23 clear --
24 MR. COLE: As prepared by us.
25 MR. FUSONIE: -- there are 88 parcels

1 identified on this map identified as "Doner, et al.
2 parcels" that -- there are more than that at issue
3 than 88.
4 MR. COLE: Right.
5 MR. FUSONIE: And there are more owners
6 at issue than identified in the 88.
7 Q. (By Mr. Cole) Do you see that?
8 A. I see that but I really don't have any --
9 I testified as to my knowledge of this map.
10 Q. Did you refer to a map when you drafted
11 your affidavit?
12 A. Yes, but it wouldn't be this map. It
13 would have been one of the other illustrations.
14 Something similar. The format I used was something
15 similar to that format that you see in the Case
16 Leasing reports.
17 Q. Are you -- are there any -- do you know
18 if there are any Doner landowner parcels that are
19 closer to the spillway than Case Leasing?
20 A. As I told you, I don't know.
21 Q. Okay. You say you referred to the map.
22 How did you use the map in your report? How did it
23 assist you?
24 A. It assists me by understanding the
25 spillway and the location and the proximity to the

1 tributaries and to the state line.
2 Q. I'm going to take you -- I'm going to
3 talk a little bit about the July 2003 storm.
4 A. Very good.
5 Q. I think you -- I asked you previously
6 about a recurrence interval. Based on your
7 experience as an engineer and as someone who was
8 familiar with hydraulics and hydrology and who has
9 studied rainfall data, do you believe the July 2003
10 flood is typical of what the Mercer County residents
11 can expect?
12 MR. FUSONIE: Objection.
13 A. I don't think that I would characterize
14 it that way.
15 Q. How rare was that? Was that an extreme
16 event?
17 A. I forget the term I used this morning but
18 it's certainly a significant event.
19 Q. Has --
20 A. May I look at a figure from the --
21 Q. Yes.
22 A. I want to look at the figure in
23 Respondent's No. 2.
24 Q. Yes.
25 A. The format of figure 7A and those other

1 figures, 6A, that's the format where I'm used to
2 looking at the Beaver Creek and rather than this map
3 format.
4 Q. That's fine.
5 A. I was just trying to let you -- you're
6 asking questions about this map. I'm more accustomed
7 to looking at a map in this format than in this
8 format.
9 Q. My question about the 2003 flooding
10 wasn't related to the map, but I'm sorry if I didn't
11 make that clear.
12 Let me ask you this, based on your
13 knowledge, since 1997 has there been a storm that
14 severe in Mercer County?
15 A. I haven't studied the storm-by-storm
16 events that are fresh in my mind since 1997. What I
17 did, as I indicated earlier, what I did do was go to
18 the Linn Grove record and pulled the Linn Grove
19 record for whatever, 64 years of record, and
20 calculated that the mean flow and the monthly average
21 flow is higher since '97.
22 I broke the record of from the beginning
23 of the Linn Grove record up to 1997, made that a data
24 set, then I took from 1997 to 2010 and made that a
25 data set and calculated the mean monthly flow for the

record and the two of the -- ten of the 12 months are higher, two of the 12 months are lower.

Q. What did the --

A. But the overall average is higher.

Q. What did the Linn Grove gauge data tell you about the 2003 flood?

A. I would have to look at it. I don't recall it just sitting here to talk about it without looking at it.

Q. Do you recall any of the data that you got from Linn Grove showing a flood of the severity that July 2003 had?

A. 2003 is a flood of record. It's the event of record. It's the highest event of the record. That I recall.

Q. Talked a little bit earlier about -- could the flow increase that you saw at the Linn Grove gauge be due to factors other than the spillway?

A. The answer to that question is of course it could, but is it more likely than not? No. It's caused by the change in the spillway.

Q. Well, could it be -- could rainfall affect that?

A. Well, of course rainfall affects, there's

no record in any gauge except for there's rainfall. The rainfall gauge is reflecting the record. The stream flow gauge is reflecting the rainfall. So I mean, rainfall causes there to be a record.

I don't understand your question.

Q. Well, let me ask it, what -- besides the spillway what factors would influence or affect the flow of, for example, the Wabash River?

A. The flowing of all its tributaries.

Q. What other factors?

A. Again, there's no flow without rainfall and runoff.

Q. Log jam?

A. Who?

Q. Log jams?

A. Surely. But let's talk about what might be causing flooding. Yes, log jams can cause floods, but that's not the reason we're having a litigation.

Q. Well, I understand that's what your clients feel is the case.

A. Okay, well, log jams.

Q. What about sedimentation, would that affect it?

A. It can.

Q. Low slopes?

A. You mean a mild river slope?

Q. Gradient.

A. Can affect it.

Q. What do you know about historical flooding along the Wabash before the spillway was modified?

MR. FUSONIE: Objection; vague.

A. I only know what was prepared and written about it in the Corps. of Engineers report and I think Burgess & Niple looked at it.

Q. You had no reason to doubt -- I'm sorry, you weren't finished, go ahead.

A. I think I recall that Burgess & Niple perhaps looked at it also.

Q. Do you have any reason to doubt that information, the accuracy of that?

A. None.

Q. What about the Beaver Creek, same answer? Historical flooding along Beaver Creek?

A. It was the Corps. of Engineers report when they evaluated the dam, the 39.4-foot spillway, and the Beaver Creek that they recommended a project of straightening and that project was done.

So that probably was done virtually immediately after the Corps. of Engineers report.

1 The Corps. of Engineers language we call it a
2 desnagging project but they basically straightened
3 the alignment of Beaver Creek so that it would be
4 able to carry flow more readily.
5 And that was done but that still was
6 not -- that did not address the adequacy of the
7 spillway, again, as I identify it this morning. So
8 that was why the ODNR then completed the design
9 evaluation and then the installation of the 500-foot
10 spillway.
11 Q. Did you look at any historical data on
12 flooding along Beaver Creek specifically?
13 A. Yes.
14 Q. And what did you find about that?
15 A. In the Case Leasing case I looked very
16 carefully at the situation between the spillway and
17 the property and immediately downstream from the Case
18 Leasing property.
19 I recall there's a couple road crossings
20 and so, again, during my visit to the site I went and
21 looked at those, looked at the cross sections that
22 were in the model that the ODNR had, and pretty much
23 validated or verified that the data that was in there
24 was based upon my visual inspection what I had seen
25 or observed. So sure, I had to look at the stream.

1 Q. But you looked at the creek in the
2 vicinity of Case Leasing property.
3 A. Sure, and when you look, you're looking
4 for highwater marks, I mean that's what we do as
5 hydrologists. When you look at a stream, you're
6 looking for everything. You're looking for the
7 places where there was a flood and the grass is moved
8 or debris in the stream, that's all part of what we
9 do as hydrologists when we look at a stream.
10 Q. Did you again or did you look at data
11 along Beaver Creek for the Doner case? And the
12 properties that they claim are affected by flooding
13 there?
14 A. I looked at the photographic supplement,
15 we talked about that this morning, that counsel
16 provided.
17 Q. So you looked at the pictures that showed
18 flooding.
19 A. Yes. And again, as I said this morning,
20 I went back and re-reviewed the Mercer County record
21 from the '03 event.
22 Q. Were the pictures you saw, the
23 supplemental pictures, of the '03 flooding?
24 A. I believe they were of the '03 flooding
25 and more recent flooding, although I don't recall

1 what the events were.
2 Q. If you would go to paragraph 7 of your
3 affidavit.
4 A. Yes, sir.
5 Q. You indicate you "analyzed all available
6 rainfall records and storm event data from 1913 to
7 2006."
8 Did you -- can you specify what records
9 those were for rainfall?
10 A. I believe I document that in the Case
11 Leasing report. Looked at a number of precipitation
12 records, attempted to make a selection as to what
13 records were available for what duration and what
14 records might be applicable to our watershed.
15 So it was a number pulled -- basically I
16 tried to work in a thorough and methodical fashion
17 where I plot all stream gauge stations nearby, all
18 precipitation records nearby, determine what that
19 record is, when it started, when it ended, how often
20 it is compiled, whether or not it's calibrated by
21 NOAA, calibrated by USGS, what's its reliability, and
22 I do all that. So that's part of what I do here.
23 Q. What rainfall records did you look at
24 after 2006 after Case Leasing was over?
25 A. I looked at the record that was the

station that I chose --

Q. The Linn Grove?

A. Well, Linn Grove is the stream gauge station.

Q. Right.

A. I don't remember the name of the meteorological station.

Q. Where was it?

A. I don't recall its name. What I'm -- I'm trying to answer the question. I'm trying to tell you that the station when I went through the overall exhaustive evaluation of the precipitation stations that were most appropriate to use for the Grand Lake St. Marys in the 2009, I came and pulled that record from the end of whenever I had pulled the record in the Case Leasing case up to that time. So certainly up to about September of 2009.

Q. And again, just so -- just because I'm having a little trouble understanding, that record, you say a "station record." Do you know where that was?

A. Yes, I do. It's in the report. I can't tell you what it is but there's a -- NOAA has things that they call precipitation or rain gauges.

Q. All right.

A. Okay? I plot them all on a map, I review all the record of what's in each one, you know, one of them maybe started in 1920 and ended in 1940. I go through that entire myriad and I find one that I believe is the most reliable record, most representative of the precipitation in the watershed.

Q. You also say "storm event data." Is that the same thing? Do you do a separate check on that or does that go hand in hand with looking at the rainfall records?

A. That goes hand in hand.

Q. Go to the next paragraph if you would.

A. Yes, sir.

Q. You indicate there saying "...would have caused between 1914 and '97, and now has since 1997, repeatedly caused frequent and severe flooding in the Beaver Creek, Wabash-Mercer County, and the properties in the vicinity of these two waterways."

And that "Such flooding would not have occurred had ODOT not replaced the spillway --" ODNR replaced that spillway in '97; is that right?

A. That's what it says, yes, sir.

Q. What do you mean by "frequent and severe"?

A. Let's do "severe" first.

1 Q. All right.
2 A. "Severe" is above the stage, above flood
3 stage. We did that this morning.
4 What is my definition of a "flood"?
5 Flood is outside the bank full stage.
6 Q. All right.
7 A. Stage is height. So severe means higher
8 than the banks.
9 Q. Well, then any flooding would be severe,
10 wouldn't it?
11 A. It could be, yes, sir. Severe might mean
12 two feet, three feet, five feet. Whatever is the
13 stage, its inundation above the flood stage. And
14 "frequent" is just an adjective meaning an often
15 occurrence.
16 Q. Let me ask you this, what's the
17 difference between flooding and severe flooding?
18 A. Severe flooding would be higher than
19 non-severe flooding.
20 Q. All right, then what's non-severe
21 flooding?
22 A. That's an abstract term.
23 Q. Well, can you -- are you able to quantify
24 what "severe" is?
25 A. No.

1 Q. And "frequent" you say means "often."
2 Can you quantify when you say "has caused" and "would
3 have caused" frequent and severe flooding, how
4 frequent were you referring?
5 A. Sir, if you analyze the record from '14
6 to '97 and then you analyze the record after '97, at
7 any -- even at the Linn Grove gauge the stage is
8 higher which means it's more severe, and the flooding
9 is more frequent. And so it's more often. So just
10 study those two records, that's what this sentence is
11 intended to mean.
12 Q. So just so I'm clear, your definition of
13 "frequent and severe" means more often and greater
14 depth elevation between after 1997 than before.
15 A. Okay, this is a -- it's a two sentence
16 paragraph and it is intended to be all encompassing
17 with all the factors that are in there. So what it's
18 saying is you look at the record from 1914 to 1997,
19 you look from 1997 to 2009 and you look at that
20 record, you're going to see that the stage is higher,
21 the stage is higher more often.
22 Q. Okay. Well, I understand that.
23 A. That's what that sentence says.
24 Q. Well, that's what it says and what I'm
25 trying to get is just a little more understanding. I

1 understand that that's what you saw and what I'm
2 trying to understand is you are using "frequent and
3 severe," I think you use it at multiple places, just
4 exactly what you mean.
5 And I believe you said severe means any
6 flooding over the limit, right? Any time
7 overtopping, that's severe flooding. Am I right? If
8 I'm wrong, correct me. I thought that was your
9 testimony.
10 A. We can get Webster out and look at
11 what --
12 Q. I don't want --
13 A. I mean what Webster means.
14 Q. What do you mean? You're the expert,
15 that's why I'm asking.
16 A. "Severe" is greater than "not severe."
17 Q. That tells me nothing.
18 A. That's good. Then you're not going to
19 get any answer better than that. That's the best
20 answer I can give you.
21 Q. All right. So let's say hypothetically
22 that Beaver Creek flooded once every ten years, just
23 say that, and now after the spillway it floods once
24 every nine years. Would that be frequent flooding in
25 your mind because it's more often than before?

1 A. It would be more frequent flooding.
2 Q. It would be more, all right.
3 A. In other words, that's right, if you
4 analyze it statistically as you're indicating in your
5 hypothesis, then that's the case.
6 Q. Then let me ask you this, and I don't
7 want to put words in your mouth, I really don't.
8 A. Maybe it's better we get the record out
9 of -- let's get the record out and put the record on
10 the table and look at the record. Because we're
11 talking about adjectives and adverbs and, you know,
12 let's talk about what the record says.
13 Q. Well, let me ask you this, you say it
14 repeatedly caused frequent and severe flooding. Are
15 you saying that what you're -- did you mean to say
16 more frequent and severe flooding than before? Is
17 that what you're telling me?
18 MR. FUSONIE: Objection.
19 A. Certainly it seems that we're getting
20 argumentative. It says what it says. That's what I
21 meant it to say. We can pull the record out and look
22 at the record. The record reflects for itself.
23 Q. Are you unable then to quantify what
24 "frequent" means? Or are you unwilling to?
25 MR. FUSONIE: Objection; form.

1 A. "Frequent" means "often." And ask me
2 what "often" means. We can each look them up in the
3 dictionary.
4 Q. Don't you think "often" is a relative
5 term though?
6 A. So is "frequent."
7 Q. They're your terms in your affidavit.
8 I'm just trying to figure out what you meant by them.
9 A. Well, it seems that we're trying to be
10 argumentative about two modifiers. Again, the record
11 can just speak for itself.
12 Q. Did you prepare this affidavit?
13 A. I did.
14 Q. Did you type it up?
15 A. No. I don't type very much.
16 Q. Who typed it up?
17 A. Probably one of the clerical staff.
18 Q. At your office?
19 A. Would be my recollection, yes.
20 Q. Was "frequent and severe" something --
21 did you understand that to be a legal term? Or were
22 you not using it in that sense?
23 A. I don't know whether it's a legal term or
24 not.
25 Q. But they, "frequent and severe" are your

words on this.

A. To my knowledge it is. But I don't know whether it's a legal term, no.

Q. But regardless of whether it's legal or not, "frequent and severe," that is -- that's your characterization of the flooding since 1997.

A. Yes.

Q. Do you know for a fact whether all of the properties in this litigation have in fact experienced more frequent and severe flooding because of the spillway?

A. No.

Q. Would you consider a flood that occurs every 25 years to be frequent?

A. If that were my property I would, yes.

Q. What's your professional opinion of whether that's frequent or not?

A. I would think frequent flooding is anything in the five- to ten-year range.

Q. Did you analyze any flooding events with the recurrence interval less than once every five years or once every ten years?

A. I believe when I started I looked at a typical, whatever we would say, an average annual storm which is basically a two-year recurrence

1 interval precipitation. So I used that as a starting
2 point but I didn't, you know, I just try to get a
3 feel for the watershed.
4 Q. When you say you "started," was that
5 starting on Case Leasing or was that starting on
6 Doner?
7 A. Starting on Case Leasing.
8 Q. What evidence do you have, again, I'm
9 staying on paragraph 8 here, that a larger spillway
10 would have caused more frequent and severe flooding
11 from 1914 to 1997? I mean, how can you know that?
12 MR. FUSONIE: Objection to the extent
13 it's already been established by the post or spec
14 case.
15 A. What I know is that's based on the Case
16 Leasing case work. And merely applying it across the
17 balance of the stream.
18 Q. Regardless of what the Court determined,
19 your own professional opinion, how do you know that
20 would have occurred?
21 MR. FUSONIE: Objection.
22 A. Because it was my analysis. That's how I
23 made the two Case Leasing reports we have here in
24 record that we've copied today, and it's very
25 clear --

1 Q. But --
2 A. -- that it caused more severe flooding.
3 Again, it was your depiction if you --
4 it's not that hard to envision that if you take a
5 39-foot spillway and make it a 500-foot spillway,
6 that the 500-foot length allows substantially more
7 flow to go into Beaver Creek. And that once it's in
8 Beaver Creek, it merely progresses the length from
9 Beaver Creek to the state line.
10 But, yes, there's input by other
11 sub-watersheds, but that's your dominant thing that's
12 carrying the water.
13 Q. But you don't know, I mean, you can't
14 know if that spillway had been there since 1914, you
15 can't know that it would have flooded all those
16 properties, would you, severely and frequently?
17 MR. FUSONIE: I'm having a continuing
18 objection, it's already been established.
19 A. I know that as part of my professional
20 evaluation, that's my professional opinion. I do an
21 analysis in a hypothetical situation. I set those
22 parameters down and that was what I did.
23 Q. What is the basis of that conclusion?
24 A. My engineering evaluation.
25 Q. Fine. What in that evaluation leads you

1 to that conclusion?
2 A. I have the water surface elevation
3 records, I have what is called a stage discharge
4 relationship for a spillway, I have it for a 39-foot
5 spillway and I have it for a 500-foot spillway and I
6 can do the calculation.
7 Q. That's supposing that all is constant
8 throughout this time, correct? To be able to --
9 A. That's a comparison of everything else
10 being the same what would be the flow at a 39-foot
11 spillway and what would be the flow at the 500-foot
12 spillway.
13 Now, I do per what I wrote about
14 Dr. DeGroot, I did make an assumption as to what the
15 effect of the lake level would be when you have more
16 outflow than the lake level is lower than if you have
17 less outflow. And I make an assumption on that and a
18 calculation on that. So I made an allowance for the
19 change in the discharge does have an impact on the
20 lake elevation.
21 Q. You indicated you had written something
22 about Dr. DeGroot; is that correct?
23 A. I thought I had put that in here. No,
24 when I did this affidavit I didn't have Dr. DeGroot's
25 report, I'm sorry. I've received Dr. DeGroot's

1 report since then.
2 Q. You've seen it. Have you written
3 something in response?
4 A. I have certainly generated for my own
5 thinking a response, yes.
6 Q. Well, I'm just asking you mentioned
7 something, I thought you said you wrote about
8 Dr. DeGroot's report. Is it -- have you supplemented
9 your affidavit?
10 A. No, I have not.
11 Q. What did you write about his report?
12 A. I wrote comments that I did not like his
13 report.
14 Q. All right. That was to yourself?
15 A. Yes, to myself.
16 Q. Were you -- you indicated you did not use
17 the HEC model in this litigation. You previously
18 testified to that, right?
19 A. What I testified was that I used the work
20 that I had done in the Case Leasing case. I did not
21 rerun anything for this case.
22 Q. All right. Why not?
23 A. Because I didn't think it was necessary.
24 Q. Were you instructed by someone else not
25 to?

A. No, I was not.

Q. Was cost a factor? In your decision not to?

A. No, it was not a factor in my decision.

Q. What were the factors in your decision not to?

A. It was not necessary.

Q. Why wasn't it necessary?

A. Because that's my engineering opinion, that it wasn't necessary.

Q. That's a conclusion. Tell me what factors did you weigh in your mind that made it not necessary.

A. It wouldn't add any value.

Q. Why not?

A. Because nothing -- because the simulations that I did then, there's nothing -- there's no difference that would make any difference in a simulation. No change.

In other words, what would be the benefit? If there's nothing to be gained by doing it again, then there's no benefit by doing it again.

Q. What did you -- you mentioned Dr. DeGroot's report. What did you not agree with? What did you not like about it?

A. He was critical that it was his opinion that I did not make an allocation for the change in the discharge of the 39-foot spillway and the 500-foot spillway and that that would have a change in the lake elevation. And I did, I made an estimate on that. And I have that included in the Case Leasing work.

Q. So you think he was simply inaccurate about that?

A. I don't know what to think. I just think that he --

Q. You don't believe he was right.

A. That's correct. I believe that he was inaccurate in his portrayal as to what I did or what I did not do.

Q. What else?

A. That's really what I would recall. I believe he made some generalizations about my report that I didn't think were appropriate.

Q. Did you review Stantec's report?

A. Yes.

Q. What did you think about that?

A. I thought the Stantec report was more professionally prepared than Dr. DeGroot's report.

Q. And what about the Stantec report made

1 you feel that way?
2 A. Their report reported on what they did.
3 They made an evaluation.
4 Q. Anything else?
5 A. That's all I remember. I don't remember
6 that much about the Stantec report other than that.
7 But their report did have some evaluation of my
8 report.
9 Q. Have you determined which properties in
10 this litigation have actually experienced more
11 frequent and severe flooding?
12 A. I think you asked that already, and I
13 said I did not.
14 Q. Okay. On paragraph 9, you have a -- you
15 use the term "severe storm event." I know we're
16 getting back to adjectives, but can you quantify what
17 constitutes a "severe storm"?
18 A. In the definition of paragraph 9 it means
19 that an event that would cause, my interpretation
20 when I penned that, is one that would cause flooding.
21 Q. All right. Any flooding or just causing
22 Beaver or Wabash to overtop?
23 A. Just flooding. Flooding anywhere along
24 the Beaver Creek from the spillway to the state line.
25 Leaving bank full stage.

Q. If you go to the next paragraph.

A. No. 10 paragraph?

Q. I'm sorry, yes, sir.

You indicate the overwhelming of the two waterways, and just so I'm clear, is that Beaver Creek and the lake or is that -- that's Beaver Creek and the lake; is that correct?

A. It's a compound paragraph again, but in terms of us obtaining clarification, I mean Beaver Creek. I mean the discharge comes over the spillway and it's in Beaver Creek.

Q. So you're talking about the natural flow of Beaver Creek plus the overtopping then of from the spillway?

MR. FUSONIE: Objection.

A. Right --

MR. FUSONIE: Hold on. I said objection.

MR. COLE: I'm sorry.

MR. FUSONIE: Paragraph 10 of the affidavit speaks for itself as two waterways, Beaver Creek and Wabash River in Mercer County.

Q. Is that what you meant?

A. Beaver Creek means over the spillway. And it's the terminology in those sentences. Beaver Creek over the spillway.

Q. You said the overwhelming caused flooding on the properties in their vicinity. What are the "properties"? Are they -- what properties are you talking about?

A. We're talking about the properties in the Doner case.

Q. All of them?

A. I don't know. Asked and answered. I didn't --

Q. He gets to do that, not you.

A. I didn't do each property, I already indicated that.

Q. So you say it caused flooding on the properties in the vicinity. Some, but you don't know which ones.

A. It might have been all.

MR. FUSONIE: Objection.

A. I didn't analyze each one.

Q. You didn't analyze any of them, right? Specifically?

A. Well, I didn't have to analyze some of them specifically because some of them are immediately adjacent to Case Leasing property.

Q. So you did.

A. I didn't analyze them each one

1 specifically.
2 Q. Are any of the landowner properties too
3 far away to be impacted by the spillway?
4 MR. FUSONIE: Objection.
5 A. It's the "too far away" where I think we
6 have to work on what the meaning of "too far away"
7 means. There are several of the properties that are
8 on tributaries to Beaver Creek and/or the Wabash.
9 And so that requires a more sophisticated evaluation
10 than those directly along Beaver Creek.
11 Q. Did you do such a sophisticated
12 evaluation on those parcels?
13 A. What I did was I looked at the stage
14 along Beaver Creek and that -- and the stage in these
15 tributaries would easily have been affected by the
16 higher stage in Beaver Creek.
17 Q. So is that --
18 A. My answer is yes. But did I do each
19 parcel by each parcel? No, I did not.
20 Q. You did it by tributary, is that what
21 you're saying?
22 A. I did it along Beaver Creek and along the
23 Wabash to the state line and then with some of these
24 parcels are on tributaries.
25 So I looked at the stage on the Beaver

1 Creek stream and the Wabash and saw where the
2 confluence was with the tributary, if the stage was
3 higher at the point of the confluence.
4 So, therefore, the stage being higher
5 being caused by the overflow of the spillway would
6 have caused the stage to be higher at the property.
7 We talked about it this morning as tailwater effect.
8 Q. All right.
9 A. Or backwater effect. Just so we get it
10 clear, if I can, I don't know how the record's going
11 to be in a deposition, but at a given point along
12 Beaver Creek if the flow over the spillway is higher
13 which then causes the stage to be higher at a given
14 point along Beaver Creek, and that given point is on
15 where a tributary flows into Beaver Creek, then
16 within that tributary its tailwater is higher because
17 of the stage in Beaver Creek and therefore the
18 "backwater" or "tailwater" affect causes its flooding
19 to be more severe because of the increased flow from
20 the spillway.
21 Q. Go ahead.
22 A. So that's how tailwater is important in
23 this effort here.
24 Q. Did you look at -- for those parcels that
25 are at some distance from Beaver Creek or the

1 spillway, did you analyze the swelling and the
2 increased levels in each of the tributaries to
3 determine whether they experience frequent and severe
4 flooding?
5 MR. FUSONIE: Objection.
6 A. There was no record available to do that.
7 And so all I was able to do was to look along Beaver
8 Creek.
9 Q. All right.
10 A. And then using my experience, evaluate
11 what might be the effect within the tailwater of the
12 tributary.
13 Q. What might be the effect?
14 A. Yeah, because there's no record.
15 MR. FUSONIE: Outside the visual
16 observation of people there.
17 MR. COLE: Why don't you wait, Counsel.
18 MR. FUSONIE: Outside of visual
19 observation.
20 A. There's a photographic record.
21 MR. COLE: I'll move to strike that.
22 MR. FUSONIE: I can ask it now or ask it
23 at the end. Might as well ask it now.
24 MR. COLE: I think it's more appropriate
25 when I'm finished.

Q. Are you able to, just by sitting here today, make a determination what parcels there would not have been impacted by severe flooding due to the spillway?

MR. FUSONIE: Objection. Assumes certain facts. He said -- well, I'll leave it at that.

A. I don't think I can do it, not in sitting here today.

Q. You can't make a determination for sure or to -- you can't make a determination which parcels were or were not flooded due to the spillway; is that correct?

A. Without pulling out the photographic record, yes, correct, no, I can't.

Q. Well, photographic records don't necessarily show the cause of the flooding, do they? Could have been other factors.

A. Okay, again, what I do is I go into the model and I look at the location along Beaver Creek with the flow coming from the 39.4-foot spillway, and then I compare that with the stage with the flow coming from the 500-foot spillway.

Then I look at that stage what that stage causes at an individual point and I see is that difference 2/10 of a foot or two feet?

1 And based upon that judgment, I can look
2 at this stream and make an estimate as to whether or
3 not it would have an impact upstream or not. But
4 sitting here today I can't tell a yes and I can't
5 tell a no.
6 Q. Now, prior to the spillway being modified
7 in 1997 you -- your review of records show it did
8 flood, correct? There was flooding on Beaver Creek?
9 A. Yes. I believe the record's clear.
10 Q. And how would you characterize that
11 flooding with regard for its frequency?
12 A. Whatever is in the record, sir.
13 Q. Would you consider that to be frequent
14 flooding before the spillway? Would you say it's --
15 would you characterize these properties before the
16 spillway was built as from the frequent flooding?
17 MR. FUSONIE: Objection.
18 A. I prepared a graph that might help us
19 talk about that. In the May '06 report. And in the
20 May '06 report, figure 3.
21 What I did was I studied at the Case
22 Leasing property what was the bank full capacity of
23 the stream. And it was 480 cubic feet per second,
24 approximately.
25 So whenever there was a historical event

that was more than 480, then that would cause flooding. So then what you do is you take that record, you then make an evaluation if the 500-foot spillway were in play and you compare the two. And that's how I make this determination.

Is it occurring more frequently or less frequently? And I think it occurs more frequently.

Now, that's all as you're saying, as you're describing, that's an engineering calculation that I do. I can also just take the stream flow record at Linn Grove, which I also articulated, and the stream flow record for the 13-year record from '97 to 2010 shows that this stage and the discharge is higher between '97 and 2010 than before '97.

Q. Linn Grove, is that gauge at the border or near the border?

A. It's I believe within five or six miles of the state line. So it's not in Ohio but it's close.

Q. What is the distance between the Indiana line and Grand Lake St. Marys, the western side?

A. I recall it was something on the order of ten or 12 miles. But I'm sure we can scale it from a map. It's whatever it is.

Q. So the Linn Grove indicator would be

1 approximately 26 miles then from --
2 A. No. Be 15. Or 18. 12 and 5 would be
3 17.
4 Q. Okay. Five miles, yeah.
5 A. Let's call it ten. So ten and five,
6 something like that. So it's something of that
7 range.
8 Q. Math's not my strong point. Thanks.
9 Does the rainfall records you looked at
10 show a difference in the frequency of rain for the
11 area before the spillway was built and after?
12 A. Not substantial, no, sir.
13 Q. What do you recall? Has it been raining
14 more recently though?
15 A. Well, again, not just at our gauge, per
16 se, but there are a number of hydrologists, it's part
17 of what I call the global warming scenario where they
18 are making an evaluation of the, certainly where we
19 have a good record which would be in the United
20 States where we have a record that there is more
21 precipitation.
22 But I don't know that 1997 is any magical
23 line to put in the sand. There's a historical trend
24 which as a statistician I call into question as to
25 whether it's statistically significant. But there is

1 an increased trend in the amount of precipitation
2 over history. Nothing magical about '97. You know,
3 whether it's '87, '97, 2007, or '77.
4 Q. Could the increase in the flow at the
5 Linn Grove gauge be due to increased rainfall?
6 A. I don't believe it is, no.
7 Q. Could it be?
8 A. It could be.
9 MR. FUSONIE: Objection.
10 A. Within the realm of "could," yes, it
11 could. But more likely than not, no.
12 Q. If you would go back to Exhibit B and I
13 understand that it's a cut off but we really, I don't
14 think -- you know what, let me just take a moment.
15 I'm going to get the whole Exhibit B here.
16 (Off the record.)
17 (EXHIBIT MARKED FOR IDENTIFICATION.)
18 Q. Back on the record.
19 Dr. Campbell, I've handed you what I have
20 marked as Exhibit 2A. I think, as we mentioned
21 earlier in the deposition, that is -- what did I hand
22 you, let me -- you put it in your own words.
23 A. What you handed me as 2A is the
24 November 2006 report that I prepared on the Case
25 Leasing case.

Q. Is that the supplement to your report?

A. It's the supplement in the Case Leasing report, yes. Or what we would refer to as the supplement, yes, sir.

Q. And I will note for the record, Dr. Campbell, you'll probably see that that was our copy and there are some redactions of notes that we would have had, comments like right on that next page that are not yours but we put in.

A. I see those, yes, sir.

Q. And let me ask you this, Dr. Campbell, are Exhibits 2 and 2A together, is that the total Case Leasing report that you did in that case?

A. To the best of my knowledge it is, yes, sir.

Q. Thank you.

Now, Dr. Campbell, did you adjust the lake level or stage in the Case Leasing evaluation?

A. I did.

Q. How did you do that?

A. When you say did I "adjust," I think what I'm assuming you to mean, the rest of that question is when I did calculations for the 500-foot spillway as a hypothetical spillway before it existed in real life did I make an adjustment to the lake elevation,

1 and the answer to that question is yes, I did.
2 Q. Can you -- where in the report do you
3 have -- do you indicate that?
4 A. I'm not sure I can find that that easily.
5 I can find that most easily, have you a copy of the
6 full report?
7 MR. DORSEY: We have just the addendum.
8 MR. FUSONIE: You have the addendum
9 report in front of you.
10 A. No, that doesn't have all the exhibits.
11 MS. WORLY: It should. I believe we just
12 copied everything.
13 THE WITNESS: It's a very many page --
14 let me see, maybe it's in the original report. It's
15 a very many page, it's just data. Goes on forever.
16 No, you don't have it in either of these.
17 It's a large attachment and it just has all the lake
18 records. You know what I'm talking about?
19 MR. FUSONIE: No.
20 THE WITNESS: It's maybe 30 or 40 pages.
21 MR. FUSONIE: That's right.
22 THE WITNESS: It's smaller than this.
23 That's where it is. What I'm saying is the easiest
24 way for me to find that is to look at that reference.
25 Because where I did that in the text, I made that

reference.

I mean we can go through and methodically find it, but that -- as the author that's the way I would most easily go and find it.

Q. (By Mr. Cole) Is it -- it is within your report though? Your written report?

A. Yes, it is. Because what we did was I attached all those to the lake elevations as a reference of those are the lake elevations that I used that we obtained from the ODNR.

Q. We could find it at a break or something but it is referenced, yes. Let's keep going. I appreciate that, thank you.

Did you determine the recurrence interval from what would be a flooding out of bank event for any point along Beaver Creek or a probability that an event would occur in any given year?

A. That's a compound question.

Q. Let me break it down.

A. Let me not do probability because I don't think I'm going to be able to answer anything about probability, okay?

Q. Fair enough.

A. What I did was I did a pretty thorough evaluation at the Case Leasing property.

1 Q. Which would be at the east end of the
2 creek.
3 A. Yes, sir. And really after that it's
4 making an estimation.
5 Q. Did you do estimates at other locations
6 along Beaver Creek or is that what you do?
7 A. That's what one would do. I did not do
8 any.
9 Q. And did you do that -- you did that
10 post-spillway modification, correct?
11 A. I think I did calculations for pre and
12 post.
13 Q. On recurrence intervals?
14 A. I think on historical events. I don't
15 know that I calculated recurrence interval.
16 Q. Do you know what the difference in the
17 recurrence intervals for out-of-bank flooding is for
18 pre-spillway and current spillway configuration in
19 any given year?
20 A. No.
21 Q. When you talk about flooding impacts,
22 what are impacts of flooding upon the Doner
23 properties? Or even the Case Leasing property.
24 A. Stage. So that's just inundation, the
25 possibility of erosion and/or sedimentation. Which

1 would be related to velocity, property loss or
2 whatever perceived property loss.
3 In other words, as a property owner, my
4 property has less value if it floods or if the
5 community knows that it floods. So those are you
6 know, and then physical literal damage.
7 In other words, when my property is
8 inundated, certainly it would apply to a structure
9 because a structure could experience severe damage by
10 an inundation. But in terms of many of these Doner
11 properties are agricultural land and it certainly
12 could affect them by loss of crop and/or loss of
13 whatever we would say, the seed in the soil.
14 In other words, whenever I plant the
15 field if the flood comes and just the moisture comes
16 in there from up wicking from a shallow groundwater
17 cable, then it can destroy the seed so I could still
18 have a loss of crop.
19 Q. Have you seen any actual evidence of
20 flooding impacts from any of the Doner owners --
21 relators?
22 A. By my recall of the photographs, yes.
23 The photographs would have depicted some of that.
24 Q. Can those impacts be quantified?
25 A. Yes, it's my opinion they can.

1 Q. How would they be quantified?
2 A. By someone other than myself. But
3 obviously there are professionals that would
4 understand that property that's more frequently
5 flooded does have an impaired value or depressed
6 value over one that is not.
7 To me the loss of the crop is just
8 straight up the loss of the crop. And/or any damage
9 as Mr. Case had several million dollars of damage to
10 his structure that he had to have reconstruction.
11 That's just a straight economic value.
12 I mean they did an immense amount of that
13 in the Katrina situation where we just, when the
14 property is inundated, it takes a certain amount of
15 rehabilitation just whatever we would say, contractor
16 work.
17 Q. Okay.
18 A. So those are ways. I'm sure there's
19 probably other things but those are certainly ways to
20 do that.
21 Q. What is your knowledge or understanding
22 of what ODNR's lake level management practice is of
23 Grand Lake St. Marys before the spillway was changed?
24 A. Only what we were able to glean from
25 their record.

Q. And what was that?

A. I recall but I'm going to try to play it from recall but I believe I put it in my report.

There was some memos and some record of the interdepartmental discussion about the lake level management procedure, and again going back to the Corps. of Engineers report and the Corps. of Engineers report recommendation that the 39.4-foot spillway was inadequate for the designed storm event.

Part of the design criteria when ODNR redesigned the spillway was they wanted the -- they wanted to end lake level management. So part of their goal in the design of the new spillway was to have a spillway that they called -- they would call unregulated.

Q. Let's not get too far ahead because you're anticipating my next question.

A. I'm trying to answer the question.

Q. I understand that.

A. That's what I recall in the record.

Q. Do you recall what the actual -- what did ODNR do to the lake before the spillway? How did they manage the levels? Did they do anything?

A. They drew the lake down usually, and that's a very common practice among many entities

that manage reservoirs. So that's a very longstanding practice in the United States Army Corps. of Engineers where they lower the lake as you go through the winter coming to spring because you have spring rains and you have the spring that you -- so you have a lot more water available in the spring.

So what you're doing is you're drawing the lake down so you have capacity so when the spring floods come, it's collected in the lake and you don't have to release the water to flood the downstream people on the creek.

Q. If ODNR had not changed the spillway but they stopped doing that practice of drawdown, what impact would that have had on properties along Beaver Creek?

MR. FUSONIE: Objection.

A. That's one of the things that was really an integral evaluation in the Case Leasing litigation. And I was never able to be able to get enough information to analyze which was worse or which caused more flooding. But they both had a severe impact.

Q. Why weren't you able to get that information?

A. Because there's not sufficient

1 information. The procedure or the policy that was in
2 place for lowering the lake was not codified. It was
3 not documented.
4 So whether they would draw it down let's
5 say 3/10 of a foot or 6/10 of a foot or a foot, that
6 wasn't there. So you can't study it when I don't
7 know what the procedure would be.
8 I mean, and I'd hate to divert, but what
9 happens is if you study the Corps. of Engineers and
10 many -- most reservoirs, the Corps. of the Engineers
11 lay out a particular program and policy: We will
12 draw it down one foot in November or one and a half
13 feet in January or whatever. And there was no such
14 of a record in the ODNR.
15 Q. So your opinion is that the frequent and
16 severe flooding was caused by a combination of the
17 new spillway and the no longer doing these lake level
18 management practices?
19 A. That's exactly correct, sir. Which is I
20 recall from the record there was a change with
21 regards to the stop logs in '88, but the record would
22 reflect what that is.
23 Q. But within that you can't attribute it's
24 mostly due to the spillway or it's mostly due to the
25 lake level management. You can't break that down.

A. That's correct. And again, this engineer, that was my -- that he and I did so much of the calculations, Mr. Munce.

We kind of flip flop because as you're doing an evaluation like this day in and day out and week in and week out, you kind of think this kind of looks like it's more the lake level, this is more the length of the spillway.

So we never could get enough information to be able to make a clear distinction one or the other. But it's a combination of the two.

Q. In paragraph 14 of your affidavit, that's in Exhibit 1, it's at the bottom of page 3, top of page 4.

A. Yes, sir, I'm there.

Q. You talk about, and I'm kind of going toward the end, it's a big sentence, this, but you say if the prior spillway was in place and accompanying lake level management ODNR practice before 1997 were followed, only one storm event would have caused the discharge to overflow the banks. Am I correct that that's the July 2003?

A. It is.

Q. So based on that, your opinion is there would have been overflowing regardless. They

1 wouldn't have been able to stop it even if they had
2 been doing the same thing.
3 A. Yes.
4 Q. In paragraph 17.
5 A. Yes, sir.
6 Q. You indicate that the combination of "the
7 spillway and ODNR's lake level management policies
8 described more fully below." And again, that policy
9 is what, not to do lake level management?
10 A. Yes. Again, that was part of the design
11 of the 500 was they wanted to have the terminology
12 that's in their literature, an unregulated lake.
13 Q. So --
14 A. So in other words, they did not want to
15 have to manage the lake level.
16 Q. So assuming that ODNR followed that
17 policy, they changed the spillway but they have not
18 been drawing down or doing any other active
19 management of the lake level. Is that your
20 understanding?
21 A. That's my understanding.
22 Q. All right. 17 you talk about you refer
23 to the combination of the two has substantially
24 increased the risk of flooding, a risk that has
25 become a reality repeatedly since 1997.

What do you mean by "risk" there? Do you mean just chance or is it something you can quantify?

A. It's either "risk" or "frequency." That would have been an alternative term, "frequency."

Q. Your understanding is lake level management policy has not changed at all since the spillway has opened, correct?

A. I haven't seen anything that would cause me to change, no, sir.

Q. Are all of the downstream owners in the Doner case at an equal risk of the same degree and duration of flooding?

MR. FUSONIE: Objection.

A. As I previously stated, I didn't study each one of them so I can't answer that question.

Q. Several points throughout your -- tell me again, what calculations did Mr. Munce do?

A. Mr. Munce and I worked on this project together. So we were doing immense -- this analysis and evaluation we were doing together.

Q. What did you do and what did he do?

A. We worked together. He's really direct report of mine and so he was working at my direction.

Q. Who calculated the data?

A. Both of us together.

Q. Was there a particular area that he handled and you reviewed, or?

A. Not really. I usually don't do my projects like that.

Q. At several points I noticed when I was reviewing paragraphs 5, 8, 12, and 14 you talk about -- and you don't have to look at each one of those.

A. Okay.

Q. But you referred to using historic lake level elevation data. And do you know whether the old spillway included an overflow wearing gates that could be opened?

A. Yes, I believe it did. That's my recollection.

Q. Did you get any information, historical data about being the -- about when those gates were opened?

A. I certainly asked for. Any data I got was provided by the ODNR.

Q. Do you recall if and when the gates were ever opened before the spillway --

A. I don't recall.

Q. Would -- do you know if you included that in your report?

1 A. I recall the, what I would in my memory I
2 would call the first trial. In the first trial --
3 Q. You mean case?
4 A. Yeah, in the first case trial when we
5 went to trial, the Schottenstein, Zox & Dunn firm had
6 sought for and asked for all the lake elevation
7 records possible and when we got to trial the expert
8 that represented the ODNR referred to some records
9 that had not been provided to Schottenstein, Zox &
10 Dunn, so the Court agreed and stipulated both parties
11 would have all the records.
12 And then there was another clarification
13 of a point is the -- there was survey elevation mark
14 of the elevation of the spillway of the 39.4-foot
15 spillway notch or the 39.4-foot spillway where the
16 crest was and then the new 500-foot spillway and
17 where the notch was.
18 And so the Court stipulated, we
19 dispatched a surveyor to go out so that both parties
20 had supposedly all the records that were available.
21 And so my answer to your question is by
22 the Court's directive, all the records that were
23 available to the ODNR were provided to the Case
24 Leasing case counsel and, therefore, I had all those
25 records as of that point in time.

1 So to the best of my knowledge and
2 belief, if there was any record about any opening of
3 any spillway or any of this or any of that, it would
4 have been included in that record that I was provided
5 at that time. That's a hundred percent of what I
6 know.
7 Q. Well, I'm going to ask one more question.
8 A. You can ask questions but I only know
9 that we suspended the trial to get all the records
10 and for all the records to be provided to me.
11 Q. Right.
12 A. And so I only know that record and that's
13 the appendix that I referred to that's printed page
14 after page after page.
15 Q. Okay.
16 A. That was the outcome of that and then
17 that was the outcome of where I did the analysis that
18 are documented in the "addendum report."
19 Q. How did you establish historic lake
20 levels to determine the discharge with the modified
21 spillway? How did you use that information?
22 A. Let me see if I can try to -- I think you
23 may be asking the crucial question related to
24 Dr. DeGroot's question.
25 What I did was I -- we assumed that the

storage, that is the storage capacity of Grand Lake St. Marys was vertical from the surface area of the lake.

And what that means, that means something to the hydraulic engineers but what happens is as the -- if you withdraw more water from a spillway, if you think about a bathtub, if I have a bathtub and I have a two-inch drain versus a six-inch drain, if I drain from the six-inch drain, the water elevation in the lake will drop faster than if I use the smaller drain.

Q. And -- hang on, I do want to interrupt you on this just so I could follow because I think you're going to get into some things.

A. Sure.

Q. You say you "assume." I presume when you assume the vertical storage capacity that sometimes you use it and sometimes you don't. Why did you assume it here?

A. Well, what happens is when you have a lake elevation and you have an incoming hydrograph and you have an outgoing hydrograph, then what we do to study the relationship is we have what we call a stage storage curve. What that means is for any given lake elevation there's a certain storage

capacity that that lake has.

And so there wasn't one available so I manufactured one. Again, it relates to this attachment. Is I took the surface area of Grand Lake St. Marys and assumed there was vertical walls that just went straight up like a bathtub. So I then created an artificial storage relationship and then I used that in the calculations. So I did make an assumption.

And if you -- and it's actually in this report, this table here with the redacted black marks, where it actually shows the results of that analysis where I studied there's a column on that table 1 that shows the difference of the lake elevation and it shows that it's only a few tenths or a few or one particular storm it was one foot.

So my point for my explanation for Dr. DeGroot is theoretically it's correct that you do have to make an account for it. It doesn't change the lake elevation that significantly when you have this 12-square-mile lake that there's a very large storm volume if you increase it a tenth of a foot or two/tenths of a foot.

So now, that's a long answer to your simple question and I hope it explains it.

Q. I appreciate it. I appreciate that.

A. So I did make account for it.

Q. When you did that assumption did you make any adjustments on a stage storage?

A. Well, I manufactured a stage storage.

Q. All right.

A. Then I used that stage storage relationship in the calculation.

Q. Did you make any adjustments to offset that or because of your manufacturing that?

A. No. It's a pretty good assumption.

Q. Why is that?

A. Well, because you have to allow that there is storage capacity there. And certainly when you consider the lake elevation, which is only fluctuating a foot or two, and I don't know whether you've been to Grand Lake St. Marys but if you've been to Grand Lake St. Marys, is within the -- within a foot or two of normal pull, vertical is not a bad assumption.

If you follow what I'm saying is, you know, the banks are reasonably steep so within that foot or two of movement is a pretty good assumption.

If it was flooding 20 feet, then it would not be applicable. But it's only fluctuating up and

1 down a small incremental amount.
2 Q. Now, when did you gather the lake level
3 data?
4 A. We gathered a lot of that before the
5 trial, but then again at the trial when we compared
6 the lake elevation there was some disparity between
7 the two parties that were at trial and so then we
8 were provided all of the records.
9 And again, that's that appendix that I
10 printed again for the -- certainly to illustrate
11 mostly for the record of the Court that here we were
12 at trial and we got suspended and here's all the lake
13 records that's there.
14 So that -- so it goes up to 2006. It
15 doesn't go past 2006. If that's your question.
16 Q. Well, when you gathered the data on lake
17 levels pre-spillway modification, what -- would the
18 modified spillway affect the lake level data
19 differently than the spillway in place when that data
20 was collected? In other words, if the new spillway
21 had been in place some time ago.
22 A. Again, we can only do that by a
23 hypothetical calculation.
24 Q. In paragraph 12 you refer your
25 calculations in Exhibit B on -- let me wait till you

1 get there.
2 How did you calculate the water flows for
3 the old spillway? What was your methodology?
4 A. We had a stage discharge curve and we had
5 a lake elevation.
6 Q. Did you change your methodology at all
7 for the new spillway? Calculating the water flows?
8 A. No. I just did as I described, we had a
9 stage discharge relationship from the 500-foot
10 spillway.
11 Q. Did you consider discharges from Beaver
12 Creek watershed -- when you looked at water
13 discharge, did you only look at Grand Lake St. Marys?
14 A. Again, yes. That's all we did, we're
15 doing the HEC-1 and the HEC-2 using the ODNR model
16 exactly.
17 Q. Okay.
18 A. So that model did not make any allocation
19 for tributary inflow downstream from the spillway.
20 Q. So you did or did not use any hydrology
21 models?
22 A. Well, we keep going back to this same
23 point. It's in the -- it's very clearly explained in
24 the May 2006 report, the bottom of page 7. Says "All
25 modeling conducted by CRA was performed using the

1 HEC-1 and the HEC-2 models as set up by ODNR; no
2 parameters were changed."
3 Q. And that was again because that was to
4 stay consistent, that's what the Court had ordered?
5 A. Again, that was what the -- that was the
6 strategy of the lawsuit was to not modify the model.
7 Q. Why was that? What was the follow-up
8 purpose of that strategy?
9 MR. FUSONIE: Hold on, objection. I
10 think that's straight into attorney work product.
11 And I'm sure the Schottenstein law firm would believe
12 that was attorney work product that's the strategy
13 for that decision. I'm not -- I just don't want --
14 it's up to him to answer.
15 A. I mean I can answer it as best I can.
16 Q. Go ahead and answer.
17 A. Let me answer it as best as I can recall.
18 Because had I made my own model, then there would
19 have been tremendous scrutiny and dispute about the
20 ingredients of that model. By using the ODNR model
21 precisely as the ODNR did it, I took that parameter
22 in that argument out of the formula.
23 And I'll be so much as to tell you, I
24 might have been the one that proposed that as a point
25 of argument to counsel, and counsel agreed with it.

1 But that was the reason is it took that parameter of
2 the model out of the evaluation.
3 Because we were not then disputing of
4 Stantec makes a model, CRA makes a model, DNR makes a
5 model, John Jones makes a model. How we can look at
6 the ultimate results of all those different models
7 determining the ingredients of the models. By just
8 doing their model we took that out of their
9 evaluation.
10 Q. When you adjusted the lake level data for
11 the 1997 spillway, what was your source of inflow
12 hydrology?
13 A. The HEC models. Exactly this right here.
14 Q. In paragraph 15, a and b, you cite the
15 lake elevation above 870.6 feet for only 21 percent
16 of the measurements. They speak for themselves,
17 let's move on.
18 A. They do.
19 Q. How did you reach those figures? How did
20 you reach those percentages?
21 A. Just by brute numbers. Comparison of the
22 numbers. No magic.
23 Q. In paragraph 16, referring to that, what
24 type of storm is more likely to cause Beaver Creek to
25 overflow when its lake elevation is above 870.6 feet?

A. I'm not sure there's a precise single answer to that question.

Q. What can you tell me?

A. My opinion is that when the antecedent moisture condition is high and then you have a storm, which in the history of the storms or the history of the flood events are dominantly what we would call the spring or early summer. I think if you look at the historical records is far away the preponderance of the floods occur in that scenario.

Q. Did you do any -- look at any data or reach any conclusions with regard to how long water was remaining on -- I should say proposed.

For post-'97 after the new spillway did you do any determinations of how long water was -- how long there was standing water on property after flooding versus what it had been previously?

A. No.

Q. Paragraph 5 which is on page 2.

A. Thank you.

Q. You refer to surveying records. How did you use those? Or why did you use those?

A. Well, as the author of the sentence what I believe I was referring to was the Mercer County surveying records from the 2003 event.

You see how it says "surveying records from the Mercer County Soil and Water Conservation." That's what I believe I was referring to.

Q. I asked you before I believe and I won't ask you again about the recurrence level of the July 2003 flood.

Do you -- did you make a determination or did you see data on the recurrence level of just the rainfall for that storm?

MR. FUSONIE: Objection as to form.

A. Yes, I did look at that and it's surprising that it's again it's not a very significant rain event. Again, that's why antecedent moisture condition plays a very big role in the watershed.

Q. Do you know what the recurrence interval for that kind of rainfall was?

A. I don't recall but it was not especially severe. If you understand what I mean, it was like 15 year or 25 year. It was no -- it wasn't an alarmingly adverse recurrence interval precipitation value.

I mean, I think it's in my report. Let's talk in terms of this thing because I think it's in the report.

If the 100-year rain is 7.9 inches, then the total rain for -- and that's a 24-hour duration, then the total rain of this event for five days or seven days was less than that.

So trying to get -- and it's in the report but I'm just trying to get it in statistical perspective.

Q. You mentioned you don't recall the actual -- you mentioned 15, 20 was it? I don't want to put words in.

A. Yeah, whatever, it's just not a significant precipitation event. I'm pretty sure I have that in the report somewhere.

Q. We'll look at that.

And you had testified that you had gotten the -- again, I'm sorry to make you jump back and forth here, but 15 in a and b, on the elevations, I think you earlier testified that the stop logs were added to the old spillway in 1988; is that right?

A. That's my recollection.

Q. Would the placing of those stop logs affect the percentages of those percentages on your -- that you reached in your 15a and b?

A. Cannot fine tune it that much. I mean that's asking for too much of an analysis. I

1 couldn't get there. I could look at it in terms of
2 more or less.
3 Q. They could affect.
4 A. Well, they do affect it. There's no
5 question they affect it. Because when they stopped
6 the lake level management, which was the stop logs.
7 You understand when the -- by putting the stop logs
8 in, they ended lake level drawdown.
9 Q. All right.
10 A. So when they're drawing the lake down,
11 then they are allowing lake level management.
12 Q. So let me just get it straight. Your
13 understanding is lake level management ended in 1988
14 with the stop logs.
15 A. That's my recollection.
16 Q. All right.
17 A. I could stand corrected but that's my
18 recollection.
19 Q. So --
20 A. So when they stopped that, they ended
21 lake level management.
22 Q. I see. Okay, that's fine.
23 A. So I mean, that's my memory. The record
24 will reflect whatever the record reflects. That's my
25 memory.

Q. I don't know, I don't have actual page here but in your report on the Case Leasing I believe you indicated that the inundated area as a result of the new spillway for the four -- you have four events, one was in 1913, 1992, 2003, and 2005.

Do you know what the recurrence interval for any of those events would be?

A. No. Not sitting here today, per se, no, sir.

Q. What is -- what's your understanding of the current notch -- what is the wear currently in place in the spillway? What's the size of that?

A. I don't recall. The record says what it is. There's a notch.

Q. Fifty-foot sound accurate?

A. Could be. My brain won't pull that recall out. It's in the record.

Q. Would you expect a 50-foot spillway to cause significantly more flooding than a 39.4-foot spillway?

A. No, I would not.

Q. Does Grand Lake discharge through the 50-foot notch for more frequent runoff events?

A. I think Grand Lake discharges through the 50-foot notch most of the time.

Q. Let's take a break.

(Off the record.)

Q. Let's go back on, please.

Why did you draft the or create the map of the Doner properties setting those forth? What was the substantive purpose of that?

A. To see where they were.

Q. Was that -- why did you need to know that?

A. Well, need to know the relationship between the Beaver Creek and the Wabash River.

Q. Was that for the relators or for their counsel to see or strictly for your use?

A. Not for the realtors, for -- so it would be for me and counsel.

Q. And you testified that you had used the -- it was a strategic decision to go ahead and use the ODNR model in the Case Leasing case. Why use it in this case?

A. Carry over the same logic.

Q. All right.

A. That's what ODNR used.

Q. Any other purpose?

A. To me that's the most logic. It's ODNR's dam and it's their use, it's their analysis, it's

1 their model.
2 Q. Did you --
3 A. Makes it much more complicated when I
4 start doing my own.
5 Q. Did you see any flaws in the analysis or
6 in the modeling?
7 A. I would think that you could say yes.
8 Q. Can you elaborate?
9 A. Well, I would see places -- rather than
10 call flaw, I would say I would see places for
11 improvement.
12 Q. Can you specify what areas can be
13 improved?
14 A. Surely. The place I would start with
15 improvement would be in the development of the
16 rainfall and runoff analysis that would make
17 substantial consideration for the antecedent moisture
18 condition.
19 Because the history of the watershed was
20 such that most of the flood events were related to
21 the whatever again near the break between the winter
22 and the spring and the spring rain and/or the soil
23 conditions. So that would certainly be one thing.
24 Certainly again the ODNR model was
25 prepared for the spillway redesign and so while it

1 would be preferred obviously to have, if you're
2 trying to look at downstream conditions to have
3 hydrologic input from the tributaries downstream,
4 that would be the place where I would make an
5 improvement to it.
6 Certainly for something such as
7 applicable to this litigation whereas you would take
8 and modify it in that regard.
9 So those would really be -- and the other
10 thing is you have to -- there's this thing of
11 calibration of a model where you have to take a model
12 and calibrate it against one or more severe
13 historical events, and then when you do that you have
14 to -- you have multiple parameters in the model that
15 you can then adjust to match the flow.
16 And so in other words, you have multiple
17 parameters in the model so what you have is you have
18 a historical flow so you can simulate the historical
19 flow.
20 You then have let's say three or four
21 sets of model parameters that you can have that will
22 still match your calibration. Then it behooves you
23 if you're an expert modeler to try to understand what
24 one might need to do within those parameters to
25 select the parameters that are best for use of the

1 model.

2 And my insight into that is that we are

3 really, we are trying to make a model that is a model

4 that's designed to handle this severe event. So

5 while a model is a nice thing to have for the

6 everyday flow, that's not the point of interest.

7 So what happens is you -- the other

8 suggestion that I would have is that the stream and

9 the flood plane would have in the cross sections the

10 change that's the mannings in and that's a model

11 parameter that those of us that do modeling

12 understand, it's a roughness, an indication of the

13 roughness, as the stage gets higher, the -- it's the

14 HEC model allows you to change the manning in whereas

15 frequently I see so many models in this particular

16 model kept mannings in as a constant, and that's fine

17 for running certain sets of discharges.

18 Q. What's a "manning"?

19 A. "Manning in" is a roughness coefficient.

20 That's a gentleman named Manning that developed the

21 steady uniform flow formula which we apply to

22 unsteady uniform flow routine. But basically we

23 apply the Manning formula. I mean HEC uses Manning

24 formula. So what that means is you then have to make

25 an estimate of the roughness coefficient.

Q. Were you finished answering my prior?

A. Well, I mean, you know, there are many, many things. But that's where I would start.

MR. COLE: Dr. Campbell, thank you.

MR. FUSONIE: I just have a couple clarifying questions if I may.

- - -

DIRECT EXAMINATION

By Mr. Fusonie:

Q. Dr. Campbell, you have -- I believe your testimony was you have visually inspected or and observed the what I call the new spillway; is that correct?

A. Yes.

Q. Did you visually observe any outlets for the new spillway?

A. Yes.

Q. And is it your professional opinion as a civil engineer that those outlets can still function to drawdown the lake?

A. Yes.

MR. COLE: Objection; leading.

A. Yes, they can.

Q. And have you attempted to make a comparison of those outlets compared to any outlets

that the old spillway had?

A. I have.

Q. What comparison have you made?

A. Well, the outlets are certainly adequate for the dam. In the new configuration it's actually an improvement over what the outlet structures were in the old dam.

Q. Have you used the HEC HMS model?

A. Yes, I have.

Q. When you use that if you have a stream gauge available would you calibrate your model to that stream gauge?

A. Yes. Again, as I was describing to Mr. Cole, at the beginning of evaluation of any watershed I try to plot all the records all where there are records and then select the appropriate one. In this particular configuration it's what we call the Linn Grove gauge is the most reliable longstanding record.

Q. And would you find a HEC HMS model that does not calibrate to such a river gauge to be flawed?

A. Yes, I would. It would be a place where I think you would make an improvement to include calibration.

MR. FUSONIE: I don't have anything else.

MR. COLE: You know I have to have the last word.

MR. FUSONIE: Only if it's a recross.

- - -

RECROSS-EXAMINATION

By Mr. Cole:

Q. When did you use HEC HMS last?

A. Used it within the last several months. Different projects.

Q. And how do you use that? How did you use it?

A. You know, it's a code that we have and we go in and we put in the cross sections and make the entries. And model a flow.

Q. Do you -- is HEC HMS steady, unsteady, both, neither? When is it appropriate to use HEC HMS?

MR. FUSONIE: Objection as to form.

A. It's appropriate to use HEC HMS when the project is such of a size that one should go through the energy and effort to set up that much of a sophisticated model.

Q. Is it used for steady flow analysis?

A. It is used for steady flow. It also has

a capability to be used for unsteady flow.

Q. Is it equally valid for both?

MR. FUSONIE: Objection.

A. It's valid depending upon its input parameters.

Q. Is it equally appropriate assuming all else is equal?

MR. FUSONIE: Objection.

A. Well, I mean it can be used to evaluate steady flow and unsteady flow and it's a matter of having the data so that you can make the entries and make the evaluation.

Q. Thank you.

A. Thank you.

MR. FUSONIE: You have the -- Dr. Campbell, you have the right to review your transcript, to review it to correct any errors that need to be corrected. I obviously can't advise you one way or another on that other than it's common in Ohio to read.

THE WITNESS: I usually like to read it.

(Signature not waived.)

(Deposition concluded at 4:00 p.m.)

- - -

State of ~~Ohio~~ Louisiana :
Parish : SS:
~~County~~ of East Baton Rouge :

I, Pressley L. Campbell, do hereby certify that I have read the foregoing transcript of my deposition given on Wednesday, April 28, 2010; that together with the correction page attached hereto noting changes in form or substance, if any, it is true and correct.

Pressley L. Campbell

Pressley L. Campbell

I do hereby certify that the foregoing transcript of the deposition of Pressley L. Campbell was submitted to the witness for reading and signing; that after he had stated to the undersigned Notary Public that he had read and examined his deposition, he signed the same in my presence on the 10th day of May, 2010.

Notary Public ID #83530
Phaedra Carright
Commission - Ascension

My commission expires Lifetime, _____.

- - -

ERRATA SHEET

Please do not write on the transcript. Any changes in form or substance you desire to make should be entered upon this sheet.

TO THE REPORTER:

I have read the entire transcript of my deposition taken on the 28th day of April, 2010, or the same has been read to me. I request that the following changes be entered upon the record for the reasons indicated. I have signed my name to the signature page and authorize you to attach the same to the original transcript.

Page	Line	Change	Reason
174	19	"Manning's n"	mis-typed
174	10	Manning's n	mis-typed
174	14	Manning's n	mis-typed

Date 5/10/10 Signature: Presslyn L Campbell

1 CERTIFICATE

2 State of Ohio :
: SS:
3 County of Franklin :

4 I, Julieanna Hennebert, Notary Public in and for the State of Ohio, duly commissioned and
5 qualified, certify that the within named Pressley L. Campbell was by me duly sworn to testify to the whole
6 truth in the cause aforesaid; that the testimony was taken down by me in stenotypy in the presence of said
7 witness, afterwards transcribed upon a computer; that the foregoing is a true and correct transcript of the
8 testimony given by said witness taken at the time and place in the foregoing caption specified and
9 completed without adjournment.

10 I certify that I am not a relative, employee, or attorney of any of the parties hereto, or of any
11 attorney or counsel employed by the parties, or financially interested in the action.
12

IN WITNESS WHEREOF, I have hereunto set my
13 hand and affixed my seal of office at Columbus, Ohio, on this 2ND day of May, 2010.
14

15 Julieanna Hennebert
Julieanna Hennebert, Registered
16 Professional Reporter and RMR and Notary Public in and for the
17 State of Ohio.

18 My commission expires February 19, 2013.

19

20 (JUL-1554)

21 - - -

22

23

24

25

IN THE SUPREME COURT OF OHIO

STATE EX REL. WAYNE T. DONER, et al.,	:	
Relators,	:	Case No. 2009-1292
	:	Original Action in Mandamus
v	:	
SEAN D. LOGAN, Director, Ohio Department of Natural Resources, et al.,	:	
Respondents.	:	

AFFIDAVIT OF PRESSLEY L. CAMPBELL, Ph.D., PE

STATE OF OHIO)
) ss:
COUNTY OF FRANKLIN)

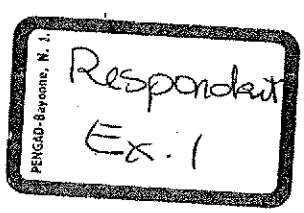
My name is Pressley L. Campbell, Ph.D., PE. I am over the age of 21, and I am competent to make this affidavit. The facts stated herein are within my personal knowledge and are true and correct. I state as follows:

1. I am a Registered Professional Engineer (PE) in the State of Ohio, No.56681. A true and accurate copy of my curriculum vitae is attached as Exhibit A.

2. I am in good standing with the Ohio State Board of Registration for Professional Engineers

3. I am a shareholder with Conestoga-Rovers & Associates in Baton Rouge, Louisiana.

4. I have evaluated the impact of the replacement in 1997 of a 39 4-foot spillway with a 500-foot western spillway at Grand Lake St. Marys on flooding along the Beaver Creek and its tributaries (hereafter referred to as "Beaver Creek") and the Wabash River and its



tributaries from its confluence with the Beaver Creek to the Indiana state line (hereafter referred to as the "Wabash-Mercer County").

5. My analysis was completed using precipitation data obtained from the National Oceanic & Atmospheric Administration ("NOAA"). I also used Grand Lake St. Marys' water elevation data from 1927-2006 obtained from the Ohio Department of Natural Resources ("ODNR") and surveying records from the July, 2003 storm event of Mercer County Soil and Water Conservation District and Mercer County Engineer's Office.

6. In forming expert professional opinions, I rely on documents, records, and other materials which are regularly relied upon by persons in my profession, including records on file with federal, state and local agencies, such as NOAA, ODNR, and the Mercer County Soil and Water Conservation District and Mercer County Engineer's Office.

7. I analyzed all available rainfall records and storm event data from 1913 to 2006 to determine the potential for flooding along the Beaver and Wabash-Mercer County.

8. The lake elevation data demonstrates that the 500-foot self-regulated spillway completed in 1997 would have caused between 1914 and 1997, and now has since 1997, repeatedly caused frequent and severe flooding in the Beaver Creek, the Wabash-Mercer County and the properties in the vicinity of those two waterways. Such flooding would not have occurred had ODNR not replaced the 39.4-foot spillway with the 500-foot self-regulated spillway in 1997.

9. When a severe storm event occurs, rainfall causes the water in the Grand Lake St. Marys to rise above the crest of the western spillway.

10. When the storm event is sufficiently severe -- an event that has occurred on at least sixteen occasions between 1913 and 2006, with seven of those occasions between 1997 and

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2006 -- the amount of water that enters Beaver Creek over the 500-foot spillway overwhelms the Creek's carrying capacity and, consequently, overwhelms the Wabash-Mercer County's carrying capacity. The overwhelming of these two waterways' carrying capacities caused flooding on the properties in their vicinity.

11. In order to determine which historical storm events were "severe", it was necessary to examine both precipitation data and corresponding streamflow information. The precipitation data was obtained from seven NOAA meteorological stations within a 35-mile radius of the western spillway; the streamflow was derived from obtaining lake-elevation data to determine the stage-discharge relationship, e.g., the height of water at a particular point along a lake with the rate of water that will flow past that point, i.e., over the western spillway.

12. Using the historical lake elevation data provided by ODNR, I have calculated the actual discharge of water that flowed (or would have flowed) over the 39.4-foot spillway and the 500-foot spillway respectively into the Beaver Creek and the Wabash-Mercer County between April, 1927 and August, 2006. The results of the calculations are illustrated on Figure 1, attached as Exhibit B.

13. As demonstrated by Exhibit B, it is highly unlikely, if not impossible, Relators' property downstream of the 500-foot spillway and in the vicinity of the Beaver Creek and Wabash-Mercer County would have flooded from Grand Lake St. Marys if the 39.4-foot spillway were still in place and ODNR had engaged in the lake-level management practices it had prior to 1997.

14. Using the lake elevation data, this analysis reveals that, had the ODNR-designed 500-foot spillway been constructed 70 years earlier (in 1927), fifteen storm events between 1927 and 2006 would have resulted in flow that exceeds the capacity of Beaver Creek and Wabash-

Mercer County, resulting in flooding; an average of approximately once every five years. Conversely, if the 39.4-foot spillway was in place and accompanying lake-level management ODNR practiced prior to 1997 were followed, only one storm event would have caused the discharge to overflow the banks of the Beaver Creek and Wabash-Mercer County

15. I also did an analysis of the lake levels from 1927 through 1997 – when ODNR ceased managing lake levels – and 1997 through 2006, when ODNR chose not to manage lake-levels. The results in table form are attached as Exhibit C. The results follow:

a. Since 1997, 73.3 percent of the daily measurements taken reflect lake elevations above 870.6 feet msl (mean sea level), the elevation at which water overflows the spillway and enters into the Beaver Creek. Before 1997, the lake elevation was above 870.6 feet for only 21.4 percent of the measurements.

b. Since 1997, 26.3 percent of the daily measurements collected reflect lake elevations above 871.5 feet msl, the elevation at which water overflows the entire 500-foot length of the spillway. Before 1997, the lake elevation was above 871.5 feet for only 2.4 percent of the measurements.

16. Based on the data above, since the construction of the 500-foot spillway in 1997 and ODNR's abandonment of prior lake-level management practices, the lake elevations of Grand Lake St. Marys are consistently higher than prior to 1997. When the lake elevation is above 870.6 feet msl, water is discharging into Beaver Creek. If the lake is at or above that elevation when a storm event occurs, the storm is more likely to cause flooding outside the banks of Beaver Creek and Wabash-Mercer County regardless of the severity of the events; and the higher the lake elevation at the onset of the storm event, the more extensive the flood impact

17. Since 1997, the combination of the 500-foot spillway and ODNR's lake-level management policies, described more fully below, has substantially increased the risk of flooding for downstream property owners -- a risk that has become a reality repeatedly since 1997

18. The fact that the 500-foot spillway discharges a substantially larger quantity of water into the Beaver Creek and the Wabash-Mercer County than the 39.4-foot spillway has resulted in flooding of downstream properties in the vicinity of Beaver Creek and Wabash-Mercer County.

19 During severe storm events, the water that discharges into the Beaver Creek and Wabash-Mercer County has the potential to be moving at high velocities and can overflow the banks at a significant depth. These two factors threaten human activity in the vicinity of Beaver Creek and Wabash-Mercer County downstream of the spillway.

20. The frequent and severe flooding caused by the 500-foot spillway was and is a necessary consequence of the construction and installation of that spillway.

21. ODNR has been and is able to mitigate the effect of severe precipitation events by maintaining the Grand Lake St. Marys' elevation water level at less than the crest height of the western spillway, thus increasing the Lake's storage capacity. When severe storms occur the Grand Lake St. Marys would be able to store a significant volume of inflow therefore decreasing the flow to the Beaver Creek over the western spillway and preventing or minimizing flooding. ODNR has refused, and to my knowledge, continues to refuse to take such steps, rather, electing to treat the Grand Lake St. Marys as a self-regulated lake.

22. Another option available to ODNR is to develop additional outlet channels located on the Grand Lake St. Marys to divert some portion of the water that flows into the lake.

Diversion of some of the water away from the western spillway would prevent excess amounts of water from flowing into Beaver Creek. A possible diversion location is Coldwater Creek.

23. ODNR could also construct an emergency spillway. The current western spillway could be used to pass normal inflows, while an emergency spillway could be constructed that would be designed to engage during large flood events. The emergency spillway would act to discharge the additional flows.

24. An eastern outlet structure on Grand Lake St. Marys exists. It discharges into a feeder canal, which flows into the St. Marys River. However, because of its size and design, only very minimal discharges from Grand Lake St. Marys into the canal can occur. ODNR could modify the eastern outlet and its accompanying canal to provide an east/west split of the discharge of overflow from Grand Lake St. Marys, which would decrease the outflows in Beaver Creek and Wabash-Mercer County. In my professional opinion, this option would safely handle the probable maximum flood such that the embankments of the Grand Lake St. Marys' dam would not overtop.

25. It is clearly foreseeable that severe and frequent flooding will continue. By choosing not to manage Grand Lake St. Marys' lake-levels, ODNR will cause further downstream flooding over the banks of the Beaver Creek and Wabash-Mercer County during severe storm events.

26. I have reviewed correspondence (true and accurate copies of which are attached as Exhibit D) that ODNR received in 1991-1992 prior to the construction of the 500-foot spillway from the community and from Mercer County Soil and Water Conservation District and Mercer County Engineer's Office warning that the 500-foot spillway would cause flooding

downstream in the Beaver Creek and Wabash-Mercer County. Thus, the flooding caused by the 500-foot spillway was foreseeable to ODNR when it built that spillway.

27. From my review of materials, I understand that the western spillway is used by ODNR to prevent the flooding over the embankment that serves as the Grand Lake St. Marys' western shoreline. However, the public use that the western spillway serves has caused, and continues to cause, frequent and severe flooding downstream of the Grand Lake.

FURTHER AFFIANT SAYETH NAUGHT.

Pressley L. Campbell, Ph.D., PE

Sworn to in my presence and subscribed before me this 29th day of September, 2009.

Notary Public

NOTARIAL SEAL STATE OF OHIO

JOSEPH R. MILLER
Attorney at Law
Notary Public, State of Ohio
My Commission Has No Expiration
Section 147.03 R.C.

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EXHIBIT A

TO

AFFIDAVIT OF

PRESSLEY L. CAMPBELL, Ph.D.,PE

PRESSLEY L. CAMPBELL, PH.D, P.E.

EDUCATION

B.S.	Civil Engineering, Carnegie-Mellon University, 1967
M.S.	Civil Engineering, Carnegie-Mellon University, 1969
Ph.D	Civil Engineering, Carnegie-Mellon University, 1973

EMPLOYMENT

1999-Present	Project Manager/Shareholder Conestoga-Rovers & Associates, Baton Rouge, LA
1997-98	Project Coordinator, CRA Services (formerly G&E Engineering) Baton Rouge, LA
1993-97	Director of Engineering, Advanced Pollution Technologists, Ltd., South Bend, IN
1989-92	Director of Major Projects, IT Corporation, Chicago, IL
1984-89	Regional Technical Manager, IT Corporation/D'Appolonia, Baton Rouge, LA
1981-84	Group Project Manager, D'Appolonia, LA
1979-81	Senior Liaison Engineer, D'Appolonia, New Orleans, LA
1977-79	Project Supervisor, D'Appolonia, Pittsburgh, PA
1976-77	Project Engineer, GAI Consultants, Pittsburgh, PA
1973-76	Project Supervisor, D'Appolonia, Pittsburgh, PA
1969-72	Commissioned Officer, National Oceanic and Atmospheric Administration, Norfolk, VA

LICENSES/AFFILIATIONS

Licensed Professional Engineer: TN #101880, LA #19704, MS #8842, AR #5772, IN #60900194, AL #14340, OK #13887, TX #76931, IL #62045495, MI #6201036422, WI #13768, OH #E56681, PA #19613E, FL #36327, KY #10961, MO #E27414, IA #12942, KS #10004, NC #22373, SC #17667, IN #60900194, and WV #014983

American Society of Civil Engineers

National Society of Professional Engineers

National Association of Corrosion Engineers

Society of Petroleum Engineers

International Society of Environmental Forensics

National Academy of Forensic Engineers

ASTM Sustainability Committee

EXHIBIT
tabbies
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PROFILE OF PROFESSIONAL ACTIVITIES

Dr. Campbell has more than 20 years of experience in multiple states completing multi-disciplinary projects in hazardous waste management, solid waste disposal, engineering design, hydrogeology, water resources, hydrology, corrosion, risk assessment, construction, and Client-Agency interface.

Dr. Campbell is a hazardous waste lecturer and has given seminars at local, regional, national, and international conferences. The majority of his experience in the hazardous waste management field has involved collection of data, design of site remediation, coordination with Agencies and Clients, construction oversight, and project documentation. The range of project types are civil works and hydrologic based and extend to landfill and closure design, mine spoil management, groundwater treatment, cutoff wall and leachate collection systems, biotreatment, building decontamination, watershed analysis, and audits for corporate acquisitions and property transfers.

Dr. Campbell has directed significant groundwater, soil, and surface water projects, including sophisticated groundwater computer models, recovery of groundwater and Dense Non-Aqueous Phase Liquids (DNAPLs), sophisticated soil and groundwater interaction investigations including fate and transport of constituents, corrosion engineering studies, aerial mapping, drilling, permitting, geotechnical engineering evaluations, working with on-site operations personnel to implement engineering recommendations, aquifer risk assessment, slurry trench construction, state-of-the-art vault landfill designs, and indoor air quality assessments. Most projects included the development of comprehensive work plans with sampling and analysis plans, quality assurance project plans, health and safety plans, and subcontractor plans. Dr. Campbell, as an officer of the IT Corporation frequently, prepared subcontracts including scope, oversight, and reimbursement.

A summary of project experience follows:

also p. 8

Hydrology and Hydraulic Projects

- Completed an evaluation of the potential surface water impact of a release from a facility in the Atchafalaya Basin. Work included evaluation of EPA and LDEQ models, development of an independent model and reporting to counsel
- Completed an evaluation of the flood events near Baraboo, Wisconsin, for an industrial facility. Reviewed flood analyses completed by the Federal Emergency Management Administration (FEMA) and local communities. Recommendations included practical, flood channel modifications (at the facility), and early warning models to reduce the potential adverse financial impact caused by future flood events
- Completed an evaluation of the rainfall, runoff, and sediment discharge for a watershed near Asheville, North Carolina. Work included evaluation of analyses completed by others, implementation of computer models, cost estimation, and site modifications to minimize impact to the site. Work involves potential litigation and is attorney-client confidential
- Completed a probable maximum flood and probable maximum precipitation evaluation of the Missouri River at Omaha, Nebraska for licensure of a nuclear power plant site. Work included comprehensive evaluation of the watershed, unit hydrographs, precipitation records, and optimization consistent with the flood study requirements of the Nuclear Regulatory Commission
- Completed an evaluation of the Delaware River near Philadelphia. Work included a comprehensive review of the flood study completed by the National Flood Insurance Program (NFIP) and submittal of hydrologic and hydraulic analyses that accompanied a submittal of a challenge to the study. As a result, the NFIP lowered the 100-year flood plain elevation at the facility in question that resulted in a multimillion dollar savings
- Completed evaluation of four dam sites in Pennsylvania and West Virginia to evaluate the hydraulic suitability to withstand probable maximum flood events pursuant to dam safety analyses. Work was consistent with federal standards

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Design Engineering

- Design engineer and oversight engineer for the construction of slurry walls at 11 facilities in the Gulf Coast Region including the following Louisiana locations: Baton Rouge, Napoleonville, Livingston, Uncle Sam, and St. Francisville. The projects involved hazardous and non-hazardous waste sites; federal, state, and local regulations; and diverse leachates and groundwater conditions. The size of the slurry walls ranged from depths of 12 feet to 70 feet and lengths of several hundred feet to over 10,000 feet and backfills ranged from soil/bentonite to cement/bentonite mixtures. The majority of the applications were to affect groundwater containment to reduce potential long-term liabilities
- Design of closure of two solid waste (non-hazardous material) landfills at industrial sites in Louisiana. Work included collection of soil and groundwater samples, alternative evaluation, collection of design data, engineering design including drawings and specifications, construction oversight, and submittal of documentation to regulatory agencies
- Design and agency coordination of a site investigation including surface runoff, soil, groundwater, and petroleum hydrocarbon at the former Westinghouse facility on Choctaw Drive in Baton Rouge, Louisiana. A groundwater recovery program was developed and implemented to recover non-aqueous phased liquids (NAPL) that contained substantial concentrations of polychlorinated biphenyls (PCBs). A design that removed soil impaired with PCBs and backfill was implemented. The work included the design and construction oversight of 500 feet of 8-foot diameter reinforced concrete pipe (RCP) to allow storm water to be conveyed in an existing ditch near the property boundary. All work was completed successfully and closure approved by environmental agencies with jurisdiction
- Design of the closure of a solid waste management facility in northern Indiana in accordance with regulatory requirements. Design included collection of design data, slurry wall, synthetic liner cap, groundwater recovery system, drawings, specifications, construction oversight, and submittal of documentation to agencies. A portion of the cap and slurry wall extended beneath a building and railroad yard that presented unique engineering and construction criteria
- Design engineer for two hazardous waste landfills and reviewing engineer for the design and construction of four solid waste landfills in the Gulf Coast region. Work included engineering design, drawings, and specifications; construction oversight; and permit applications to regulatory agencies
- Design of containment and groundwater recovery, treatment and discharge system at a 17-acre site under the jurisdiction of a U.S. EPA Region 5 - 106 Order. The site is in northern Indiana and the work is funded by a group of respondent PRPs. The constituents of concern include oils, solvents, and heavy metals. Special features involved in the project included wetlands mitigation, slurry wall design, recovery and recharge wells, NPDES permitting, biological treatment of groundwater, carbon treatment, and air quality permitting. Engineering design included drawings and specifications
- Design of investigation plans, collection of needed data, design of overall site demolition plan at the former Godchaux-Henderson sugar refinery in LaPlace, Louisiana, for the Port of South Louisiana. Work included preparation of remediation demolition bid packages for numerous buildings (one building was 12 stories with galbestos-sheet exterior), water treatment facilities, two smoke stacks (205 and 255 feet tall), boilers, and related structures including disposition of asbestos-containing materials, PCB-laden transformers and ballasts, fluorescent light bulbs, mercury, and other chemicals and construction debris, recycle of all material possible, construction oversight and documentation of activities. Additional related work included administrative submittals to obtain brownfield funds, public relations plan, OSHA compliance, explosive demolition plan, and design of scaffold systems
- Fifteen to twenty on-site remediations involving sludge and drum handling, and design oversight and documentation of construction

- Five on-site projects including design/construction of new ponds/landfills
- Responsible for over 30 projects involving the remediation design of brine ponds, permitting of solids, water and waste disposal, environmental baseline and impact reports, corrosion engineering, and flood/channel improvements
- Design of corrosion control protective measures including implementation of corrective actions at five Strategic Petroleum Reserve (SPR) sites in Louisiana and Texas for brine collection, pumping and transport. Work included collection of representative samples, evaluation of extent and impact caused by corrosion, evaluation of alternative remedies, and oversight of selected remedy to reduce corrosion substantially
- Design of a groundwater pump and treatment system for several sites impacted by BTEX compounds The sites use extraction wells, air stripper treatment, soil vapor extraction, and reinjection wells of permitted effluent
- Design, construction oversight, and operational monitoring of a vapor extraction system for several industrial sites in Indiana, Illinois, and Michigan. The release of organic compounds to the vadose zone in shallow soils is being effectively remediated
- Design of an air sparge and soil vapor extraction system for a site in south central Michigan that exhibited groundwater impairment due to the presence of chlorinated solvent compounds

CERCLA and Inactive Sites

Dr. Campbell has managed several Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Superfund projects and administrative orders. He has managed activity within remedial investigation, feasibility study, risk assessment, remedial design, and remedial action phases with CERCLA. A list of example projects follows.

- Project Director of RI, risk assessment FS, RD, and RA at Louisiana's No. 1 Superfund site, Old Inger. This site proceeded through the Superfund process from discovery until site restoration from 1983 to 2004. It was of the bioremediation sites in Superfund. The project scope included Agency negotiation, contract administration, health and safety, public liaison, engineering documentation, and design of site remediation including on-site land treatment cells designed consistent with hazardous waste landfill cell requirements and groundwater pump and treatment
- Project Manager for one or more RI, FS, RD, or RA tasks at the following CERCLA sites:
  - Petro Processors, Inc., Baton Rouge, LA
  - Bayou Bonfouca, Slidell, LA
  - Cleve Reber, Geismar, LA
  - Louisiana Army Ammunitions Plant, Minden, LA
  - Bayou Sorrell, Plaquemine, LA
  - Hardage/Criner, McClain County, OK

  Accordingly, Dr. Campbell is knowledgeable with pertinent CERCLA guidance documents
- Project manager for the Star Lake Canal Superfund Site in Port Neches, Texas Assistance in the preparation of the Tier 1 Remedial Investigation (RI) work plan including the sample and analysis plan (SAP) and quality assurance project plan (QAPP). Management of a comprehensive field team and field effort during completion of the Tier 1 RI field work. Review of site data including the evaluation of sediments and surface water in a tidally influence coastal environment. Preparation and submittal of the draft Tier 1 RI Report and revised draft Tier 1 RI Report. Preparation of a draft Tier 2 RI work plan and completion of comprehensive meetings with representatives of the USEPA, Texas Commission on Environmental Quality, National Oceanic and Atmospheric Administration, U.S. Fish and Wildlife, Texas Department of Fish and Wildlife, and numerous other agencies The

primary topics of the work included human health risk assessment, ecological risk assessment and evaluation of potential remedial alternatives

- Project manager for the plugging and abandonment of over 138 wells at the Tar Creek Superfund Site in Ottawa County, Oklahoma. The work was authorized by a Record of Decision (ROD) for Operable Unit Number 1 (OU1) that included actions to eliminate acid mine drainage and protect citizens from the impact of mining waste over an approximately 40-square mile area in southwestern Missouri, southeastern Kansas and northeastern Oklahoma. The Tar Creek site includes the Old Picher Field lead and zinc mining area Underground mining using the room-and-pillar method began in the 1890s and ended in the early 1970s As water entered the abandoned mine workings, the reaction with exposed formations caused acid mine drainage with high concentrations of metals with discharges to the surface via springs, boreholes, and shafts. The area has over 800 acres of floatation ponds and over 75 million tons of chat above grade. Tar Creek was previously ranked No. 1 on the National Priorities List of CERCLA sites. OU1 included design and construction of diversion canals to direct surface runoff along controlled pathways rather than through mining wastes and plugging and abandonment of wells so that groundwater would not impact the underlying Roubidoux aquifer, the primary drinking water source for the area Dr Campbell attended numerous public meetings and presented progress reports Work included daily supervision of the well abandonment
- Project Manager for the Ninth Avenue Superfund Site in Gary, Indiana in USEPA Region 5. The work included collection of over 300 soil and groundwater samples with the field team in Level B personal protective equipment; sample analysis including data validation; remedial investigation report including risk assessment, feasibility study, remedial design of a soil bentonite slurry wall and related site remedial action
- Design of containment and groundwater recovery, treatment, and discharge system at a 7-acre site known as the Goose Farm Superfund site in U.S. EPA Region 2, New Jersey. The site is funded by Potentially Responsible Parties (PRPs) and involved volatile and semivolatile organic constituents. Special features involved groundwater modeling, design of slurry wall cap, infiltration trenches, recovery wells, air stripper, fume incinerator, and carbon treatment
- Review of the remedial design of a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site within U.S. EPA Region 5 and within the jurisdiction of the Illinois Environmental Protection Agency (IEPA). The site remedy involved the cleanup of chlorinated organics and their transformation compounds in soils and groundwater. The proposed remedy used a series of off-site recovery wells, air stripper, carbon adsorption, and infiltration at a cost of about $4 million. A significantly less expensive alternative was proposed and implemented
- Completion of Risk Assessment and Feasibility Studies for a 1,600-acre Army site near St Louis, Missouri. The work was done in accordance with CERCLA and SARA criteria and the constituents of concern are nitroaromic and lead compounds in soils and groundwater
- Project Director for two Superfund sites within USEPA Region 6 under the Superfund Amendment Reauthorization Act (SARA) involving the technical and legal-regulatory issues pertaining to volume, toxicity, and mobility of contaminants and site remedial actions
- Evaluation of the potential impact of facilities within a former topping plant that included tank farms, pipelines, and related facilities. Managed all work that has encompassed several years of effort and includes the preparation of work plans, collection of data, and submittal of documents consistent with Louisiana RECAP requirements. Based on the site investigation and successful risk evaluation, over 90 percent of the site has been released from additional investigation and 4 areas remain as Areas of Investigation (AOIs)
- Dr. Campbell completed an evaluation of the threat of a release to navigable waters, including a determination of the potential existence of navigable waters in the vicinity of the Muslow 20 Tank Battery located within the Caddo Pine Island Oil and Gas Field, Caddo Parish, Louisiana The site is

approximately 28.7 stream miles from the Red River. The Muslow Site consisted of a tank battery, an oil/water separator, 19 production pits, and 17 abandoned/orphaned wells. The Coast Guard and EPA completed a removal action and the basis for the action was a determination that the conditions at the Site posed a substantial threat of a release to the environment. The Oil Pollution Act of 1990, authorizes the appropriate agency to take actions at locations that present imminent and substantial danger to the environment, as a result of a discharge of oil into "navigable waters" Dr. Campbell demonstrated that the unnamed tributary located approximately 3,000 feet south of the Site is not a contiguous body of water and is instead designated as an intermittent stream. Research did not reveal any data that indicated that the intermittent stream was ever used for commerce

- Project Director of a Consent Order from U.S. EPA Region 6, requiring implementation of project tasks including Agency negotiations, remedial investigation, detailed analysis of alternatives, design and construction management, and closures for 17 solid waste management units (SWMUs). The work resulted in budgeted expenditures exceeding $50 million. The RCRA-driven project encompassed 10 years of site activity

Groundwater Projects

- Project Coordinator for a site assessment of a commercial property in southern Louisiana with impact by perchloroethylene to 180 feet depth. The site received regulatory and legal assessment in the development of alternative action plans
- Development of a groundwater recovery program for a site in northern Indiana involving DNAPLs and Floating Non-Aqueous Phased Liquids (FNAPLs). A recovery program was successful in DNAPL recovery
- Project Director of several investigations and remediations involving DNAPLs encountered in the subsurface at depths to 200 feet. Dr. Campbell has authored technical publications and made presentations at seminars in this area of specialized expertise
- Completed Underground Injection Control (UIC) projects for sites in Louisiana, Arkansas, and Texas consistent with state and OSEPA regulations and permit requirements
- Development and oversight of over 20 groundwater monitoring plans
- Conducted and completed eight groundwater migration investigations with aquifer risk assessments, including constituent computer modeling, technical representative for the nation's largest abandoned hazardous waste site, and expert testimony in litigation cases Most work routinely required frequent Client and Agency liaison
- Completed evaluation of the groundwater at several sites which resulted in pursuit of natural attenuation with monitoring as an alternative
- Completed an evaluation of a groundwater pump and treat project with 20 years of operational data Prepared a comprehensive analysis report that was accepted by the EPA and state agencies for reduction and cessation of pumping. The primary constituent of concern was trichloroethylene
- Completed a comprehensive groundwater model for a portion of the Red River Waterway watershed for the U.S. Army Corps of Engineers, New Orleans District, for the design of five locks and dams. The objective of the model was to define the impact (if any) of the locks and dams (pools) on the shallow groundwater table including the potential impact that the groundwater may have on the soil stability and agriculture near the waterway
- Project manager in support of litigation to defend industrial operations for 25-year duration site activity with dominantly potential groundwater impact, work included evaluation of activities on ground surface that may have impacted the subsurface including, leaching of salt caverns, brine ponds, surface water drainage, effectiveness of soil bentonite slurry walls, electromagnetic survey

interpretation, groundwater pump treatment, and evaluation of investigation collected data including Cone Penetrometer Testing

Compliance / Permitting

- Provides Professional Engineer (PE) review of permit applications for National Pollutant Discharge Elimination System (NPDES): Publicly Owned Treatment Work (POTW) discharge permits, Stormwater Pollution Prevention Plan (SWPPP) permits; Spill Prevention, Control, and Countermeasures (SPCC) permits; and erosion and sediment control plans
- Provides PE review of permit applications for Comprehensive Nutrient Management Plans (CNMPs) for agricultural facilities throughout the Midwest and South
- Provides PE review of permit applications for U S Army Corps of Engineers (USACE) Wetlands Section 404 permits
- Provides PE review of permit applications for remedial designs in accordance with CERCLA, RCRA, and state programs including waste minimization plans Such permits frequently include an air permit application or verification of compliance with air quality regulations
- Prepared a Resource Conservation Recovery Act (RCRA) Facility Investigation work plan for a major chemical facility in northern Ohio that was under the jurisdiction of the Ohio Environmental Protection Agency (OEPA), U.S. EPA Region 5 and the Nuclear Regulatory Commission (NRC). The RFI work plan was implemented and resulted in several additional activities that included a corrective measure study (CMS) and closure of solid waste management units (SWMUs) on-site in accordance with USEPA and the NRC using 10CFR Part 20.2002. The sample collection and laboratory analysis plans were included in the Quality Assurance Project Plan (QAPP) consistent with EPA and NRC standards and met all Quality Assurance/Quality Control (QA/QC) requirements of NRC and EPA The design and construction of a RCRA on-site landfill cell were consistent with all EPA RCRA criteria. The design served as the basis to allow authorization of the on-site cell to be used for placement of materials that contained concentrations of uranium within accepted regulatory limits

Property Transfer Projects

- Property acquisition analyses at multiple facility locations for five major corporations. Nearly all of the facilities had RCRA permits or were applying for RCRA permits at various waste management units. The work at more than 50 RCRA-regulated facilities involved the preparation of project planning documents, the execution of field work, analytical testing, data evaluation, estimation of potential remediation costs, and completion of compliance review opinions The work was completed on a rush basis due to schedule requirements
- Site and building decontamination. Removal of drums, contaminated soils, asbestos, biologic wastes, stacks, siding, foundations and piping, razing of several structures consistent with Agency requirements
- Development of remediation plan for a major paint manufacturing plant, Agency liaison for a Consent Order, and coordination of building decontamination including razing of structures, asbestos cleanup, tanks, and associated debris
- Completed several Phase I/Phase II environmental site assessments and compliance audits in accordance with ASTM standards

Mine and Mine Tailing Related Projects

- Promoted, planned, supervised, completed, and reported on over 20 projects in mine tailings disposal and water resource investigations. Aspects of work included sophisticated subsurface, field and

laboratory investigations, slope stability analyses using computer methods, maximum probable flood studies, hydrogeology, seepage, and spillway designs; erosion control, and wastewater treatment designs. Each project included field implementation of designed remedies and frequent Client and Agency liaison

- Completed hydrology and hydraulic design of spillways, channels and related appurtenances for over 15 coal refuse disposal facilities in Pennsylvania, West Virginia, Virginia, Tennessee, Kentucky, and Ohio All facilities were designed to withstand 40 percent of the probable maximum flood consistent with federal and state requirements hydrology
- Completed site assessment and evaluation of potential impact to surface water and groundwater by a release of about 250 million gallons of coal slurry from a mining operation in Appalachia. Work included collection of data, development of sampling and analysis plans, coordination with numerous regulatory agencies, the public, and development of a downstream water user forecast or notification program, including streamflow and sediment transport analyses. The accurate forecast model resulted in savings to downstream water users of several millions of dollars
- Completed an evaluation of the generation of acid rock drainage (ARD) at a large highly-publicized gold mine in Colorado that is under the jurisdiction of CERCLA. Work was completed on behalf of a law firm in support of litigation. The work included evaluation of historical production of ARD and potential addition of ARD as caused by mining operations during the 1980s
- Completed mining and mine plan investigations for ore reserves in the western U.S. that included precious metals, ore reserve and environmental studies; completed mining plans for coal reserves in Wyoming, Illinois, Indiana, Ohio, and Pennsylvania that implemented a decision tree matrix method of selection of reserves, below ground and near surface, ore management facilities planning, transportation and delivery of product to market. Work in the western U.S. included substantial environmental characterization work to meet federal standards

Dewatering and Groundwater Control

- Project engineer for the design and implementation of a dewatering project to dewater a 10-ft diameter tunnel, 80 feet below grade with the static groundwater depth 30 feet below grade and underlying bedrock, approximately 10 feet deeper than the tunnel invert elevation. The length of the tunnel was more than 10,000 feet and the number of wells was approximately 1,000 (all wells were not required to be pumped simultaneously) The groundwater pump for dewatering was discharged into the aquifer at a distance sufficient so that there was no impairment to the ongoing groundwater effort. The tunneling project required approximately three years duration for construction and periodic evaluation of changes in site conditions and pumpage requirements along the tunnel alignment
- Project engineer for the design and implementation of a dewatering project in southern Louisiana to dewater an excavation of depth approximately 15 feet below ground surface immediately adjacent the firewater storage pond of the facility. The dewatering was accomplished through the design and construction of a sheet pile wall in combination with well points to depress the groundwater table to allow stability of the excavation beneath the groundwater table
- Project engineer in southern Louisiana of a dewatering system using well points to excavate the foundation for a landfill approximately 15 feet below ground surface for a facility near New Orleans and near the Mississippi River The wellpoint dewatering system depressed the groundwater table to allow safe construction without the use of structural barriers for a duration of two years
- Project engineer in southern Louisiana of a dewatering system using well points to excavate the foundation for a large excavation to a depth of approximately 15 feet below ground surface for a facility near New Orleans and near the Mississippi River. The wellpoint dewatering system depressed

the groundwater table to allow safe construction without the use of structural barriers for a duration of one year

- Project engineer for the design of a dewatering project for the excavation of a lock and dam along the Tennessee Tombigbee Waterway. The design involved the use of wellpoint system to depress the groundwater table nearly 30 feet below its static elevation and maintained the drawdown for a period of 2 years during construction

Civil Engineering/Geotechnical/Vibration

- Engineer of Record for over 950 structural assessments on behalf of insurance companies for residential and commercial structures in Louisiana, Mississippi, Alabama, and Texas following hurricanes Katrina and Rita Activities included site inspections, evaluations and report preparation The emphasis of the scope of work was an estimate of wind and water damage, the potential cause of damage and recommendation for repair
- Geotechnical engineer of record of the slope stability analyses, structural analyses, and submittals to Cook County, Illinois in the matter of excavation of over 200,000 cubic yards of soil from the streets and neighborhood of Barrie Park. The site was immediately adjacent to an interstate highway, a railroad, residences, utilities, including water, sewer, telephone, and internet cable. All engineering was submitted on behalf of Commonwealth Edison to multiple organizations to review to allow verification that damage to the nearby facilities would not occur
- Completed investigation, analyses and documentation of potential damage caused by vibrations as the result of pile driving near construction of substantial buildings in Shreveport, Louisiana. Work included assessment of subsurface geotechnical conditions, review and analysis of comprehensive vibration measurement records, inspection of utilities, including large diameter buried storm sewer, evaluation of soil settlement, retaining walls, and building distress
- Completed inspection, analyses and documentation of potential damage caused by vibrations to eight residences near Livonia, Louisiana, as the result of an explosion during drilling of a deep well Work included inspection of residences, structural evaluation of potential deflects, preparation of remediation cost estimates and reporting to counsel. Work is underway
- Completed inspection, analyses and documentation of potential damage to properties including residences and retaining walls caused by vibrations near a highway construction site near New Iberia, Louisiana. Vibrations were potentially caused by pile driving near a highway construction site. Work is underway
- Completed geotechnical evaluation of derailment site in northern Louisiana including analyses and design of a sophisticated wall system to support railroad loading during excavation of soil. Work was reviewed in detail by railroad and Louisiana Department of Transportation and Development (LDOTD) engineers to verify geotechnical and structural integrity
- Complete inspection, analyses and documentation of potential damage caused by vibrations to properties near the construction of a highway and bridge near Columbia, Louisiana. Work is underway
- Evaluation of construction during 1998 at the Louisiana Department of Wildlife and Fisheries facility at Woodworth, Louisiana regarding 92 impoundments, soils, synthetic liners, pumps, pipes, racerways, and appurtenances to estimate the cause for settlement, cracking, loss of watertight integrity and impairment. Additional facilities investigated included structures, parking areas, restrooms, and visitor stations regarding earthwork, concrete, and steel construction and quality. Numerous soil, concrete and synthetic liner samples were obtained, tested and evaluated by several engineering specialists in an effort to reconcile potential differences in opinions

- Evaluation of concrete at a facility near Alexandria, Louisiana to define alternative causes of an incident that included strength, surface treatment, curing chemicals, temperature, and moisture and the potential impairment to the performance characteristics Work included a reasonably comprehensive review of American Concrete Institute (ACI) and American Standard for Testing Materials (ASTM) for concrete Site samples were obtained and tested by CRA and others
- Evaluation of concrete at a construction site near Lafayette, Louisiana. Work included evaluation of concrete batch design, delivery records, temperature, time, placement techniques, water content, and related matters. The work included several site inspections and review of concrete test records completed by others

Risk Assessments

- Development of risk assessments in joint effort with toxicology experts for five sites to submit to regulatory agencies regarding corrective action
- Completion of a Risk-Based Corrective Action plan for a groundwater pump and treatment project involving chlorinated solvents released in a high yield aquifer. Implementation of the pump and treat has had substantial success during a 15-year pumping history
- Development of a risk assessment for an apartment complex near a site impacted by chlorinated solvents. Worked with toxicology experts and Louisiana RECAP criteria including submittal to the Louisiana Department of Environmental Quality and Louisiana Department of Health Services
- Review of project reports submitted in accordance with the Risk Evaluation Corrective Action Program for sites in Louisiana

Train Derailments

- Project Manager for the evaluation of subsurface impact as the result of a train derailment near Shreveport, Louisiana, on June 17, 2002 Approximately 18,000 gallons of a naphthalene-based solvent was spilled. The extent of the free product plume was determined and three French drains were installed to collect the LNAPL. Sheet piling was installed and approximately 6,800 cubic yards of impacted soil were removed. A risk assessment was conducted in accordance with the Louisiana RECAP. The LDEQ issued site closure in less than one year of the derailment
- Project Manager for the evaluation of subsurface impact as the result of a train derailment in Livingston, Louisiana, on September 28, 1982. Twenty-seven of the 43 cars carried hazardous waste. One tank car contained perchloroethylene (PCE) that was lost during the derailment. A slurry wall, recovery wells and a sump recovery system were installed to recover the PCE from the subsurface. The extent of impact was determined and approximately 70,000 cubic yards of soil was removed Groundwater pump and treatment continued for about 10 years
- Technical support including engineering evaluations, cost analyses, and agency liaison for the evaluation of subsurface impact from a gasoline spill In the mid-1980s a train struck a 5,000-gallon gasoline truck stalled on the tracks in Kenner, Louisiana. Due to the resulting gasoline spill and inferno, nearby residents were evacuated. The subsequent investigation showed gasoline constituents in soil and groundwater to depths of 20 feet below grade. The LDEQ took action with the transporter and eventually restored the site through the inactive and abandoned site division
- Technical support including engineering evaluations, cost analyses, and agency liaison for the evaluation of subsurface impact after a train derailment. On August 14, 2003, a train derailment occurred that consisted of 136 railcars. Of the 33 cars remaining on site, four of the railcars had a release of contents consisting of approximately 15 pounds of cyanuric acid crude, approximately 20,000 gallons of petroleum oil, approximately 50 gallons of a liquid containing ethoxylate, and approximately 40 gallons of creosote material The released materials were contained in the proximity

of the derailment and did not enter the surface waters of the State. Approximately 400 cubic yards of impacted soil was excavated and removed from the site. Groundwater monitoring continues

Administrative Order Work

- Development of Agency Consent Order for closure of over 20 waste management units at one site including issues of solidification, chemical recovery, incineration, on-site vaulting, in-place closure, groundwater control, treatment and disposal, and deep well injection
- Completion of four CERCLA Remedial Investigation/Feasibility Study (RI/FS) investigations of major abandoned sites
- Development of eight closure plans submitted for Agency review

Underground Storage Tank (UST) Projects

- Management of four regional contracts with major oil companies for definition, Agency liaison, and remediation of UST management. Work responsibilities included. safety, planning, subcontracting, drilling. sampling, testing. Agency liaison, and reporting

Agronomy and Agricultural Projects

- Completed coursework and projects for providing technical services to the United States Department of Agriculture Natural Resources Conservation Service in multiple states Typically these evaluations and designs include nutrient management planning, rainfall-runoff analyses and vegetation or revegetation issues
- Completed four projects at sites with the specific project objective to restore vegetation The constituent of concern was salt at each site

Other Projects/Experience

- Project manager for a site evaluation of an industrial facility in Baton Rouge, Louisiana that discovered concentrations of polychlorinated biphenyls (PCBs) in soils that exceeded the acceptable regulatory limit. The detections were encountered beneath concrete pavement, parking areas, and drainage pathways. After an investigation a plan was prepared, approved by LDEQ and implemented that involved removal and off-site disposition of concrete and soil, backfill, and site restoration. The investigation, closure and approval were under the jurisdiction of LDEQ
- Project manager of an investigation of potential soil and groundwater impact of a site in northern Louisiana in accordance with Louisiana RECAP requirements. Work required coordination with regulatory agencies and a confidential client The project area evaluated was several hundred acres and included potential impact to residences, commercial buildings, apartments, churches, pipelines, and other facilities
- Project manager of site evaluation of detection of polychlorinated biphenyls (PCBs) in a transformer at an industrial facility near Houma, Louisiana. The transformer oil and carcass were tested and an off-site disposition plan implemented that included incinerator of the PCB-impaired oil and landfill disposal of the carcass.
- Project manager for an owner of 27 transformers that included testing, reporting, and off-site disposition in accordance with applicable regulations of the oil and carcasses of the transformer units. Approximately 50 percent of the transformers contained oil with concentrations of polychlorinated biphenyls (PCBs) that exceeded regulatory limits and required action
- Confidential Client Management, documentation, and disposition of destruction of 12 drums of waste containing 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) or dioxin, CAS No. 1746-01-6. The

project included characterization sampling and testing to define disposal issues, and search for competent sites to complete the incineration of the solids. The activity included a comprehensive review of U.S. and international packaging, transportation, and destruction of the drum requirements. Dr. Campbell supervised staff to prepare incineration specifications, plan transportation. accompany and oversee the shipment by truck, rail and sea to the selected incinerator site in Sweden Staff traveled to the incinerator facility, oversaw the incineration and returned with certification of destruction The documentation submitted to the client included a comprehensive chronological log of activity, manifests, records, and photographic record. Confidential Client; Location: Illinois; Engineering fees: $35,000; Total cost: $150,000

- Project manager of site evaluation of detection of polychlorinated biphenyls (PCBs) in a transformer at an industrial facility near Houma, Louisiana. The transformer oil and carcass were tested and an off-site disposition plan implemented that included incinerator of the PCB-impaired oil and landfill disposal of the carcass.
- Project manager for an owner of 27 transformers that included testing, reporting, and off-site disposition in accordance with applicable regulations of the oil and carcasses of the transformer units. Approximately 50 percent of the transformers contained oil with concentrations of polychlorinated biphenyls (PCBs) that exceeded regulatory limits and required action
- Confidential Client. Dr. Campbell provided expert testimony support regarding the loss of integrity to a benzene pipeline located in Geismar. Louisiana. The benzene pipeline extended beneath a highway and lost it is integrity as a result of corrosion Extensive emergency response and long-term response were required to restore the Site An evaluation was performed on the site and of nearby pipelines to determine the potential cause of the failure and the potential interrelationship of the surrounding pipelines that may have caused the pipeline failure and potential loss of the pipeline integrity
- Project manager to evaluate and address the potential for stress corrosion cracking in an ethanol pipeline near Arlington, Texas. It was anticipated that an existing 8-inch diameter underground pipeline constructed of carbon steel in about 1988 was to be used to transport the ethanol. The pipeline was designed and constructed in 1988 and was about 4,000 feet in length. Dr. Campbell determined that the primary cause for concern for a pipeline in service to carry ethanol is the "insidious" characteristic that there is little or no indication (or warning) of damage until a failure occurs
- Project manager of an investigation of the indoor air quality (IAQ) complaints at the Lafayette, Louisiana airport Air Traffic Controller building Dr Campbell evaluated the history of "asthmatic conditions" experienced by workers, the building design, operation, and maintenance, and the design, operation, and maintenance of the HVAC system. The work included an evaluation of IAQ circulation and building comfort as defined by air controllers. The investigation determined that the HVAC system was not operated with recommended guidelines. A questionnaire was designed based on interviews with building user groups
- Project manager for the completion of secondary containment feasibility study and preliminary design for a pipeline terminal in Jefferson County, Texas. The pipeline terminal consisted of eight 80,000 barrel aboveground storage tanks and associated station piping. Activities included topographic survey review, release scenario evaluation. containment volume calculation, development and evaluation of containment alternatives and design calculations and recommendations
- Preparation and submittal of a Potable Water Distribution Identification Plan for two pipeline facilities in southern Louisiana. Activities included the identification of on-site potable water piping and outlets, performance of a formal cross connection control survey of the facilities, and preparation and submittal of a formal Distribution Identification Plan for all on-site piping

- Project Coordinator for investigation of a 10-story office building in the southern U.S. to define existing conditions regarding assertions that the building exhibited poor indoor air quality (IAQ). The investigation included review of building design, HVAC system audit, and collection of qualitative IAQ samples for determination of the presence/absence of molds, fungi, and bacteria. The investigation is continuing
- Project manager assessing the IAQ odor problem experienced at the Methodist student center on the LSU-Natchitoches campus After building inspection and interview with management, the potential source of IAQ molds, constituents, and odors was defined. The building was modified by elimination of the potential odor source and the problem resolved
- Promoted, planned, supervised, and reported on over 15 projects in soil mechanics, water resources, and land development. Work elements included dam and spillway designs, foundation settlements, river modeling, shopping center developments, pipeline subsurface investigations, vibration analyses, and expert testimony. The majority of the projects required securing numerous permits from multiple regulatory agencies
- Promoted, planned, conducted, supervised, and reported on projects in civil engineering including soils, water, and environmental aspects. Work elements included probable maximum flood studies, expert testimony, hydrographic surveying, dredging, environmental impact studies, pipeline design, dam and spillway design, sediment transport, and hydrogeologic investigations. The majority of the work required frequent Agency liaison
- Completed analysis, testing, and modification of pump and piping networks experiencing corrosion, erosion, surface deterioration; design and analysis of materials of construction to combat attack from products being transported and the environment, including design of double-walled piping systems to reduce the potential of a release to the environment
- Served as a commissioned officer aboard NOS ships Rude, Heck and Whiting on Atlantic and Gulf Coasts from 1969 to 1972. Also, served for engineering underwater diving for dam safety inspections from 1973 to 1976.
- Served as operations officer aboard three survey ships conducting photogrammetric, hydrographic, and oceanographic surveys along the Atlantic and Gulf coasts

Expert Testimony and Lectures

- Expert witness in litigation involving technical issues
- Lecturer at conferences and association meetings
- International lecturer at Commonwealth of Independent States (CIS) hazardous waste seminars and other international, regional, and local conferences
- Participated in comprehensive review of work plans, agency review history, data collection programs, RIFs and ecological risk assessment of an ecological site reportedly impacted by surface water discharges for a 50-year duration. The southern Louisiana site received high visibility and review by federal, state, and local regulators. The work involved coordination with and management of specialists in planning, estuarine ecology, surface water and dredge spoil assessment, leachate studies, and construction cost estimation. The work product resulted in settlement of the litigation

PUBLICATIONS/PRESENTATIONS

- Campbell, P.L., H.L. Crouse, and J.T. Gormley, "Carbon Dioxide Problems in Compressed Air Tunneling", Proceedings, Rapid Excavation and Tunneling Conference, published by the American Institute of Mining, Metallurgical and Petroleum Engineers, Inc., Vol. 1, pp. 206-221, 1979

- Campbell, P.L. and B.P. Bundy, "Clean-up of the Tate Cove Abandoned Hazardous Waste Site, Evangeline Parish, Louisiana". ASCE, Environmental Division Conference, Atlanta, GA. 1984
- Campbell, P.L., R.C. Bost, and R.W. Jacobsen, "Subsurface Organic Recovery and Contaminant Migration Simulation". Proceedings, Fourth National Symposium and Exposition of Aquifer Restoration and Ground Water Monitoring, Columbus, Ohio, 1984
- Park, D.W. N.E. Garland, and P.L. Campbell, "Case History: Remedial Action Program for Ground Water Contamination with Chlorinated Hydrocarbons at Major Industrial Site", AIChE, Hazardous Waste Conference, 1984
- Campbell, P.L., "Automated Hydrographic Survey Systems", Ocean Engineering III Conference, Newark, Delaware, 1975
- Campbell, P.L., "Time Series Analysis of Stream Flow Data at Adjacent Allegheny River Gaging Stations", Doctoral Dissertation, Carnegie-Mellon University, Pittsburgh, Pennsylvania, 1973
- Campbell, P.L., "Recovery of Heavy Organics, Case History", Canadian Petroleum Association, Prevention and Treatment of Groundwater and Soil in Calgary, Alberta, Canada, May 1989
- Campbell, P.L., "Recovery of Dense Non-Aqueous Phase Liquids Using Wells", Proceedings, Third Annual Hazardous Materials Management Conference/Central, Rosemont, Illinois, March 1990
- Campbell, P.L., "Hydrology Related to Hurricane Katrina", Louisiana Claims Association 12th Annual Educational Conference & Expo, Paragon Casino Resort, Marksville, Louisiana, June 2006
- Campbell, P.L., "Protecting Groundwater Resources Through a Successful Wellhead Protection Program in Louisiana", Lorman Education Services, Baton Rouge, Louisiana, July 2006
- Campbell, P.L., "PAH Biodegradation Techniques and Applications: Old Inger Superfund Site & Paradis Gas Plant", Environmental Protection Agency Region 6, and the Louisiana Department of Environmental Quality, Louisiana, August 2007

DON001179

EXHIBIT B

TO

AFFIDAVIT OF

PRESSLEY L. CAMPBELL, Ph.D.,PE

Figure 1
Grand Lake St. Marys
ver Creek and the Wabash River in Mercer County, Ohio[1]

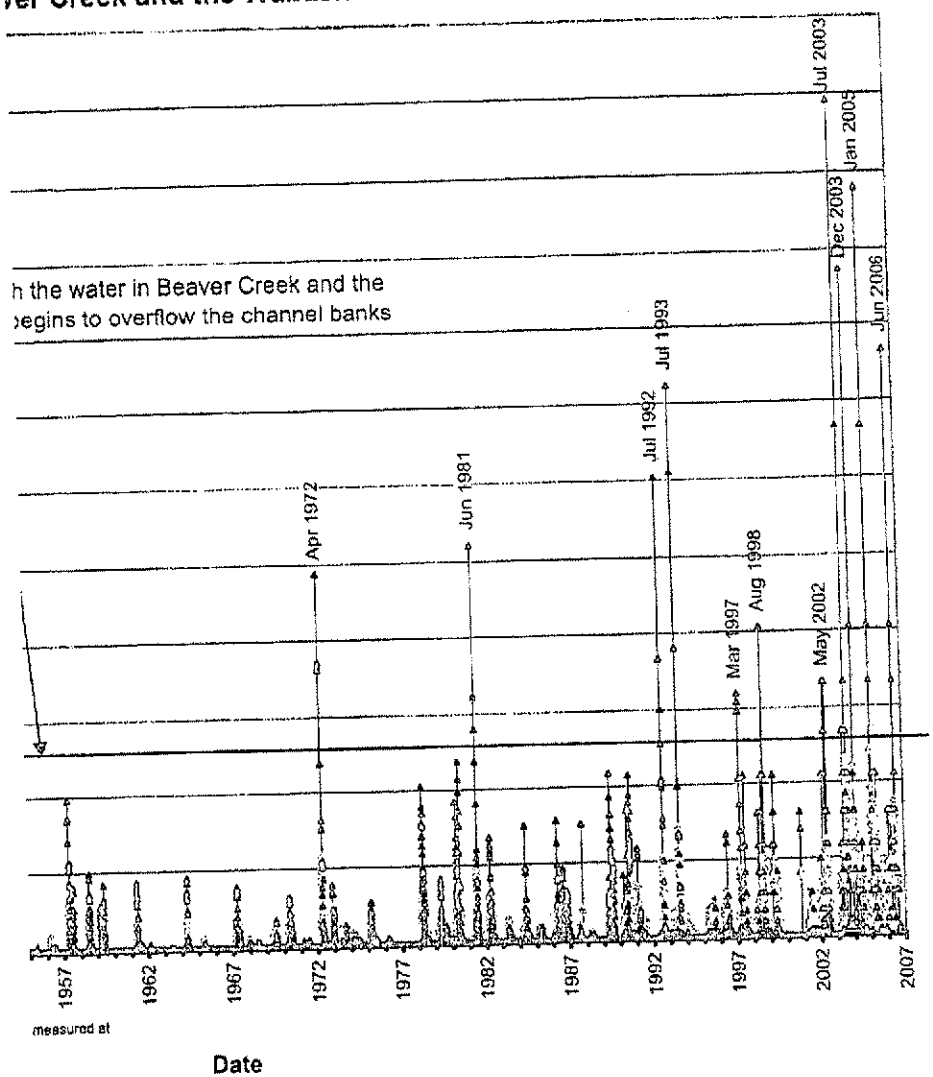

EXHIBIT C

TO

AFFIDAVIT OF

PRESSLEY L. CAMPBELL, Ph.D.,PE

TABLE 1

SUMMARY OF LAKE SURFACE LEVEL MEASUREMENT DATA
GRAND LAKE ST. MARYS
MERCER AND AUGLAIZE COUNTIES, OHIO

	APRIL 1, 1927 THROUGH JUNE 1, 1997 [1]		*JUNE 1, 1997 THROUGH AUGUST 21, 2006* [2]		*Difference in Percentage*
	Number of Measurements	*Percentage of Total Measurements (percent)*	*Number of Measurements*	*Percentage of Total Measurements (percent)*	
Total	23,305	100	521	100	0
Above 870.6 (feet msl)	4,994	21.4	382	73.3	51.9
Between 870.6 and 870.99 (feet msl)	2,720	11.7	78	15.0	3.3
Between 871.0 and 871.49 (feet msl)	1,711	7.3	167	32.1	24.7
Between 871.5 and 871.99 (feet msl)	461	2.0	122	23.4	21.4

Notes:
[1] Time period cited was prior to the construction of the 500-foot spillway.
[2] Time period cited is subsequent to the construction of the 500-foot spillway
msl = mean sea level

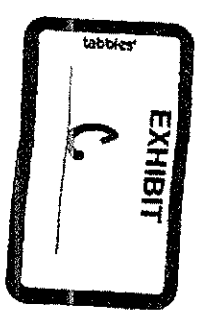

EXHIBIT D

TO

AFFIDAVIT OF

PRESSLEY L. CAMPBELL, Ph.D., PE

MERC
SOIL & WATER CO

717 W. Logan Stree

Telephor

Bob -
OFBF mtg is 12/3 & 4
Zumberge is a high ranker in OFBF & this may come up.
What are your thoughts on the Mercer SWCD letter.
Thanks in advance -

Karen -
Can these questions be answered. If so, I think we should respond.
I'll reply to Sally P for my thoughts to date.

RECEIVED
NOV 14 1991
SOIL & WATER CONSERVATION

Larry Vance
Ohio Department of Natural Resour
Fountain Square Building E.
Columbus, OH 43224

Dear Mr. Vance:

Larry, there is much heated discussion on the proposed west bank spillway. Much of the heat comes from the fact that the Division of Water has not had a good answer or any answer to questions the landowners along Beaver have. The Mercer SWCD office was not informed of the public meeting held in the county by the Division of Water. Many to be affected landowners also were unaware of the meeting.

Did SWCD contact landowners and inform them of the public meeting?

Concerns about Proposed Spillway

1. Data from the Division of Water indicated higher flows in Beaver Creek with proposed spillway but only out of bank flow at one place. This is not reasonable to anyone who sees Beaver Creek flow out of bank every year.

2. A study needs to be done showing what will happen to flood levels when spillway is operating and when the tributaries downstream of the lake are also contributing water to Beaver Creek.

Can hydraulic modeling be used to answer this.

3. The proposed spillway will remove water from the lake faster than the present spillway. How will existing road bridges be affected by this increase flow?

What is opinion of Co. Engineer on this?

4. How will the existing road bridges affect flood levels and duration?

5. The Wabash River is the outlet for Beaver Creek. How will the increase flow affect the flooding at this bottleneck?

6. What effect will the increase flow from the proposed spillway have on crops, bridges, roads and buildings? Will damage be more or less, with numbers to back up the statements?

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7. The landowners in the Beaver Creek watershed downstream of the lake did pay construction assessments and an paying maintenance assessments. They have a right to know what will happen - not just someone's best guess.

8. What does it take to have the state pay their share toward maintenance?

9. A management plan for drawdown of the lake needs to be developed. This would seem the best way of solving the varied interests between farmers and recreationists.

Your assistance in this matter is greatly appreciated.

Roger Knapke

Roger Knapke
Mercer SWCD Board Chairman

dw

Enclosure

KEITH G. EARLEY, P.E., P.S.
MERCER COUNTY ENGINEER
101 N. MAIN ST. - COURT HOUSE - ROOM 205
CELINA, OHIO 45822
PHONE 419-586-7759

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Dept. of Natural Resources
Division of Water

RECEIVED
DOW - DIRECTOR'S OFFICE

November 19, 1991

Francis Buchholzer
Director, Ohio Department of Natural Resources
Building 3D
Fountain Square
Columbus, Ohio 43224

RE: Grand Lake West Spillway Replacement

Dear Ms. Buchholzer,

The replacement of the west spillway is an important safety related project. I have reviewed information supplied by O.D.N.R., and I have reviewed the 1981 "Survey Report for Flood Control and Allied Purposes" prepared by the Louisville, Kentucky District of the Army Corps of Engineers. There are wide discrepancies between the two sources of data and I believe additional detailed analysis should be performed.

The Corps Report indicates an observed bankful flow of the Beaver Creek outlet being about 250 c.f.s. O.D.N.R. indicates a capacity of over 700 c.f.s. The Corps report indicates peak stage lake levels for the ten year through 100 year storms being approximately one foot higher than O.D.N.R. based on 51 years of record measurements. If the Corps report is correct, larger outflow will pass uncontrolled for long periods over the proposed 40 percent enlarged spillway to an outletting stream of very limited capacity. This situation could cause very costly damages especially to structures such as the Lakefront Racket and Health Club.

It appears to me that enlarging the spillway crest would cause more damage than good, even if O.D.N.R. figures are correct. Outlet graphs supplied by O.D.N.R. indicate no reduction in lake peak stage elevations for storms smaller than a 50 year storm. Even the 100 year storm only shows a 0.2 foot peak stage reduction. It appears that this minute rarely occurring reduction would be more than offset by increased damages along the Beaver Creek outlet. According to O.D.N.R. charts, the peak discharge is quadrupled for all storms larger than a ten year event and smaller storms were not analyzed.

It appears desirable for a lake regulation policy which balances the value and probability of attaining the desired recreation pool during desired periods with the cost of flood damages likely to occur around the lake and along the Beaver Creek

outlet. Perhaps the Beaver Creek outlet could economically be improved to safely handle increased outflows. Perhaps combining this increased capacity with a lake regulation policy, that includes the benefits of weather forecasting, could allow routing of peak flows through the Beaver Creek outlet at times when the outlet can handle the flow, and allow holding back flows during short periods while the peak from local storms subsides. Widening the upper three miles by approximately six feet is one alternative I believe should be studied.

A detailed study such as those designed by the Corps of Engineers Hydraulic Engineering Center (HEC) would be time consuming and expensive, but valuable. It is quite possible that such a study could not only provide much improved results, but even reduce construction cost. The study should include detailed damage analysis around the lake and along the outlet including acres inundated, crop damage, structure damage, transportation and utility damage, along with benefit analysis for different alternatives along with an optimization procedure.

Mercer County maintains ten bridges over the Beaver Creek outlet and has long range plans to replace six of these structures. We intend to utilize federal highway off system funds known as BRZ funds. Perhaps enlarging those structures should also be studied.

I sincerely hope that O.D.N.R. gives these items adequate consideration.

Sincerely,

Keith Earley

Keith Earley, P.E., P.S.
Mercer County Engineer

KGE/arn

cc: Mercer County Commissioners
Senator Robert Cupp
Representative Jim Davis

KEITH G. EARLEY, P.E., P.S.
MERCER COUNTY ENGINEER
101 N. MAIN ST. - COURT HOUSE - ROOM 205
CELINA, OHIO 45822
PHONE 419-586-7759

RECEIVED
FEB 14 1992
Dept. of Natural Resources
Division of Water

February 12, 1992

Bob Goetemoeller
Ohio Department of Natural Resources
Building 3D
Fountain Square
Columbus, Ohio 43224

RE: Grand Lake West Spillway Replacement

Dear Mr. Goetemoeller,

The additional information which you provided to me was helpful and the meeting was also helpful. The improved lakeside flood relief of the proposed spillway is quite valuable and evidently the dam safety requirements do not allow any reduction in outlet capacity. It also appears that any additional flooding along the Beaver Creek is negligible in the lower portions of the Beaver Creek. However, I still have concerns regarding flooding near the spillway especially at the Lakefront Racquet and Health Club. The ground floor elevation at that facility is 858.8 and the lowest floor elevation is about three feet lower, where there are two racquet ball courts, locker rooms, saunas, whirlpools, tanning beds, baby sitting room, laundry room, and a furnace room, much of which is carpeted. If flood elevations get above 859 there could be some very expensive damage.

It appears certain that the new spillway will increase the likelihood of very damaging flooding to this facility. Perhaps this increased flooding could be eliminated by removing bottlenecks in the upper three miles of the Beaver Creek without any damage to the downstream owners. Perhaps a capacity equal to a twenty-six foot wide bottom width could be obtained at a reasonable price. I believe that floodplain elevations should be determined for the proposed spillway with the existing channel and for the proposed spillway with an enlarged channel. Those elevations should then be compared to the existing floodplain elevations.

The proposed spillway without the enlarged outlet stream will probably be a benefit to many people, but a detriment to a few. With the enlarged outlet stream, it could be a benefit to all. Since FEMA evaluated the current floodplain in 1989, it should be revised for any significant changes in the watershed. It shouldn't take that much additional work to elevate an enlarged channel condition at the same time. If it is relatively certain that the effects of this study would not change the spillway design, then this would not delay that project and could prevent future delays.

We appreciate the work and commitment that you have devoted to this project. It is to our mutual benefit that all aspects are adequately studied.

Sincerely,

Keith Earley

Keith G. Earley, P.E., P.S.
Mercer County Engineer

KGE/an

cc: file

MERCER COUNTY
SOIL & WATER CONSERVATION DISTRICT

717 W. Logan Street • Celina, Ohio 45822

Telephone: (419) 586-2548

3/9/92

February 26, 1992

Ohio Dept. of Natural Resources
Division of Water
Fountain Square, Bldg. E-3
Columbus, OH 43224

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SOIL & WATER CONSERVATION

Dear Chief,

We, as a board of supervisors, feel the proposed spillway at Grand Lake St. Mary's needs several things addressed or further studied to protect the cropland along Beaver Creek.

We understand the weir is being raised by 4" to the plank, that is now across the existing weir. If this is done, we request that the lake draw down be kept at the original weir level and the plank be used as a buffer zone. We feel the management of the lake level is a very important issue. A written management plan needs to be developed before spillway is built.

We feel the Department of Natural Resources has forgotten the farmer, as the Q10 design of the spillway will put 4 feet in Beaver Creek itself. The past year we had Q25 storms which puts out additional 3 feet of water in to Beaver. The increased flood over a dam of this nature will cause higher peak flows in Beaver Creek. We have a total of 7 feet of water into Beaver without any consideration of drainage into the Beaver Creek. The charts ODNR has, does not reflect a true picture of the banks. There is a difference between spoil bank and field levels. The average dept of Beaver Creek without spoil banks is approximately 8 feet.

We as a board of supervisors requested our staff to calculate the design of Beaver Creek with drainage from farm land into Beaver at State Route 118. There are 6828.40 acres. The ditch design used was the counties as built of Beaver Creek. The design used was as follow:

(a) 2:1 side slope
(b) 24' bottom
(c) 0.0003 slope ft/ft
(d) 0.040 n' value
(e) capacity 383.14 CFS Required for 6828.40

DON001190

The Beaver Creek, itself, would have 6.4 feet of water in it. The ditch itself is approximately 8' deep average. Therefore, in a peak rainfall all the drainage is going to be much greater with a 500 foot dam with a 50' weir 11" deep. Sure the spillway will handle Q10, but if not kept down below the buffer zone there will be no protection for the farmers downstream. We need to know what the new peak flood elevations will be and their duration.

Another thing we would like to address is the states water. If a landowner uses water from the lake for anything, they must have permission and pay for it. We feel, if you claim ownership of the water then you have an obligation when the water enters into Beaver Creek. There has been no maintenance money paid to the county for the permanent county maintenance as of this date. It can't be all a one way street. The state assumed 2/3 of the cost of clean out and should include in their budget on a continuing basis an amount for 2/3 of the annual maintenance. We realize their will be flooding at times, but sometimes measures can be taken to prevent these things before the get out of hand.

Sincerely,

Sam Hellwarth Jr.

Sam Hellwarth Jr.
Chairman
Mercer S.W.C.D.

cc: Jim Davis
Mercer Co. Commissioners
Bob Bash
Senator Cupp

DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
P.O. BOX 59
LOUISVILLE, KENTUCKY 40201-0059

November 23, 1992

RECEIVED
NOV 3 0 1992
DEPT
Chief Engineer

Operations and Readiness Division
Regulatory Branch (North)
ID No. 199101165-pmr

Mr. J. Bruce Pickens
Ohio Department of Natural Resources
Office of Chief Engineer
Fountain Square
Columbus, Ohio 43224

Dear Mr. Pickens:

This is in regard to your letter dated October 13, 1992, concerning a proposal to place fill material to replace an existing spillway, construct a new lake drain, and replace a bridge in Grand Lake St. Marys, in Celina, Mercer County, Ohio.

We have reviewed the hydrology and hydraulics data submitted involving the new spillway design. It has been determined that there is insufficient information to make a decision as to the effects that increasing the spillway capacity will have on flood frequencies and damages. You need to reevaluate the discharges downstream of the dam for the full range of events and use those discharges in the HEC-2 and evaluate the starting elevation used in the HEC-2 analysis. Further, it has been determined that the Ordinary High Water (OHW) elevation on the lake would be 871.0 rather than 874.5 shown on the application drawings. Our point of contact regarding the additional information requested is Mr. Ron Holmberg. Mr. Holmberg can be reached at (502) 582-5513.

If you have any questions concerning this matter, please contact this office at the above address, ATTN: CEORL-OR-FN or call Mrs. Rucker at (502) 582-5607.

Sincerely,

Doug Shelton
Chief, North Section
Regulatory Branch

HYDROLOGIC AND HYDRAULIC ANALYSIS
GRAND LAKE ST. MARYS DISCHARGE TO BEAVER CREEK
MERCER AND AUGLAIZE COUNTIES, OHIO

Case Leasing and Rental, Inc. Property
Celina, Ohio

Prepared for:

Schottenstein Zox & Dunn Co., LPA
250 West Street
Columbus, Ohio 43215

MAY 2006

Prepared by:
Conestoga-Rovers & Associates

4915 S. Sherwood Forest Boulevard
Baton Rouge, Louisiana 70816

Office: 225-292-9007
Fax: 225-292-3614

PENGAD-Bayonne, N. J.
Respondent
2

EXECUTIVE SUMMARY

This report[1] was prepared by Conestoga-Rovers & Associates (CRA) at the request of Mr. Stephen P. Samuels of the Schottenstein Zox & Dunn Co., LPA law firm (SZD), Columbus, Ohio, counsel for Case Leasing and Rental, Inc. (Case).

Case owns 21 acres of property in the City of Celina, Mercer County, Ohio, adjacent to Beaver Creek, and a few hundred yards downstream of the intersection of Beaver Creek with the west shoreline of Grand Lake St. Marys. The Lake is owned and operated by the Ohio Department of Natural Resources (ODNR). In July, 2003, following several days of rain, Case's property was flooded, resulting in approximately two million dollars ($2,000,000) of damage to a 87,500 square foot sports complex that Case had constructed on the property. CRA was retained to investigate the cause of the flooding. As a result of the investigation, CRA has determined that the flooding was caused by the design and replacement by ODNR of a 39.4-foot long spillway with a 500-foot long spillway (occasionally referred to below as the "replacement spillway") in 1997, which allows excessive amounts of water to discharge from the Lake into Beaver Creek. (Photographs taken following the 2003 flood of the western spillway, the Case recreational complex and other affected areas are attached in Appendix A.)

CRA's evaluation of the impact of the spillway on flooding along Beaver Creek included the review of all pertinent ODNR documents, the available historical rainfall and streamflow records for the area, an analysis of historical discharges into Beaver Creek, a review of previous hydrologic and hydraulic investigations performed by ODNR and others, computer modeling of historical and hypothetical storm events, and the determination of the magnitude and frequency of potential flooding along Beaver Creek. Based on this evaluation, CRA found that ODNR did not review and analyze most of the historical precipitation and streamflow data, and failed to perform a number of essential calculations.

As a result of these and other deviations from accepted engineering practice, ODNR significantly underestimated the severity and frequency of the flooding that the 500-foot spillway would cause in and adjacent to Beaver Creek. The design of the replacement spillway selected by ODNR has caused and will continue to cause significant flooding of properties, roads and bridges near Beaver Creek. ODNR's evaluation, analysis and selection of the 500-foot spillway alternative to address flooding in the area of Grand Lake St. Marys and, specifically, Beaver Creek was not consistent with accepted engineering practice.

[1] The opinions herein are based on information available at the time of submittal.

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INTRODUCTION

This report is organized as follows. The first section ("Background") provides some basic information about Grand Lake St. Marys, its spillways and the Case property. The second section ("Methodology") identifies the major topics, documents and information that CRA considered and reviewed to determine the basis of ODNR's design of the replacement spillway, the analyses performed (and not performed) by ODNR before its selection of a flood management alternative (i.e., the 500-foot spillway) plan, the standards and guidance pertinent to dam management and spillway design, and the alternatives available to handle high water conditions at the Lake. The third ("Analysis") and fourth ("Results of Analysis") sections describe the calculations, computer modeling and evaluations performed by CRA; and the results of that work. The fifth section ("Impacts Resulting from the Spillway Replacement") describes the effects of the 500-foot spillway on the frequency and magnitude of flooding in and adjacent to Beaver Creek. The last section ("Alternatives") identifies a number of flood control/management measures that were or should have been considered and implemented by ODNR, instead of or in addition to the 500-foot spillway design that was selected.

BACKGROUND

Grand Lake St. Marys

Grand Lake St. Marys (occasionally referred to in this report as the "Lake" or the "Reservoir") is located in Mercer and Auglaize Counties in Northwest Ohio. It was constructed in 1845 to serve as a "feeder lake" (i.e., a source of water) for the Miami and Erie Canal system. The Lake currently has two outlet structures (also known as spillways) that allow, in theory, for water to flow out of (discharge from) the Lake.

The History of the Spillways

An "outlet structure" (sometimes more casually referred to as a "spillway") is a man-made structure that allows water to flow out of (discharge from) a reservoir (or body of water) in a controlled manner.

Grand Lake St. Marys currently has two outlet structures, located on the eastern and western shorelines. The eastern outlet structure was originally built in approximately 1852 and discharges into a feeder canal which flows into the St. Marys River. In 1988, the eastern outlet structure was modified. Because of the size and design of it, only very minimal discharge from the Lake into the canal can occur. In 1914, a western spillway was constructed at Beaver Creek. (Previously, the western outlet/spillway was located at Coldwater Creek, which is

approximately 1.5 miles south of Beaver Creek.) When constructed, the 1914 Beaver Creek spillway was 39.4 feet in length with a crest elevation (height) of 870.27 feet above mean sea level (msl). In 1988, the height of the spillway was raised to 870.6 feet to better accommodate boating interests.

In 1979, the United States Army Corps of Engineers ("Corps") inspected Grand Lake St. Marys and determined that the probable maximum flood event (PMF) would cause the Reservoir to overtop the embankment that serves as the western shoreline, and recommended that ODNR, the owner and operator of the Lake, "develop and implement an acceptable plan to convey the design flood (the PMF) safely through the reservoir without overtopping the embankments." (The PMF is defined by ODNR as "the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the drainage basin under study"). ODNR is the agency with oversight and regulatory authority over the planning, design, permitting, construction and operation of all dams in Ohio, to assure that they do not constitute a hazard to life, health or property.

As is discussed in greater length below, ODNR did not investigate and adequately examine the available alternatives to comply with the Corps' recommendation to safely manage flood conditions at the Lake. One alternative it did consider was the modification and use of the eastern spillway to handle a portion of the PMF, which would reduce the flow into Beaver Creek from the western spillway during flood events. However, despite the recommendation by its consultant, Burgess & Niple Limited, this alternative was not implemented. Instead, ODNR selected and implemented a plan that routes all flood water into Beaver Creek by way of the western spillway. In 1997, ODNR replaced the 39.4-foot long western spillway with a horseshoe-shaped one that is 500 feet in length.[2] (Photographs of the current western spillway, Beaver Creek, and the feeder canal on the east side of the Lake, which were taken during a CRA site visit on November 2, 2005, are attached in Appendix B. The locations of the roads and other features in the photographs are depicted on Figure 2.)

The increase in the length of the spillway from the pre-1997 length of 39.4 feet to the post-1997 length of 500 feet has resulted in a substantial increase in the amount of water that can discharge into Beaver Creek during precipitation events. This has and will continue to result in substantial and frequent flooding to properties along Beaver Creek downstream of the spillway.

[2] The center fifty (50) feet of the spillway—the "notch"—is at elevation 870.6 feet msl, the same as the previous spillway. The remaining 450 feet of the replacement spillway is at elevation 870.75 feet msl and overflows into Beaver Creek during larger wet weather events.

The Case Property and surrounding area

The Case property (shown on Figure 1) is located at 6301 U.S. Route 127, just south of downtown Celina, and encompasses approximately 21 acres. The portion of Beaver Creek which lies approximately 800 feet to 1060 feet downstream of the western spillway forms the northern property boundary of the Case property. Case purchased the property in 1972, and constructed an approximately 87,500 square foot athletic/recreational complex on it. In 2003, flooding caused by the 500-foot spillway flooded the first floor of the sports complex to a depth of nearly four feet--the recreational facilities, locker rooms and other operations located on the lower floor were completely inundated--causing severe damage to the complex. (Aerial photographs, taken between 1973 and 2006, of the area in the vicinity of the Case property are attached in Appendix C.)

METHODOLOGY

CRA obtained and reviewed documents, information and other material related to the replacement of the western outlet structure at the Lake to determine the basis of design (including the calculations that had been performed and the evaluations that had been conducted); historical precipitation, streamflow and Lake conditions; drainage basin characteristics; federal and state regulations and policy and guidance documents applicable to dams and spillways; the potential alternatives available to ODNR to safely handle flood waters at the Lake; and other related topics. The topics, documents, information and items reviewed include the following:

- Historical data, including precipitation records from the National Oceanic & Atmospheric Administration (NOAA) meteorological stations, streamflow records from the United States Geological Survey (USGS) gauging stations, and Reservoir elevations ("Lake levels") from the Corps of Engineers and ODNR;
- Drainage basin characteristics for the Grand Lake St. Marys drainage basin, including area, shape, slope, land use, topography, soil types, Reservoir area and storage and other features. The Lake drainage basin (i.e., the geographical area that drains into Grand Lake St. Marys) is shown on Figure 2;
- Characteristics of Beaver Creek, including geometry, slope, roughness, constrictions and other features;
- Statutes, regulations, policy, guidance and other documents applicable to dams and spillways, including those pertinent to or authored by ODNR, the Federal Emergency Management Agency (FEMA), the Corps, and the United States Department of Agriculture Soil Conservation Service;

- Previous analyses, calculations, modeling and other evaluations of the Lake and the surrounding areas, the spillways and the alternatives performed by, among others, the Corps, the Ohio Department of Administrative Services, ODNR and its consultants;
- All documents obtained from ODNR relating to this matter pursuant to formal discovery by counsel for Case;
- An on-site inspection of the Case property (and other areas proximate to the Lake).

ANALYSIS

The major tasks performed by CRA were the following:

(1) Using actual historical recorded Lake level measurements, a calculation of the amount of water that was (or would have) discharged over the 39.4-foot spillway and the 500-foot spillway, respectively, into Beaver Creek. Based on the documents reviewed, this analysis was not performed by ODNR during spillway investigation/design.

(2) A determination of the most significant precipitation events (i.e., those that caused the most severe flooding) in the Lake area from 1913-2005 (the period for which precipitation data exists). Based on the documents reviewed, this analysis was not performed by ODNR (or others) during spillway investigation/design.

(3) Using the same computer models employed by ODNR, a simulation of actual historical storm events to determine the discharge that was (or would have) actually discharged over the 39.4 and 500-foot spillways into Beaver Creek during and following significant storm events.[3] Based on the documents reviewed, this analysis was inadequately performed by ODNR during spillway investigation/design.

(4) A simulation, using ODNR's computer models, to compare the discharge into Beaver Creek for the 39.4-foot spillway and the 500-foot spillway during and following hypothetical storm events of various intensities (10-, 25-, 50-, 100-year).

(5) An evaluation of the increase in the magnitude, frequency and extent of flooding along Beaver Creek for both historical and hypothetical storm events as the result of the replacement of the western spillway. Based on the documents reviewed, this analysis was not performed by ODNR during spillway investigation/design.

[3] The analyses described in paragraphs 1 and 3 are two different tools (using different inputs and methodologies and therefore generating somewhat differing outputs) that can be, and should have been, used to determine the effect that the 500-foot spillway would have and will have on flooding in Beaver Creek.

RESULTS OF ANALYSIS

A. HISTORICAL STORM EVENTS

Calculation and Comparison of the Historical Discharge into Beaver Creek

In lay terms, a stage-discharge relationship (sometimes called a rating curve) correlates the height of water at a particular point along a stream (or in a lake) with the amount of water that will flow past that point [or, in the case of Grand Lake St. Marys, over the western spillway] in any given unit of time, such as cubic feet per second (cfs). (To take a "commonplace" example, one could construct a rating curve to determine the rate at which water would overflow a sink based on the amount of water one poured into the sink.)

In the case of Grand Lake St. Marys (or indeed any reservoir where a major change to a spillway is contemplated), accepted engineering practice (and common sense) dictate that a comprehensive analysis of the effect of a change in spillway size be performed. One essential aspect of such an analysis is a calculation of the amount of water that did or would have flowed over the 39.4-foot spillway and the 500-foot spillway into Beaver Creek based on historical levels of the Lake. CRA performed this analysis.

Recorded water surface elevations in Grand Lake St. Marys from 1927 to 1978[4] were used with the stage-discharge relationships for the 39.4-foot spillway to calculate the amount of water discharged into Beaver Creek through the spillway during that period. These same water surface elevations were used with the stage-discharge relationships for the 500-foot spillway to simulate the conditions that would have occurred had the 500-foot spillway been in place between 1927 and 1978.

Figure 3 depicts the amount of water, measured as cubic feet per second (cfs), which did/would have discharged into Beaver Creek between 1927 to 1978 for the 39.4-foot spillway and the 500-foot spillways, respectively. Figure 3 shows that with the 39.4-foot spillway, there was no instance during the 49-year period that the Case property was (or would have been) flooded by Beaver Creek. By contrast, had the 500-foot spillway been in place during that time period, Beaver Creek would have overflowed its banks seven (7) times.

An analogy may help to explain these results. Beaver Creek is similar to a kitchen sink (including the drain pipe). The drain is sufficient to evacuate the water that can flow into the sink through the faucet (the metaphor for the spillway), even if the faucet is fully opened. However, if a fire hose is substituted for the faucet, the drain pipe is unable to handle the substantially increased amount of water that the fire hose can generate. The result is that the sink overflows. The replacement of the 39.4-foot spillway with the 500-foot spillway had the

[4] At the time CRA prepared this report, only this time period of lake levels were available.

same effect on Beaver Creek that replacing a kitchen faucet with a fire hose has on the kitchen sink. Beaver Creek can no longer contain and evacuate the increased amount of water. Therefore, it overflowed onto adjacent property, including that owned by Case.

There is no indication in the ODNR records that this type of analysis was performed by ODNR. The failure to perform this analysis of historical discharges to Beaver Creek to determine the potential impact that the 500-foot spillway would have on flooding violates sound engineering practice.

Determination of Historical Storm Events of Record

In order to determine which historical storms were potentially "severe", it is necessary to examine both precipitation data and corresponding streamflow information. The precipitation data dating back to 1910 were obtained from seven NOAA meteorological stations within a 35-mile radius of the western spillway; the stream flow (discharge) information was derived as described in the previous section. Based on these data, CRA determined that the following events had both a relatively large amount of rainfall and a correspondingly large amount of discharge into Beaver Creek and, accordingly, were chosen as "severe" historical storms of record that could potentially result in flooding for the area:

March/April	1913
December/January	1930
May	1943
March/April	1957
May/June	1958
April/May	1972
July	1992
June/July	2003
January	2005

Obviously, ODNR could not have evaluated the 2003 and 2005 events prior to 1997, when it replaced the western spillway. However, the ODNR records indicate that ODNR did not analyze the effects of the severe storm events that did occur prior to its design of the 500-foot spillway.

The importance of determining and analyzing the significant storm events of record during a flood management study is to obtain an understanding of how rainfall in the area has previously caused flooding. ODNR's failure to have performed this analysis is like redesigning a road without reviewing the amount of traffic that previously traveled on that road during rush hour. ODNR's failure to determine and analyze the actual severe historical storms of

record for the Grand Lake area that had a high potential to have resulted in flooding of Beaver Creek is not in accord with sound engineering practice.

Simulation of Historical Storm Events

The internet-based *Wikipedia* defines "hydrology" and "hydraulics" as follows:

> **Hydrology** is the study of the movement, distribution and quality of water. Observations of hydrologic processes are used to make predictions of future water movement and quantity. By analyzing the statistical properties of hydrologic records, such as rainfall or river flow, hydrologists can estimate future hydrologic phenomena.
>
> **Hydraulics** is a branch of science and engineering concerned with the mechanical properties of liquids and focuses on the engineering uses of fluid properties. Hydraulic topics range through most science and engineering disciplines, and cover concepts such as pipe flow, dam design, flow measurement and river channel behavior, among others.

Hydrologic and hydraulic modeling was conducted by CRA using the widely used and accepted Corps of Engineers-developed HEC-1 and HEC-2 computer programs. These are the same computer models that ODNR utilized in performing its pre-1997 flood management/spillway design analysis. CRA does not disagree with ODNR's decision to employ these tools. However, ODNR failed to use these tools to perform critical evaluations and simulations necessary to complete a sound engineering analysis.

In general terms, the HEC-1 computer program uses rainfall and hydrologic information (drainage basin physical and climatological parameters) to determine the discharge (amount of flow) that will occur at a given point. The computer model also has the ability to calculate the discharge as a function of time. This type of modeling is commonly used to simulate the effect of precipitation events.

In general terms, the HEC-2 computer program uses a discharge value (amount of flow per unit of time, e.g., cubic feet per second) and cross-section information (e.g., width, depth, slope) at a number of points along a stream to calculate the elevation of the water at those points. This type of modeling is commonly used to simulate the water surface elevations resulting from a discharge into a channel, such as Beaver Creek.

The documents obtained from ODNR contained HEC-1 and HEC-2 models as "set up" by ODNR during design of the spillway replacement. In other words, the models had the inputs selected by ODNR for the relevant parameters (such as drainage basin characteristics and Beaver Creek cross sections). All modeling conducted by CRA was performed using the HEC-1 and HEC-2 models as set up by ODNR; no parameters were changed. As ODNR had done,

CRA performed the simulations based on an initial lake elevation of 870.6 msl, the crest elevation of the western spillway. This water elevation was chosen because it represents a likely-to-occur—but by no means worst case—condition (i.e., the Lake is full but not overflowing).

ODNR used the model to predict the impact of the 500-foot spillway on Beaver Creek solely during the period February 1989 through June 1991. What ODNR failed to do was use the model to determine the effect that the 500-foot spillway would have during severe storms.

CRA input the historical storm events of record into the computer models to calculate the discharge into Beaver Creek for the 39.4-foot spillway and the 500-foot spillway that would result from severe storms. The results are shown on Table 1.

The model results of the nine historical storms demonstrate that, with the 39.4-foot spillway, the Case sports complex is not flooded during a single event. However, with the 500-foot spillway, water in Beaver Creek overflows the channel banks and inundates the Case property during three of the historical events: 1913, 1992 and 2003. The lower floor of the sports complex would be completely filled with water; water on the first floor would be, depending on the event, between two and four feet deep.

The Case property is not the only property affected. Modeling of the effect of the 500-foot spillway with historical storms of record reveals that the 500-foot spillway directly impacts many other properties. The extent of flooding resulting from the storm events that occurred in 1913, 1992, 2003 and 2005 is shown on Figures 4a and 4b through 7a and 7b. As these figures show, the 500-foot spillway results in repeated flooding of numerous properties over a significant area.

Information about the impact of the 1913 and 1992 historical storm events was accessible to ODNR prior to the design of the 500-foot spillway. To derive it, CRA simply applied ODNR's model to all actual historical storm data on record. ODNR should have performed this analysis. ODNR's failure to undertake this analysis, and its construction of a spillway that will repeatedly cause a stream to overflow its banks and flood adjacent property, does not comply with acceptable engineering practice.

B. HYPOTHETICAL STORM EVENTS

Determination of the Appropriate Design Storm Duration

One way of categorizing the intensity of storm events is by their frequency. A storm event that produces a substantial amount of precipitation occurs less often than an event that generates a modest amount of rain. Hydrologists refer to these storms by the likelihood that they will occur in any given year (e.g., 1 in 10, 1 in 50) or, alternately stated, the number of years that is likely to pass before a storm of a given intensity will recur (a return period of 25 or 100 years). These events are termed 10-, 25-, 50-, and 100-year hypothetical storms.

A factor that influences the effect that a given storm (historical or hypothetical) will have is the duration of the precipitation. Different drainage basins do not respond in the same manner to storms. Some experience the maximum flood impact sooner, some later. Sound engineering practice (and common sense) dictate that, in determining how to manage floods or design a spillway, the dam owner should determine the storm duration that causes the greatest amount of flooding in that particular drainage basin.

The hypothetical storm modeling performed by ODNR during design of the replacement spillway included the 2-, 10-, 25-, 50-, and 100-year events, using a duration of 72 hours. The probable maximum flood (PMF) was also modeled. To determine if the 72-hour duration selected by ODNR to model hypothetical storm events was appropriate, CRA evaluated the rainfall durations for historical storms of record.

The historical storms of record that have resulted in flooding in Beaver Creek have occurred with durations of approximately 120 hours or longer. Accordingly, CRA modeled the hypothetical 100-year storm for durations of 24, 48, 72, 96, and 120 hours and determined that the 96-hour storm duration is the storm duration that results in the most severe flooding for the 100-year storm event.

There is no indication in the documents produced by ODNR that it analyzed the historical storm events to determine what duration storm has the most significant impact on flooding in Beaver Creek. Seemingly arbitrarily, ODNR selected a 72-hour storm duration for its modeling purposes. As a result, ODNR underestimated the flooding that the 500-foot spillway would cause in Beaver Creek.

Simulation of Hypothetical Storm Events

However, even the 72-hour storm causes unacceptable results. CRA input the ODNR-selected 72-hour hypothetical storm events into the computer model, as set up by ODNR, and calculated the discharge into Beaver Creek for the 39.4-foot spillway and the 500-foot spillway. The

results, which are identical to those obtained by ODNR, are shown on Table 2. Although ODNR did model the discharge into Beaver Creek for (72-hour duration) hypothetical storm events, the records reflect that ODNR did not take the critical next step: modeling the flows in Beaver Creek to determine the increase in water surface elevation. Had it done so, as sound engineering practice dictates it should, ODNR would have discovered that the spillway would cause an unacceptable increase in the water surface elevation of the 100-year floodplain.

The model results indicate that the spillway replacement has significantly increased the frequency and magnitude for flooding of Beaver Creek and the surrounding properties. The model shows that discharge from the 39.4-foot spillway for the 100-year hypothetical storm event is contained within the Beaver Creek channel banks. However, the 500-foot spillway will discharge quantities of water such that storms even smaller than the 72-hour 50-year hypothetical event will overflow Beaver Creek and flood the surrounding properties. The model also reveals that the spillway replacement has resulted in an increase in the water surface elevation in the 100-year flood plain by more than four (4) feet, a result that is inconsistent with accepted engineering practice, Ohio Revised Code Section 1521.13 and ODNR regulation OAC 1501:21-13-11.

ODNR should have known, prior to replacement of the spillway, that the increase in length from 39.4 feet to 500 feet would significantly increase the flooding potential for properties surrounding Beaver Creek. To construct a spillway that substantially increases the likelihood of flooding to occur to roads, bridges, and property downstream of a spillway is strongly against accepted engineering practice.

IMPACTS RESULTING FROM THE SPILLWAY REPLACEMENT

Increased Potential for Flooding Along Beaver Creek during Storm Events

The replacement of the 39.4-foot spillway with the 500-foot spillway at the western embankment of the Lake has caused a significant increase in the amount of water that is discharged into Beaver Creek. When a storm event occurs, rainfall causes the water in the Lake to rise above the crest of the western spillway. When the storm is sufficiently severe—an event that has occurred multiple times over the last 90-odd years—the amount of water that enters Beaver Creek over the 500-foot spillway overwhelms the Creek's carrying capacity and causes flooding on the properties, including that owned by Case, in the vicinity of the Creek. (See figures 4a through 4d).

Increase in the 100-year Flood Elevation

The replacement of the western spillway has increased the 100-year flood [the elevation of water that will result from a 100-year storm] in the area surrounding Beaver Creek. Sound engineering practice dictates that the floodplain must be maintained without increasing the water surface elevation of the 100-year flood more than one foot at any point. ODNR's replacement of the 39.4-foot spillway with the 500-foot spillway has increased the 100-year flood elevation by approximately 4.4 feet at the Case property (Table 2). During the 100-year hypothetical storm event significant flooding now occurs, and will continue to occur, along Beaver Creek, where it did not occur prior to the spillway replacement.

The Case Property and the 100-year Floodplain

The Case property is located within the City of Celina, Ohio. The City of Celina Flood Insurance Rate Map (FIRM) was effective on March 18, 1986. The FIRM is a map developed by the National Flood Insurance Program (NFIP) within FEMA to show base flood elevations, risk zones, and floodplain boundaries. On March 18, 1986, the Case property was designated as Zone C, i.e., located in an "area of minimal flooding." Subsequent to the replacement of the western spillway and flood of July 2003, the FIRM was revised and became effective on November 1, 2004. The revised FIRM designated the Case property as Zone A, "areas of the 100-year flood, base flood elevations and flood hazard factors not determined." (The 1986 and 2004 FIRM maps are attached as Appendix D.)

The replacement of the western spillway directly resulted in higher flooding potential for properties located directly downstream, and this change of flood risk has been recognized by FEMA.

Increased Potential to Endanger Human Life and Safety

The ability of the 500-foot spillway to discharge a significantly larger quantity of water into Beaver Creek than the 39.4-foot spillway has resulted in an increased potential for injury and loss of life. For severe storm events, there are no preventative measures in place that will act to reduce the flow into Beaver Creek. The water that discharges into Beaver Creek from the 500-foot spillway has the potential to be moving at high velocities and can overflow the banks at a significant depth. These two factors have the potential to threaten human activity in the area surrounding Beaver Creek downstream of the spillway during severe storm events. Additionally, this discharge causes stress to the roads and bridges crossing Beaver Creek directly downstream of the spillway. Any use of these roads or bridges during or following a severe storm could be dangerous and a potential threat to life and safety.

ALTERNATIVES TO SAFELY HANDLE FLOOD CONDITIONS

Although it is well beyond the scope of this report to fully analyze all of the alternatives that should have been thoroughly evaluated by ODNR before constructing the 500-foot spillway—alternatives that should now be considered to safely manage flood conditions in Grand Lake St. Marys and Beaver Creek and to avoid future flooding of the properties along Beaver Creek (see Figures 4a-4d)—such alternatives do exist.

Use of the Eastern Spillway

In 1979, ODNR's consultants completed an evaluation to safely handle the probable maximum flood (PMF) through a combination of the eastern and western outlet structures. The evaluation recommended an alternative that included modification to the eastern discharge structure and accompanying canals to, "provide an east/west split of uncontrolled discharge capacity which is proportional to the drainage areas contributing runoff to the lake." Storm modeling computations conducted by ODNR during the study indicated that a modification of the eastern spillway would decrease the outflows in Beaver Creek, increase the outflows in the Feeder Canal, and safely handle the PMF such that it would not overtop the embankments. The recommended alternative was not implemented.

Construction of an Emergency Spillway

Another alternative is the use of an emergency spillway. A primary spillway is used to pass normal inflows; an emergency spillway is designed to engage during large flood events. Evaluation of the potential need for an emergency spillway is typically completed during design of a spillway. Based on the documents produced by ODNR, ODNR did not evaluate the potential use of an emergency spillway when it decided to replace the 39.4-foot spillway with the 500-foot spillway. Use of an emergency spillway may have allowed for the design flood to be accommodated through the Lake without having to increase the length of the spillway at Beaver Creek, or at least without increasing it by an order of magnitude, as was done. In the event that the design (or some significant percentage of the design) flood were to occur, the emergency spillway would act to discharge the additional flows.

Enlargement of Beaver Creek

Beaver Creek could be enlarged by deepening or widening the channel, changing the side slopes, redesigning bridge piers and/or other modifications. Such improvements would function in much the same way as would a larger drain in a sink, allowing more water to flow into and through Beaver Creek without causing it to flood. Based on a review of documents

produced by ODNR, this alternative did occur to ODNR prior to the spillway replacement. It was, however, not implemented.

The Use of Additional Diversions

Some portion of the water that flows into the lake could be diverted to additional outlet channels (rivers, creeks) located on the Lake. Diversion of some of the water away from the western spillway would prevent excess amounts of water from flowing into Beaver Creek. Possible diversion locations include Fourmile Creek and Coldwater Creek. Based on the documents produced by ODNR, this evaluation was not conducted.

Management of Lake Levels

Another tool available to mitigate the effect of severe precipitation events would be to maintain the Lake level at less than the crest height of the western spillway, thus increasing the Lake's storage capacity. When severe storms occur the Lake would be able to store a significant volume of inflow, therefore decreasing the flow to Beaver Creek over the western spillway and preventing or minimizing flooding.

Even when concerns were raised by reviewing agencies and knowledgeable members of the community (see the correspondence and telephone memorandum attached in Appendix E) about the likelihood that the 500-foot spillway would cause flooding in Beaver Creek—some of the letters even mention the Case property—, ODNR failed to adequately consider and implement alternatives.

CONCLUSION

It is not Case's or CRA's place to fully evaluate these alternatives and determine which of them, singly or in combination, is the best option for managing severe storm events. As the owner and operator of Grand Lake St. Marys, ODNR was responsible for the development and implementation of a plan that would safely manage and convey flood waters through the Lake without endangering life, health or property. It did not do that. Its decision to replace the 39.4 foot spillway with the 500 foot spillway did not comply with accepted engineering practice, caused severe flooding in Beaver Creek and the surrounding properties and severe damage to the recreational complex on the Case property. If ODNR does not take action to correct its mistake, flooding along Beaver Creek will continue to occur.

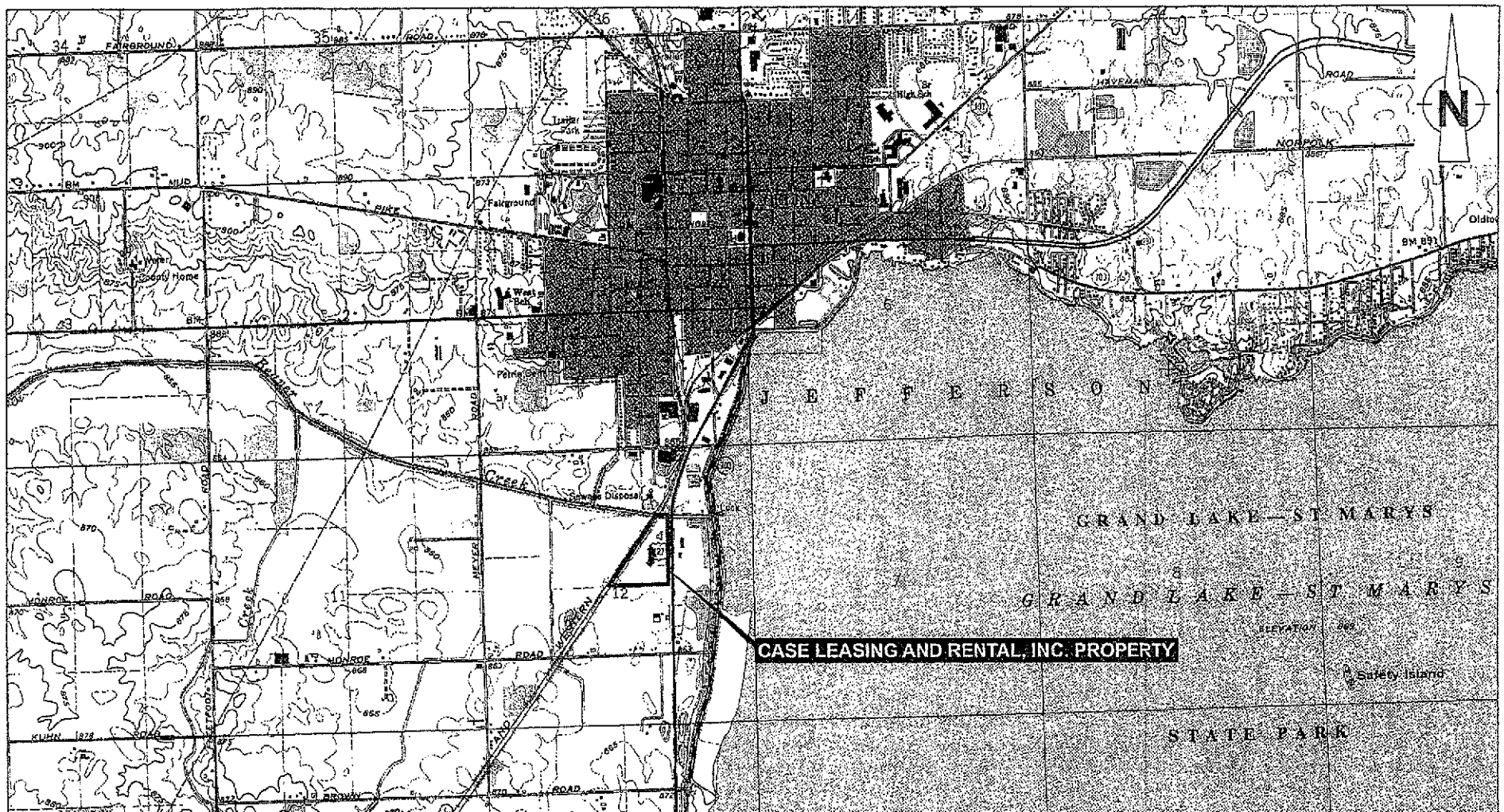
All of Which is Respectfully Submitted,
CONESTOGA-ROVERS & ASSOCIATES

Pressley L. Campbell

Pressley L. Campbell, Ph.D., PE
Ohio PE 56681

FIGURES

FIGURES



UNITED STATES GEOLOGICAL SURVEY DIGITAL RASTER GRAPHICS (CELINA AND ERASTUS)
DOWNLOADED FROM THE OHIO OFFICE OF INFORMATION TECHNOLOGY WEBSITE.

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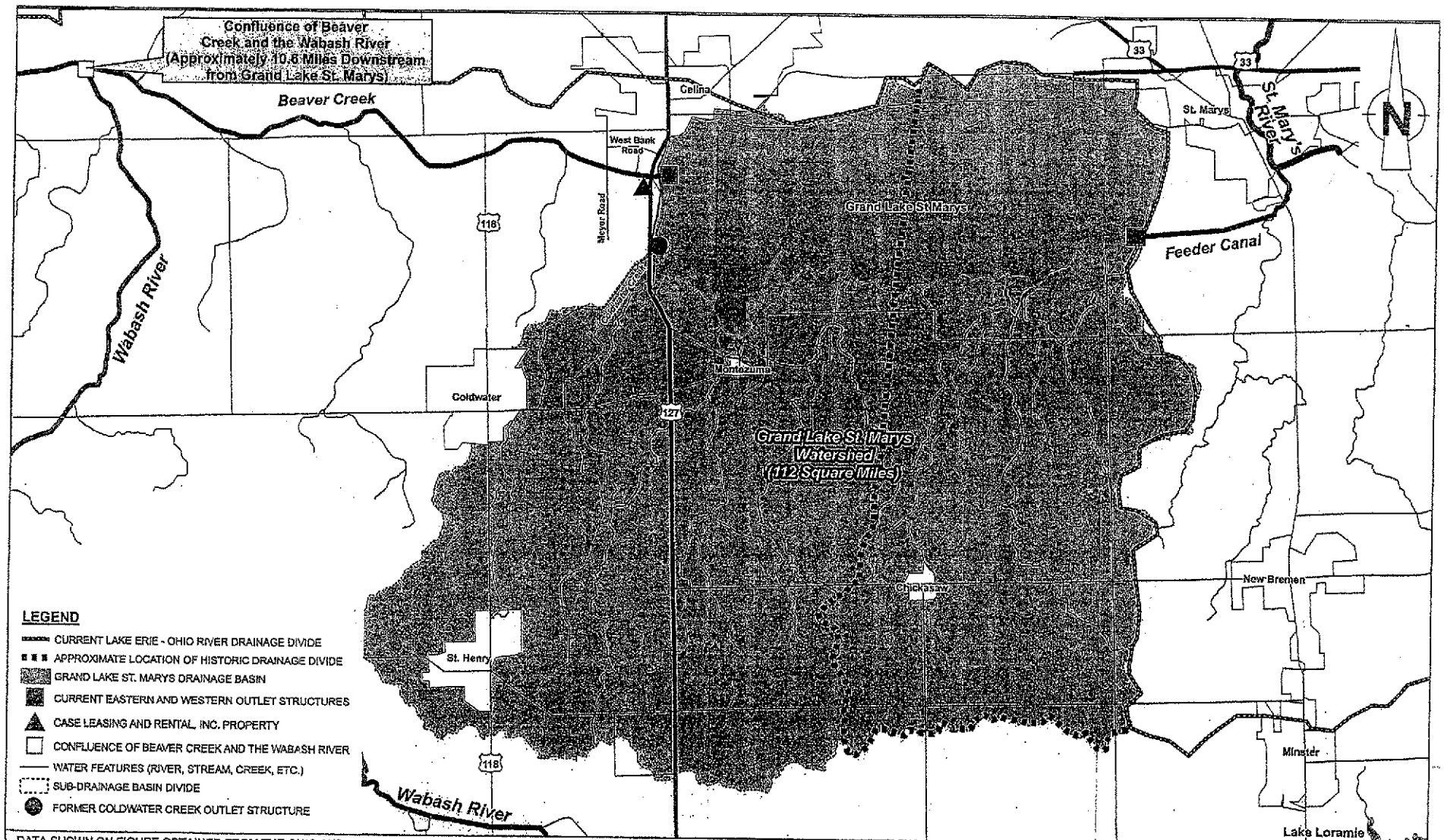
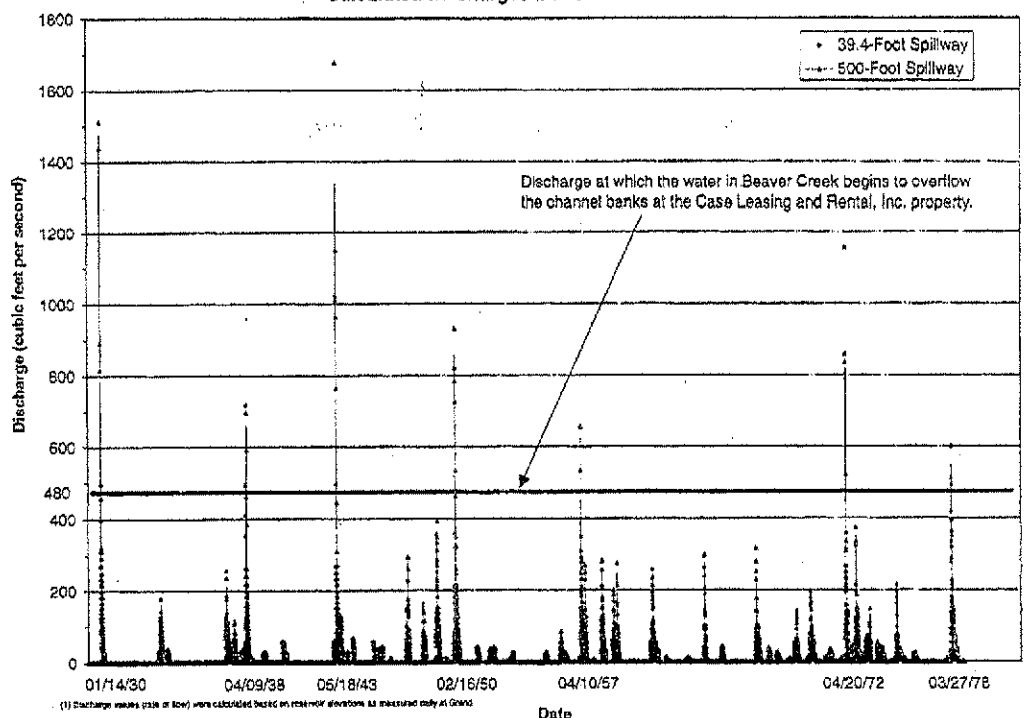
Figure 1
VICINITY MAP / TOPOGRAPHIC MAP
Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio



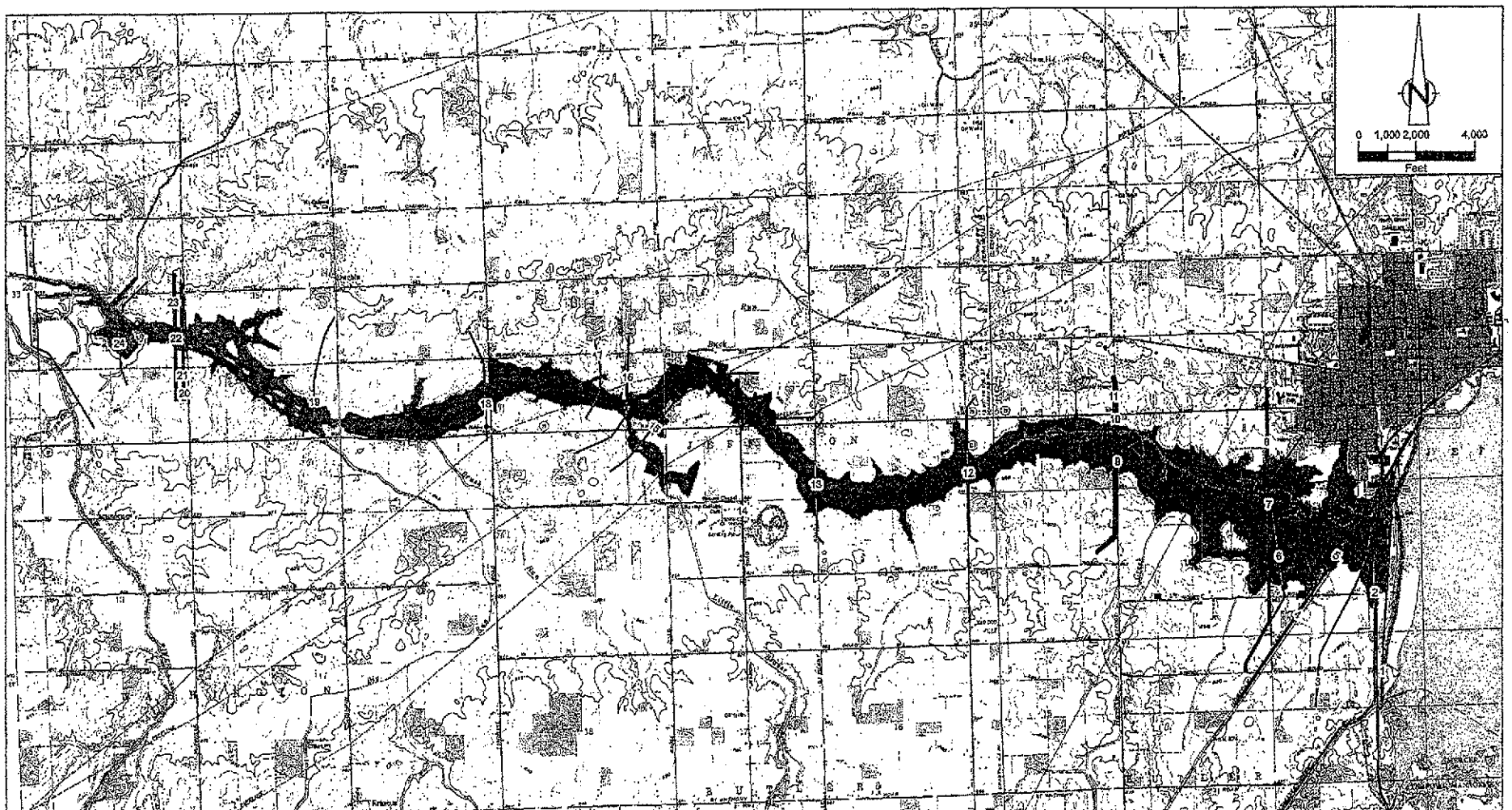
DATA SHOWN ON FIGURE OBTAINED FROM THE OHIO AND INDIANA DEPARTMENT OF NATURAL RESOURCES.

Figure 2
GRAND LAKE ST. MARYS DRAINAGE BASIN
Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio

Figure 3
Grand Lake St. Marys
Calculated Discharges into Beaver Creek[1]



(1) Discharge values (cfs or flow) were calculated based on reservoir elevations as measured daily at Grand Lake St. Marys and the stage-discharge relationships obtained from ODNR.



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LEGEND

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- INUNDATED AREA AS THE RESULT OF THE 39.4-FOOT SPILLWAY
- INUNDATED AREA AS THE RESULT OF THE 500-FOOT SPILLWAY

Figure 4a
MARCH/APRIL 1913 STORM EVENT FLOOD INUNDATION MAP

Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio

ID No.	Address	Acreage	Appraised Value	Owner	Owner Location
1	US RT 127	2.5	$75,000	West Lake Development II, Ltd.	Columbus, OH
2	1112 S Main St	1.539	$88,800	Helemiarie, David L.	Celina, OH
3	US RT 127	1.546	$46,500	Jenny Lynn Enterprises, Inc.	Wapakoneta, OH
4	US RT 127	0.581	$21,000	Neil Romer	St. Henry, OH
5	US RT 127	11.740	$293,500	West Lake Development II, Ltd.	Columbus, OH
6	West Bank Rd	0.717	$7,170	ODNR	Columbus, OH
7	West Bank Rd	0.11	$1,800	ODNR	Columbus, OH
8	US RT 127	6.63	$66,300	City of Celina	Celina, OH
9	1081 West Bank Rd	1.31	$384,310	Harry J. Welch	Celina, OH
10	US RT 127	0.82	$1,970	Mercer County Commissioners	Celina, OH
11	Schunck Rd	2.94	$65,100	City of Celina Disposal	Celina, OH
12	Schunck Rd	8.38	$26,194,360	City of Celina	Celina, OH
13	Mentor Rd	18.72	$130,350	Charles J. Meier	Celina, OH
14	S Main St	2.835	$18,000	Mercer County Commissioners	Celina, OH
15	Celina, OH	7.5	Not Available	City of Celina (Bike Path)	Celina, OH
16	5670 Schunck Rd	58.545	$515,440	Charles J. Meier	Celina, OH
17	Meyer Rd	119.5	$816,200	Charles F. Zumberge, et al, John and Virginia Zumberge Trust	Celina, OH
18	Meyer Rd	1.0	$44,130	Hayes Breedes Hay	Celina, OH
19	Schunck Rd	5.5	$2,739,840	Reynolds & Reynolds	Dayton, OH
20	522 Schunck Rd	0.96	$91,050	Rita J. Feltz, et al, John E. and Maxine Murphy Life Estate	Celina, OH
21	Schunck Rd	2.6	$52,080	Reynolds & Reynolds	Dayton, OH
22	Elm St	1.455	$8,600	Matt Schwieterman, Inc.	Coldwater, OH
23	Elm St	0.709	$6,300	Matt Schwieterman, Inc.	Coldwater, OH
24	Elm St	0.606	$5,850	Matt Schwieterman, Inc.	Coldwater, OH
25	5780 Schunck Rd	1.49	$211,280	Robert D. McKinnon	Celina, OH
26	Elm St	1.994	$9,880	Matt Schwieterman, Inc.	Coldwater, OH
27	Elm St	1.592	$8,920	Matt Schwieterman, Inc.	Coldwater, OH
28	Elm St	1.465	$320,900	C L Lee, Inc.	Greenville, OH
29	Schunck Rd	1.861	$30,970	Carolyn A. Leffler	Celina, OH
30	5750 Schunck Rd	2.276	$106,610	Nancy Ann Chaney	Celina, OH
31	5700 Schunck Rd	1.102	$102,980	Charles J. and Mary K Meier	Celina, OH
32	5656 Schunck Rd	0.25	$47,020	Ronald Stechler, et ux	Celina, OH
33	1101 US RT 127	21.23	$924,640	Case Leasing & Rental, Inc.	Bluffton, IN

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- (17) PROPERTY IDENTIFICATION NUMBER

Figure 4b
MARCH/APRIL 1913 STORM EVENT
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Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio

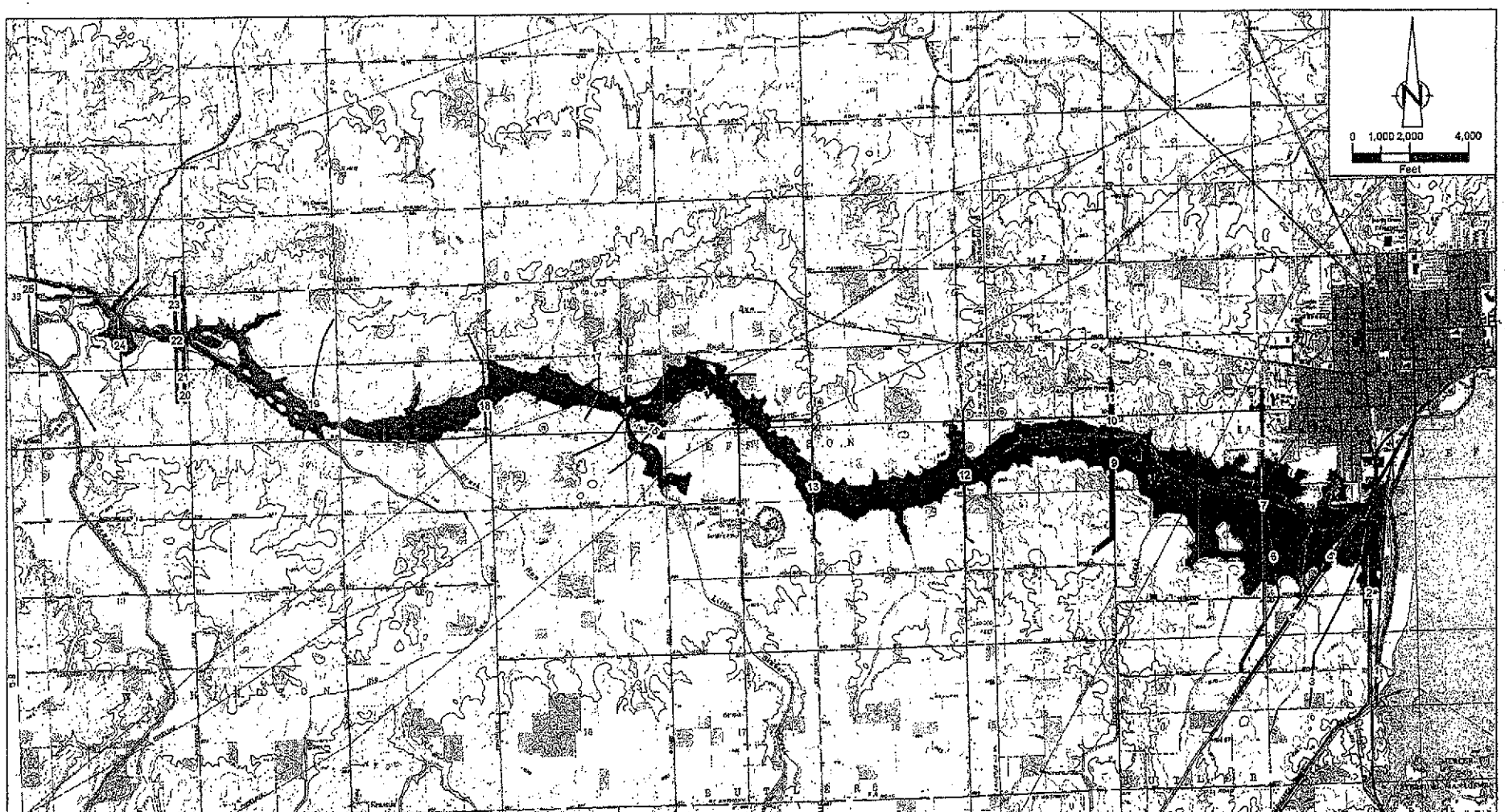

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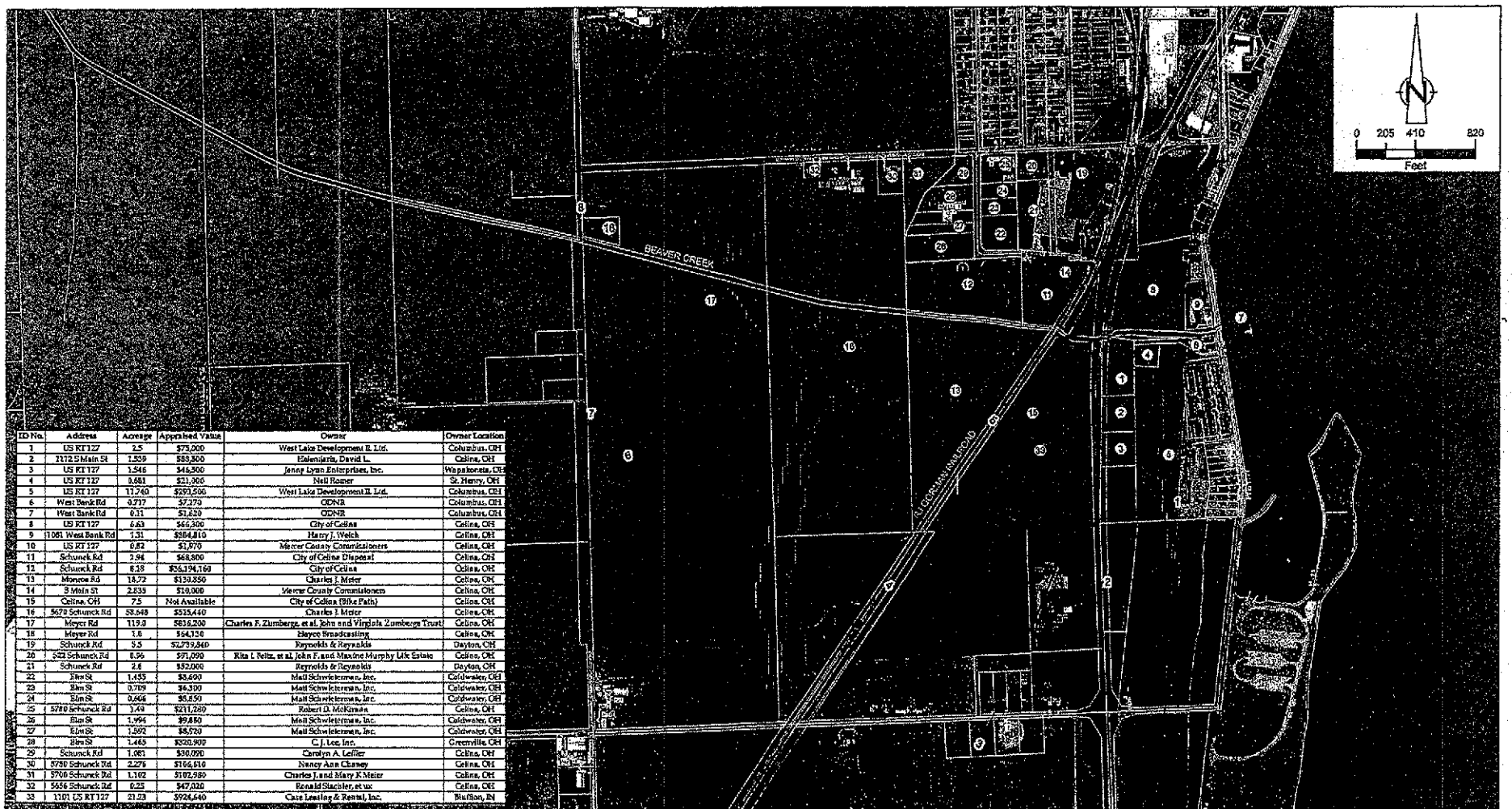
Figure 5a
JULY 1992 STORM EVENT
FLOOD INUNDATION MAP

Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio



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24	Elm St	0.606	$5,850	Matt Schwieterman, Inc.	Coldwater, OH
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26	Elm St	1.994	$9,850	Matt Schwieterman, Inc.	Coldwater, OH
27	Elm St	1.092	$8,520	Matt Schwieterman, Inc.	Coldwater, OH
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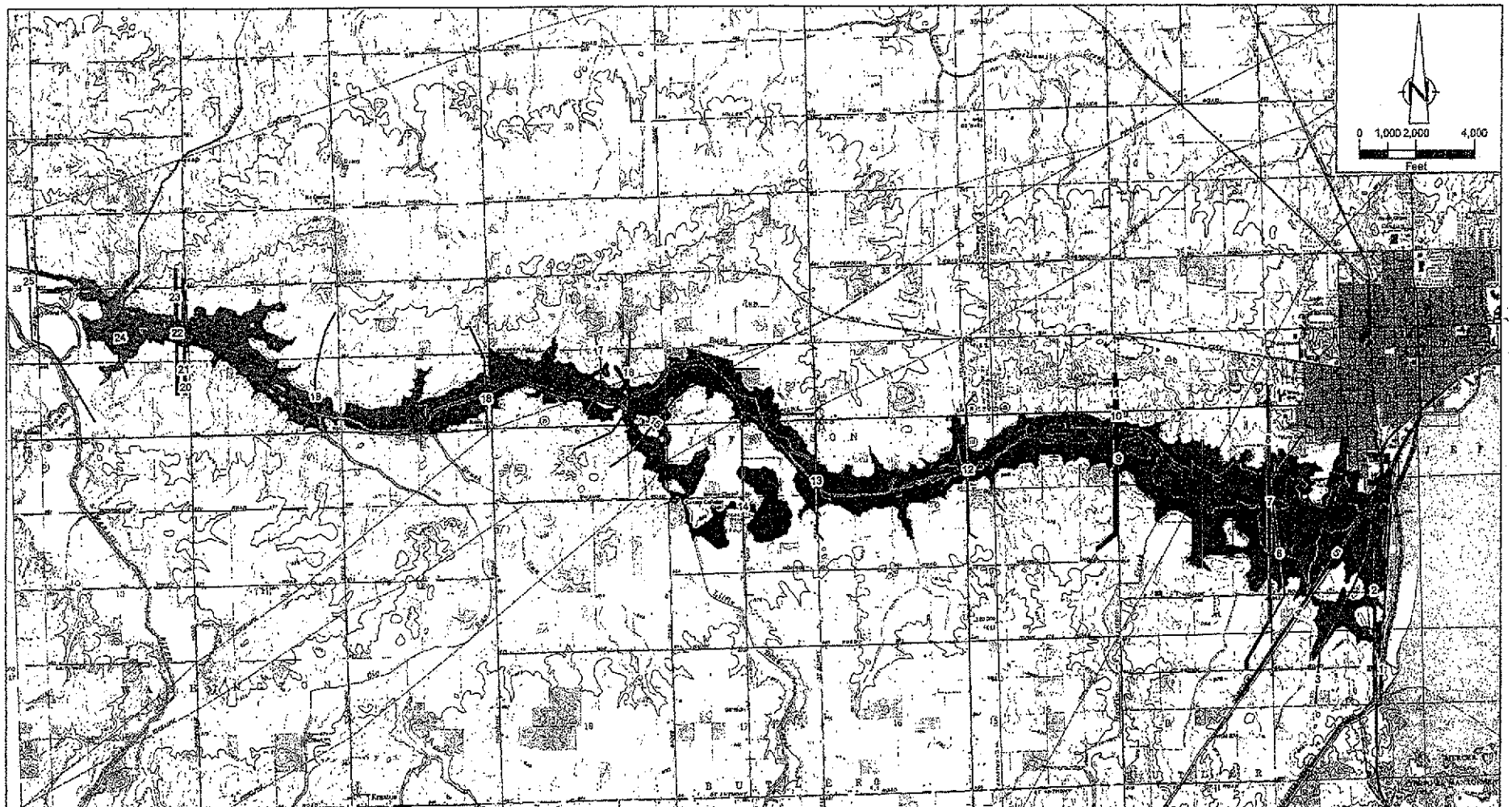
Figure 5b
JULY 1992 STORM EVENT
FLOOD INUNDATION MAP
Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio



CROSS SECTIONS OF BEAVER CREEK USED IN HEC-2 MODEL WERE OBTAINED FROM THE FINAL REPORT HYDROLOGIC AND HYDRAULIC ANALYSES, GRAND LAKE ST. MARYS, AUGLAIZE AND MERCER COUNTIES, OHIO, FEBRUARY 2, 1990, BBC&M ENGINEERING, INC.

UNITED STATES GEOLOGICAL SURVEY DIGITAL RASTER GRAPHICS (CELINA & ERASTUS) DOWNLOADED FROM THE OHIO OFFICE OF INFORMATION TECHNOLOGY WEBSITE

GROUND SURFACE ELEVATIONS USED WERE OBTAINED FROM THE OHIO 10 METER DIGITAL ELEVATION MODEL, PUBLISHED BY THE OHIO ENVIRONMENTAL PROTECTION AGENCY DIVISION OF EMERGENCY AND REMEDIAL RESPONSE, 2004

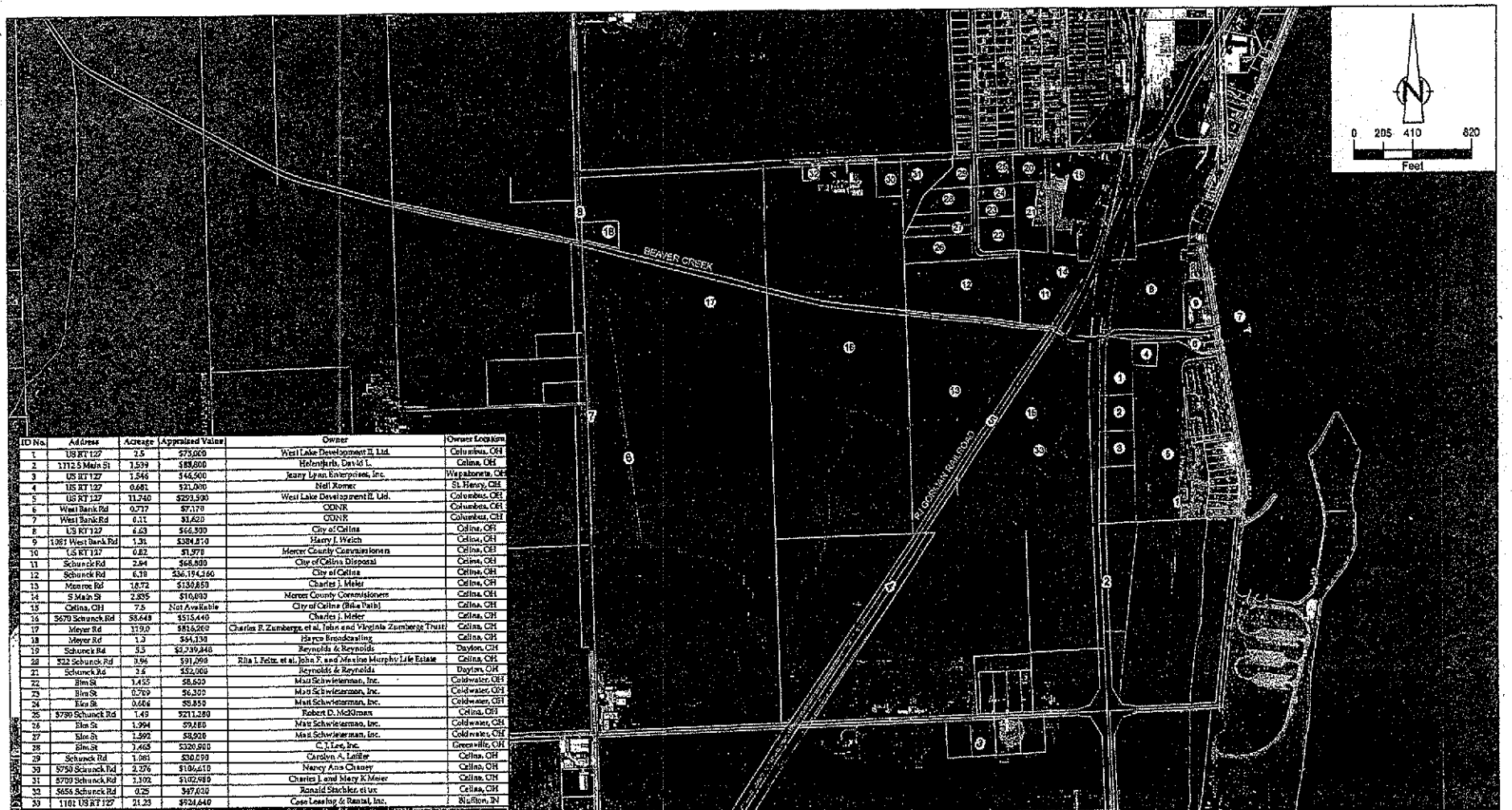
CRA

LEGEND

- CASE LEASING AND RENTAL, INC. PROPERTY BOUNDARY
- CROSS SECTION NUMBER AND LOCATIONS USED IN HEC-2 COMPUTER PROGRAM
- INUNDATED AREA AS THE RESULT OF THE 39.4-FOOT SPILLWAY
- INUNDATED AREA AS THE RESULT OF THE 500-FOOT SPILLWAY

Figure 6a
JUNE/JULY 2003 STORM EVENT FLOOD INUNDATION MAP

Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio



ID No.	Address	Acreage	Appraised Value	Owner	Owner Location
1	US RT 127	2.5	$75,000	West Lake Development II, Ltd.	Columbus, OH
2	1712 S Main St	1.599	$88,600	Helmfarb, David L.	Celina, OH
3	US RT 127	1.546	$44,500	Jenny Lynn Enterprises, Inc.	Wapakoneta, OH
4	US RT 127	0.681	$21,000	Neil Romer	St. Henry, OH
5	US RT 127	11.240	$293,500	West Lake Development II, Ltd.	Columbus, OH
6	West Bank Rd	0.717	$7,170	ODNR	Columbus, OH
7	West Bank Rd	0.11	$1,620	ODNR	Columbus, OH
8	US RT 127	6.63	$66,300	City of Celina	Celina, OH
9	1861 West Bank Rd	1.31	$384,570	Harry J. Welch	Celina, OH
10	US RT 127	0.82	$1,970	Mercer County Commissioners	Celina, OH
11	Schunck Rd	2.94	$68,800	City of Celina Disposal	Celina, OH
12	Schunck Rd	6.19	$36,194,360	City of Celina	Celina, OH
13	Monroe Rd	18.72	$130,850	Charles J. Meier	Celina, OH
14	S Main St	2.895	$10,690	Mercer County Commissioners	Celina, OH
15	Celina, OH	7.5	Not Available	City of Celina (Bike Path)	Celina, OH
16	5670 Schunck Rd	58.648	$515,440	Charles J. Meier	Celina, OH
17	Meyer Rd	119.0	$816,200	Charles F. Zumberge et al, John and Virginia Zumberge Trust	Celina, OH
18	Meyer Rd	1.3	$64,130	Harco Broadcasting	Celina, OH
19	Schunck Rd	5.3	$2,039,840	Reynolds & Reynolds	Dayton, OH
20	522 Schunck Rd	0.96	$91,090	Rita I. Fritz, et al, John F. and Maxine Murphy Life Estate	Celina, OH
21	Schunck Rd	2.6	$52,000	Reynolds & Reynolds	Dayton, OH
22	Elm St	1.455	$8,600	Matt Schwieterman, Inc.	Coldwater, OH
23	Elm St	0.769	$6,300	Matt Schwieterman, Inc.	Coldwater, OH
24	Elm St	0.606	$5,850	Matt Schwieterman, Inc.	Coldwater, OH
25	5780 Schunck Rd	1.45	$211,280	Robert D. McKiman	Celina, OH
26	Elm St	1.294	$9,880	Matt Schwieterman, Inc.	Coldwater, OH
27	Elm St	1.592	$8,920	Matt Schwieterman, Inc.	Coldwater, OH
28	Elm St	3.465	$320,900	C.T. Lee, Inc.	Greenville, OH
29	Schunck Rd	1.081	$30,090	Carolyn A. Leifer	Celina, OH
30	5750 Schunck Rd	2.376	$106,610	Nancy Ann Chaney	Celina, OH
31	5700 Schunck Rd	2.102	$102,980	Charles J. and Mary K Meier	Celina, OH
32	5656 Schunck Rd	0.25	$47,020	Ronald Stechler, et ux	Celina, OH
33	1101 US RT 127	21.23	$924,640	Case Leasing & Rental, Inc.	Nulltion, IN

CROSS SECTIONS OF BEAVER CREEK USED IN HEC-2 MODEL WERE OBTAINED FROM THE FINAL REPORT HYDROLOGIC AND HYDRAULIC ANALYSES, GRAND LAKE ST. MARYS, AUGLAIZE AND MERCER COUNTIES, OHIO, FEBRUARY 2, 1990, BROAM ENGINEERING, INC.

UNITED STATES DEPARTMENT OF AGRICULTURAL AERIAL PHOTOGRAPH DATED JUNE 23, 2004

INFORMATION SHOWN IN THE TABLE AND PROPERTY BOUNDARIES SHOWN ON THE FIGURE WERE OBTAINED FROM THE MERCER COUNTY, OHIO REAL ESTATE SEARCH RESULTS, UNOFFICIAL REAL PROPERTY RECORD CARDS, COMPLETED ON DECEMBER 21, 2005

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LEGEND

- CASE LEASING AND RENTAL, INC. PROPERTY BOUNDARY
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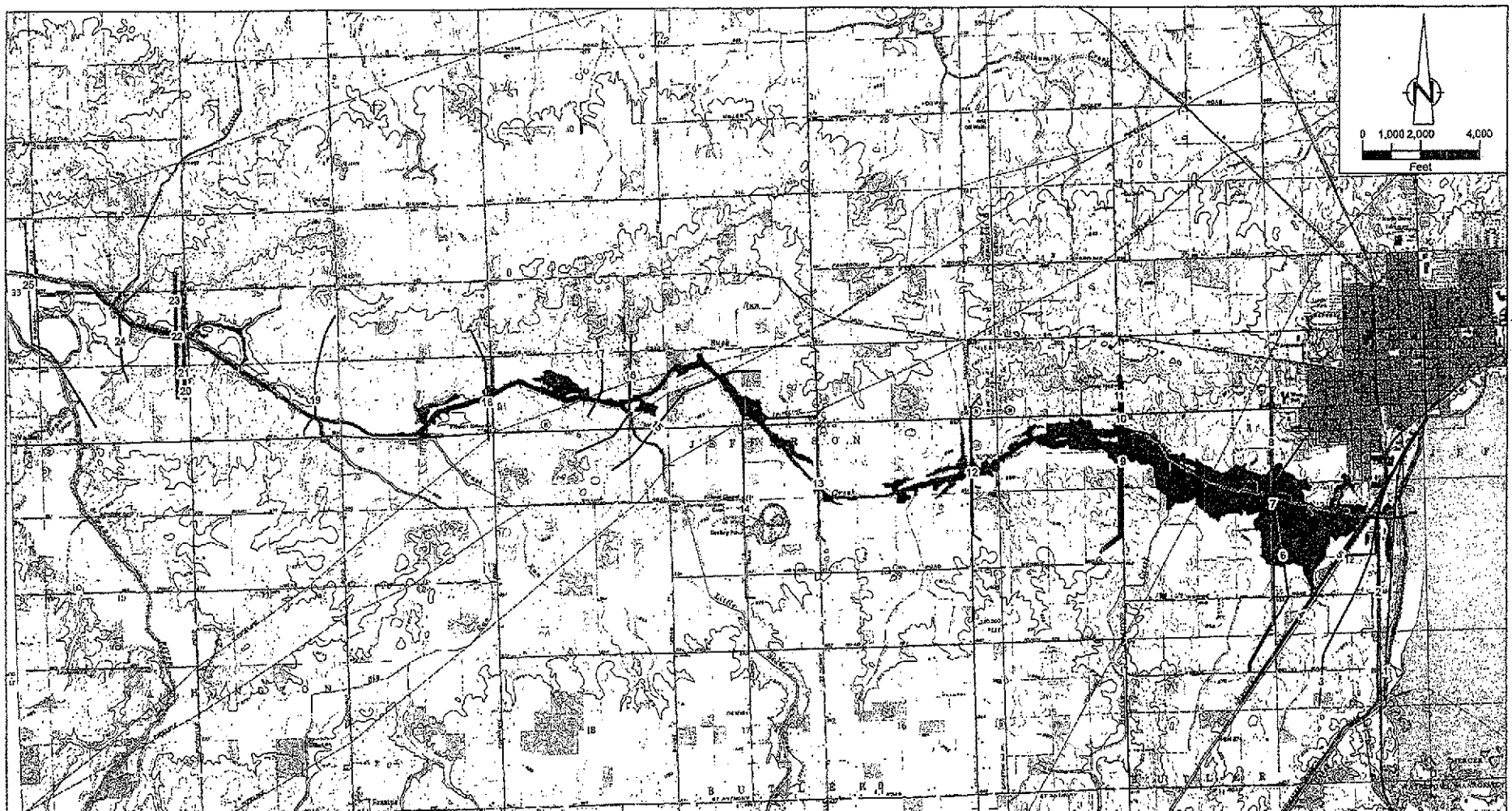
- PROPERTY BOUNDARIES
- INUNDATED AREA AS THE RESULT OF THE 39.4-FOOT SPILLWAY
- INUNDATED AREA AS THE RESULT OF THE 500-FOOT SPILLWAY
- (17) PROPERTY IDENTIFICATION NUMBER

Figure 6b
JUNE/JULY 2003 STORM EVENT
FLOOD INUNDATION MAP
Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio



CROSS SECTIONS OF BEAVER CREEK USED IN HEC-2 MODEL WERE OBTAINED FROM THE FINAL REPORT HYDROLOGIC AND HYDRAULIC ANALYSES, GRAND LAKE ST. MARYS, AUGLAIZE AND MERCER COUNTIES, OHIO, FEBRUARY 2, 1999, BBC&M ENGINEERING, INC.

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LEGEND

- CASE LEASING AND RENTAL, INC. PROPERTY BOUNDARY
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- INUNDATED AREA AS THE RESULT OF THE 39.4-FOOT SPILLWAY
- INUNDATED AREA AS THE RESULT OF THE 500-FOOT SPILLWAY

Figure 7a
JANUARY 2005 STORM EVENT FLOOD INUNDATION MAP

Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio

ID No.	Address	Acreage	Appraised Value	Owner	Owner Location
1	US RT 127	2.5	$75,000	West Lake Development II, Ltd.	Columbus, OH
2	1112 S Main St	1.559	$88,800	Heintjaris, David L.	Celina, OH
3	US RT 127	1.546	$66,500	Jenny Lynn Enterprises, Inc.	Wapakoneta, OH
4	US RT 127	0.651	$21,000	Neil Romer	St. Henry, OH
5	US RT 127	11.740	$290,500	West Lake Development II, Ltd.	Columbus, OH
6	West Bank Rd	0.717	$7,170	ODNR	Columbus, OH
7	West Bank Rd	0.11	$1,650	ODNR	Columbus, OH
8	US RT 127	6.63	$66,300	City of Celina	Celina, OH
9	1081 West Bank Rd	1.51	$384,810	Harry J. Welch	Celina, OH
10	US RT 127	0.62	$1,970	Mercer County Commissioners	Celina, OH
11	Schunck Rd	2.94	$68,300	City of Celina Disposal	Celina, OH
12	Schunck Rd	8.18	$26,194,160	City of Celina	Celina, OH
13	Monroe Rd	18.72	$138,850	Charles J. Meier	Celina, OH
14	S Main St	2.835	$10,000	Mercer County Commissioners	Celina, OH
15	Celina, OH	7.5	Not Available	City of Celina (Bike Path)	Celina, OH
16	5670 Schunck Rd	58.648	$515,440	Charles J. Meier	Celina, OH
17	Meyer Rd	119.8	$816,200	Charles F. Zumberge, et al, John and Virginia Zumberge Trust	Celina, OH
18	Meyer Rd	1.6	$64,130	Hayco Broadcasting	Celina, OH
19	Schunck Rd	5.5	$2,739,840	Reynolds & Reynolds	Dayton, OH
20	522 Schunck Rd	0.56	$91,050	Rita J. Feltz, et al, John F. and Maxine Murphy Life Estate	Celina, OH
21	Schunck Rd	2.6	$52,000	Reynolds & Reynolds	Dayton, OH
22	Elm St	1.455	$8,600	Matt Schwietzerman, Inc.	Coldwater, OH
23	Elm St	0.709	$6,300	Matt Schwietzerman, Inc.	Coldwater, OH
24	Elm St	0.685	$5,850	Matt Schwietzerman, Inc.	Coldwater, OH
25	5780 Schunck Rd	1.49	$271,250	Robert D. McKiman	Celina, OH
26	Elm St	1.946	$9,580	Matt Schwietzerman, Inc.	Coldwater, OH
27	Elm St	1.592	$8,926	Matt Schwietzerman, Inc.	Coldwater, OH
28	Elm St	1.465	$320,900	C.J. Lee, Inc.	Greenville, OH
29	Schunck Rd	1.681	$30,050	Carolyn A. Leffler	Celina, OH
30	5750 Schunck Rd	2.276	$106,670	Nancy Ann Chaney	Celina, OH
31	5700 Schunck Rd	1.102	$102,080	Charles J. and Mary K Meier	Celina, OH
32	5655 Schunck Rd	0.25	$47,020	Ronald Stuckler, et ux	Celina, OH
33	1101 US RT 127	21.25	$924,640	Case Leasing & Rental, Inc.	Huntington, IN

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UNITED STATES DEPARTMENT OF AGRICULTURAL AERIAL PHOTOGRAPH DATED JUNE 23, 2004

INFORMATION SHOWN IN THE TABLE AND PROPERTY BOUNDARIES SHOWN ON THE FIGURE WERE OBTAINED FROM THE MERCER COUNTY, OHIO REAL ESTATE SEARCH RESULTS, UNOFFICIAL REAL PROPERTY RECORD CARDS, COMPLETED ON DECEMBER 21, 2005

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Figure 7b
JANUARY 2005 STORM EVENT
FLOOD INUNDATION MAP
Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio

TABLES

TABLE 1

MODEL RESULTS FOR HISTORICAL STORM EVENTS
GRAND LAKE ST. MARYS
MERCER AND AUGLAIZE COUNTIES, OHIO

Rainfall event	Rainfall Amount [1]	Rainfall Duration [1]	Initial lake elevation [2]	39.4-Foot Spillway	500-Foot Spillway	Difference	39.4-Foot Spillway	500-Foot Spillway	Difference	39.4-Foot Spillway	500-Foot Spillway	Difference
				Maximum Discharge [3]	Maximum Discharge [3]		Upstream Case Property Limit Maximum Water Elevation [4]	Upstream Case Property Limit Maximum Water Elevation [4]		Downstream Case Property Limit Maximum Water Elevation [4]	Downstream Case Property Limit Maximum Water Elevation [4]	
	[inches]	[hours]	[feet msl]	[cfs]	[cfs]	[cfs]	[feet msl]	[feet msl]	[feet]	[feet msl]	[feet msl]	[feet]
1913	8.31	156	870.60	325	2100	1775	854.56	861.31	6.75	854.5	860.14	5.64
1930	6.15	198	870.60	120	414	294	852.13	855.35	3.22	852.08	855.29	3.21
1943	4.11	132	870.60	53	95	42	850.87	851.71	0.84	850.83	851.67	0.84
1957	5.19	204	870.60	92	224	132	851.66	853.51	1.85	851.62	853.46	1.84
1958	4.45	126	870.60	92	242	150	851.66	853.71	2.05	851.62	853.66	2.04
1972	5.72	276	870.60	116	389	273	852.07	855.14	3.07	852.02	855.08	3.06
1992	8.94	246	870.60	395	1721	1326	855.15	860.59	5.44	855.13	859.79	4.66
2003	10.67	138	870.60	543	2958	2415	856.31	861.77	5.46	856.23	860.52	4.29
2005	7.43	106	870.60	180	724	544	852.98	857.43	4.45	852.93	857.29	4.36
							Case Leasing and Rental, Inc. finished floor elevation = 858.74					

Notes: [1] Data obtained from the National Oceanic and Atmospheric Administration (NOAA) National Climate Data Center (NCDC) for the following stations: Mercer, OH (331390), Auglaize, OH (337383), Mercer, OH (332895), Adams, IN (120676), Darke, OH (338642), Shelby, OH (337693), and Darke, OH (333375).

[2] The elevations cited are the initial lake values as input into the HEC-1 model and are the elevations of the 39.4-foot spillway and the notch of the 500-foot spillway.

[3] Data obtained from HEC-1 simulation output.

[4] Data obtained from HEC-2 simulation output.

Highlighted values exceed the elevation of the Case Leasing and Rental, Inc. finished floor.

msl = mean sea level

cfs = cubic feet per second

TABLE 2

MODEL RESULTS FOR HYPOTHETICAL STORM EVENTS
GRAND LAKE ST. MARYS
MERCER AND AUGLAIZE COUNTIES, OHIO

Rainfall return period [1]	*Rainfall amount* [1]	*Rainfall duration* [1]	*39.4-Foot Spillway*	*500-Foot Spillway*	*39.4-Foot Spillway*	*500-Foot Spillway*	*Difference*	*39.4-Foot Spillway*	*500-Foot Spillway*	*Difference*
			Maximum Discharge [2]	*Maximum Discharge* [2]	*Upstream Case Property Limit Maximum Water Elevation* [3]	*Upstream Case Property Limit Maximum Water Elevation* [3]		*Downstream Case Property Limit Maximum Water Elevation* [3]	*Downstream Case Property Limit Maximum Water Elevation* [3]	
[years]	*[inches]*	*[hours]*	*[cfs]*	*[cfs]*	*[feet msl]*	*[feet msl]*	*[feet]*	*[feet msl]*	*[feet msl]*	*[feet]*
10	4.7	72	76	125	851.36	852.21	0.85	851.32	852.16	0.84
25	5.4	72	108	352	851.94	854.81	2.87	851.89	854.75	2.86
50	5.9	72	131	520	852.30	856.15	3.85	852.25	856.08	3.83
100	6.4	72	163	689	852.76	857.19	4.43	852.71	857.11	4.40
					Beaver Creek Channel Bank Elevation = 856.4 [4]			Beaver Creek Channel Bank Elevation = 855.8 [4]		

Note: [1] Data obtained from Ohio Department of Natural Resources (ODNR) records

[2] Data obtained from HEC-1 simulation output.

[3] Data obtained from HEC-2 simulation output.

[4] Bank elevation obtained from the Final Report Hydrologic and Hydraulic Analyses, Grand Lake St. Marys, Auglaize and Mercer Counties, Ohio, February 2, 1990, BBC&M Engineering, Inc., a consultant retained by ODNR.

Highlighted values exceed the elevation of the Beaver Creek channel bank at the Case Leasing and Rental, Inc. property.

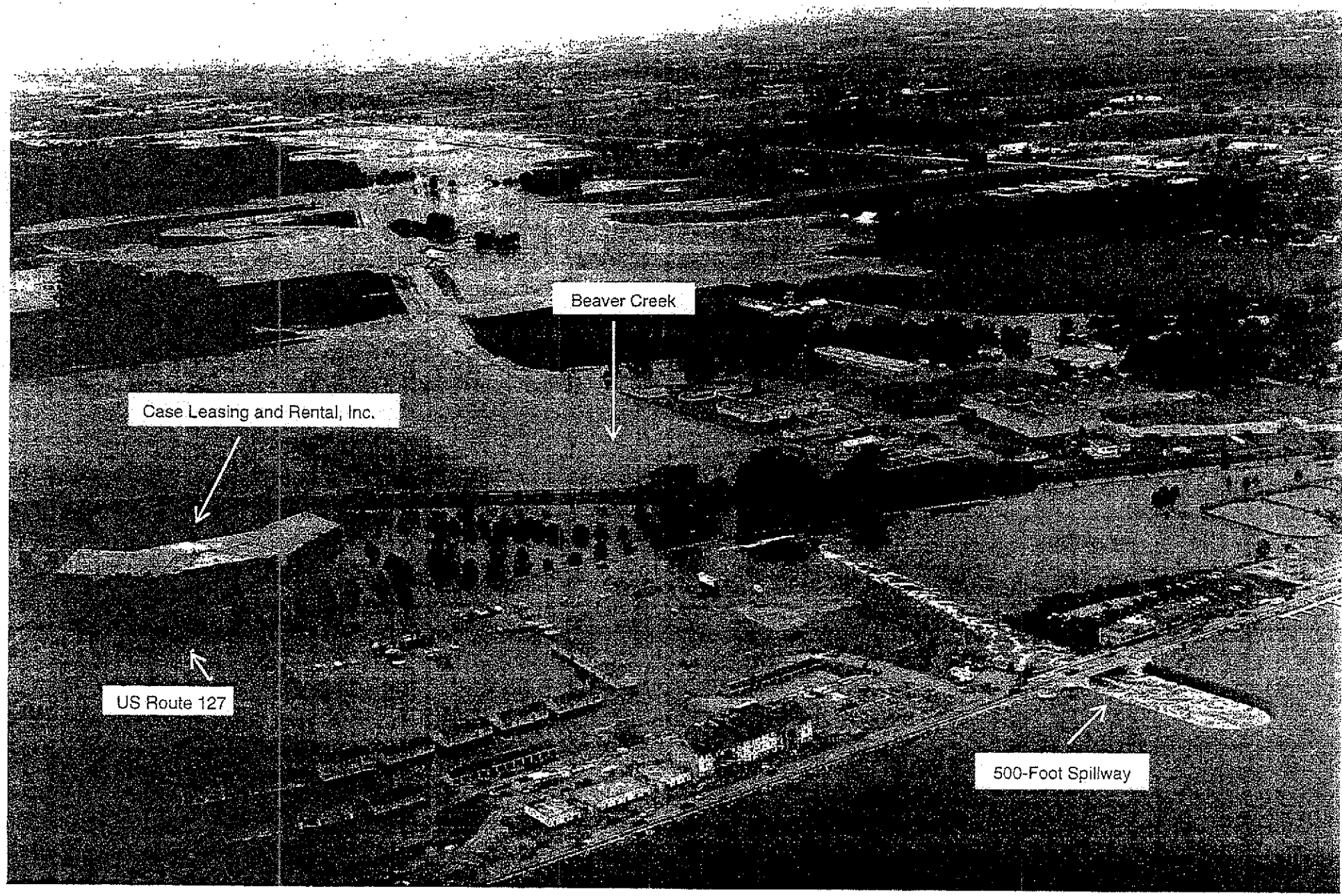
msl = mean sea level

cfs = cubic feet per second

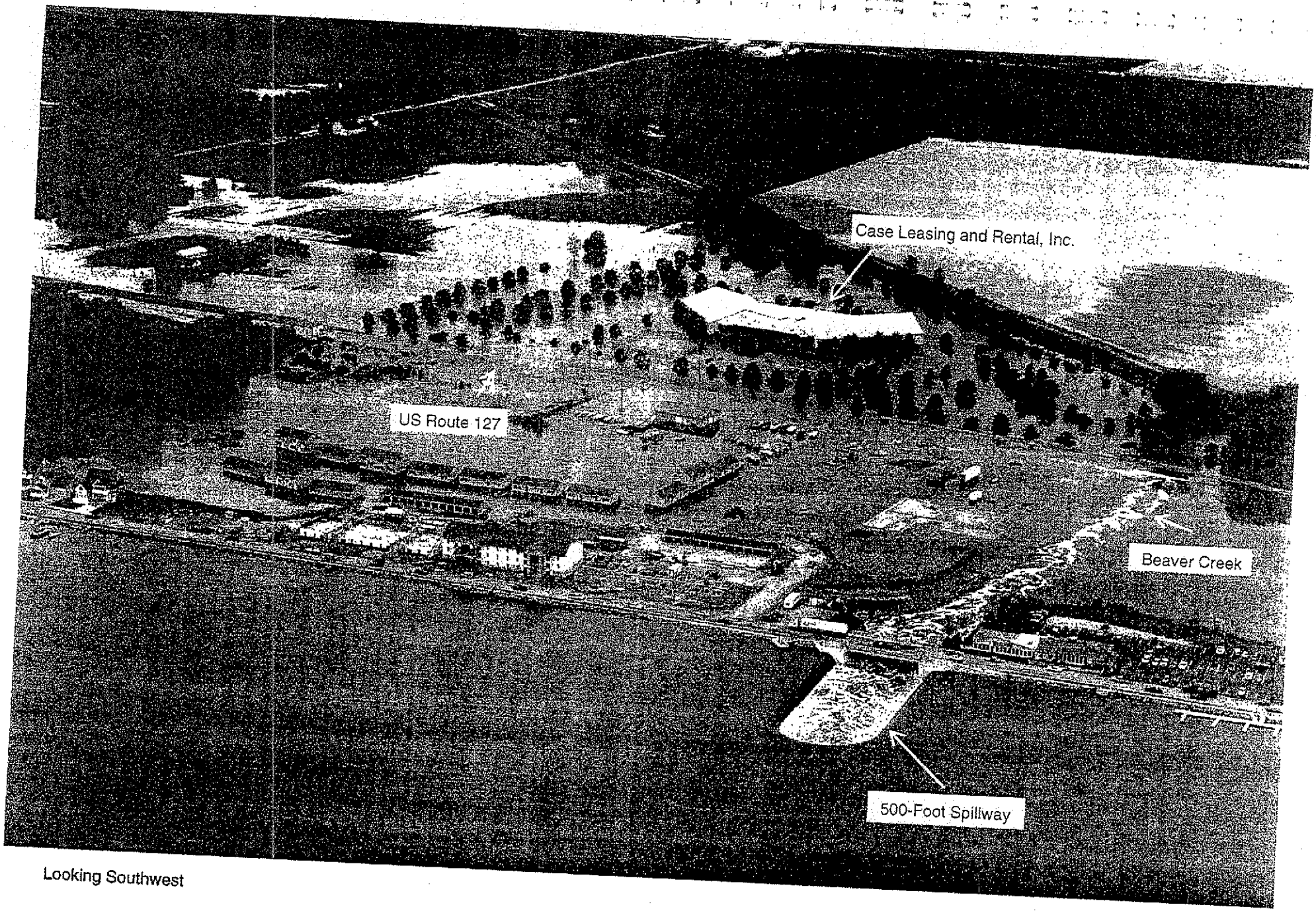
APPENDIX A

PHOTOGRAPHS OF THE 2003 FLOOD EVENT

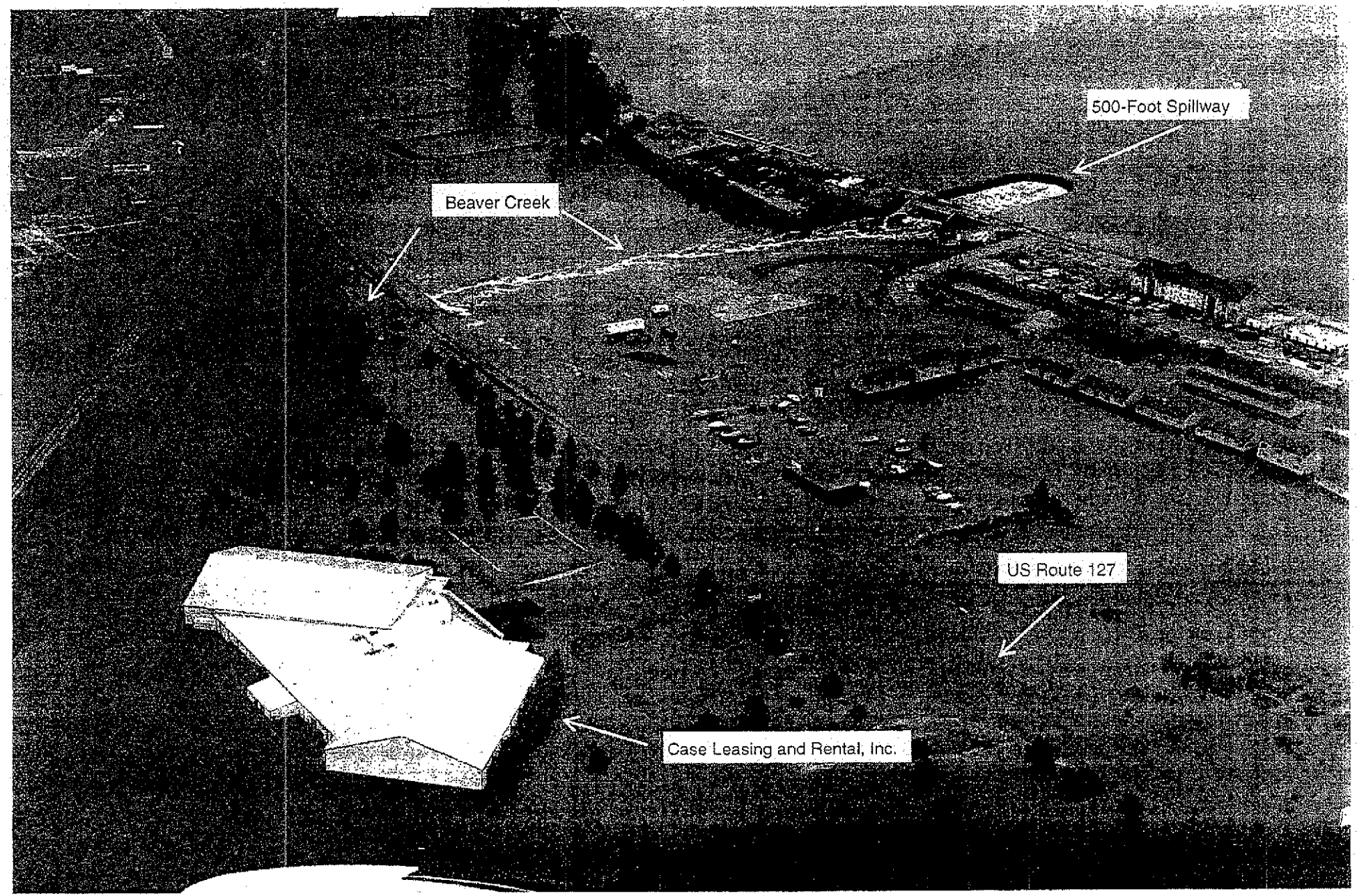
(Referenced in the text on page i)



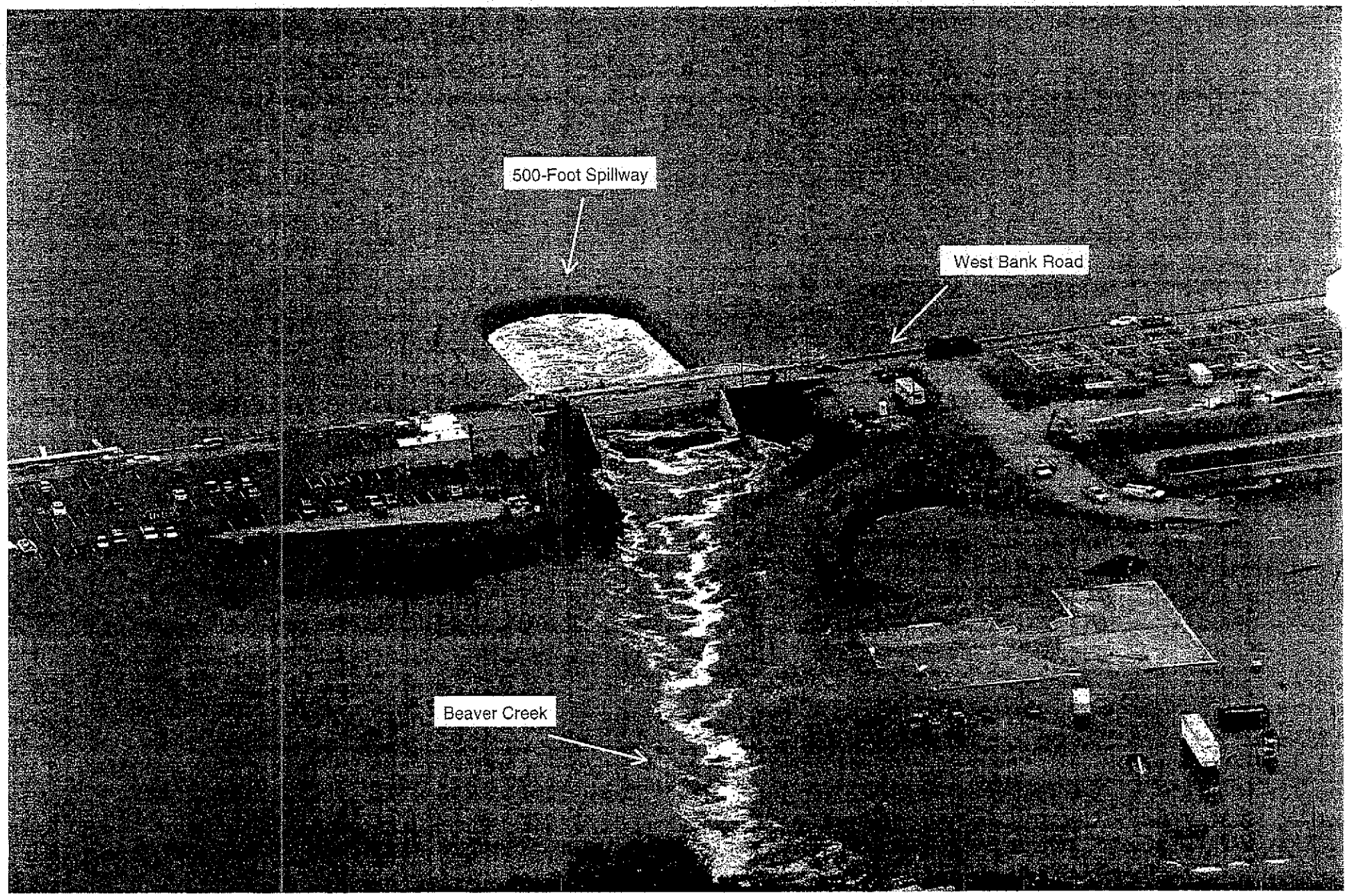
Looking Northwest



Looking Southwest



Looking Northeast

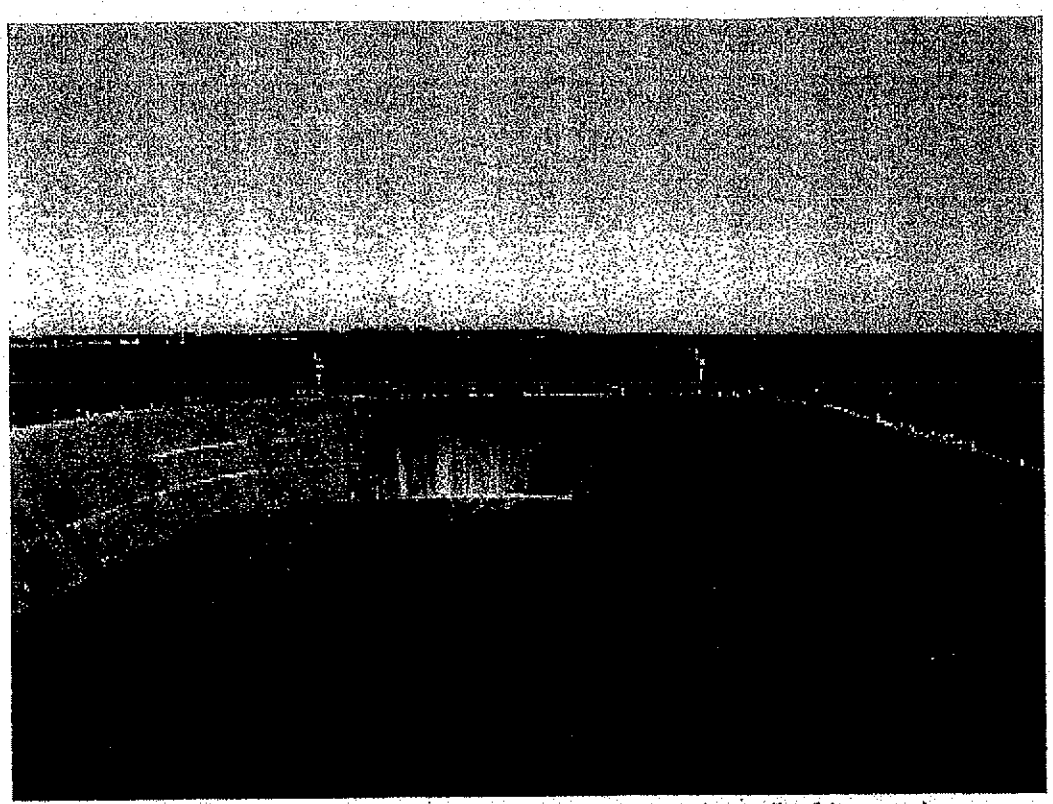


Looking East

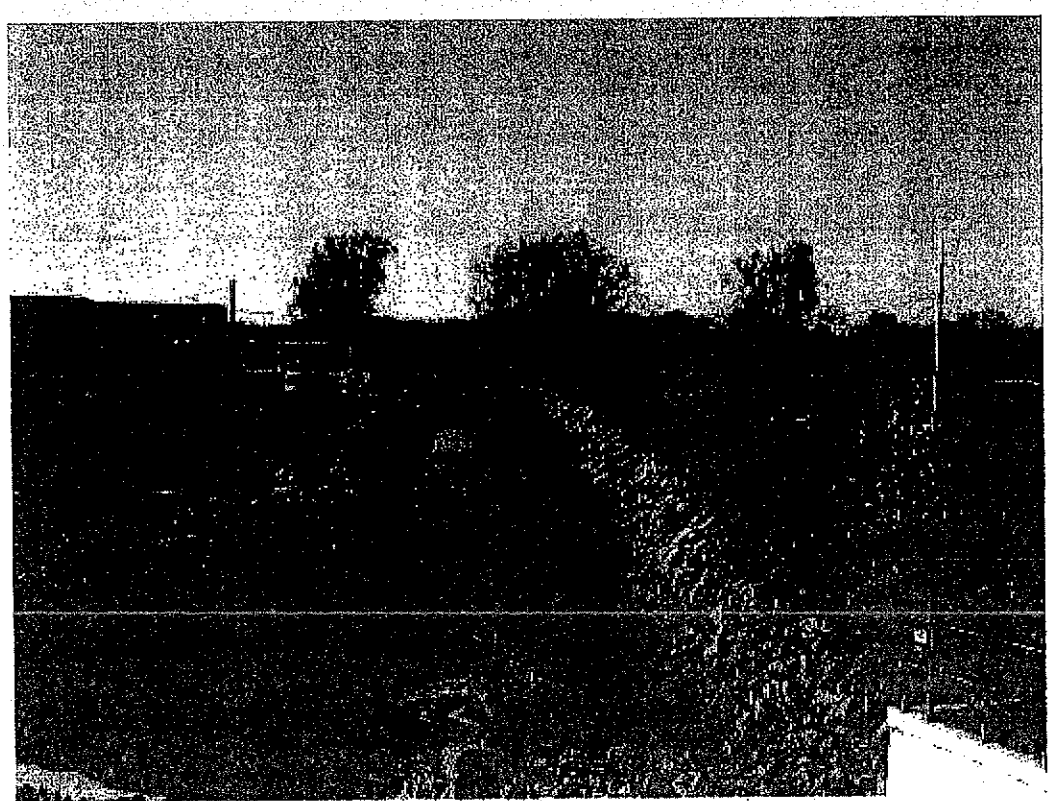
APPENDIX B

PHOTOGRAPHS TAKEN DURING THE CRA SITE VISIT ON NOVEMBER 2, 2005

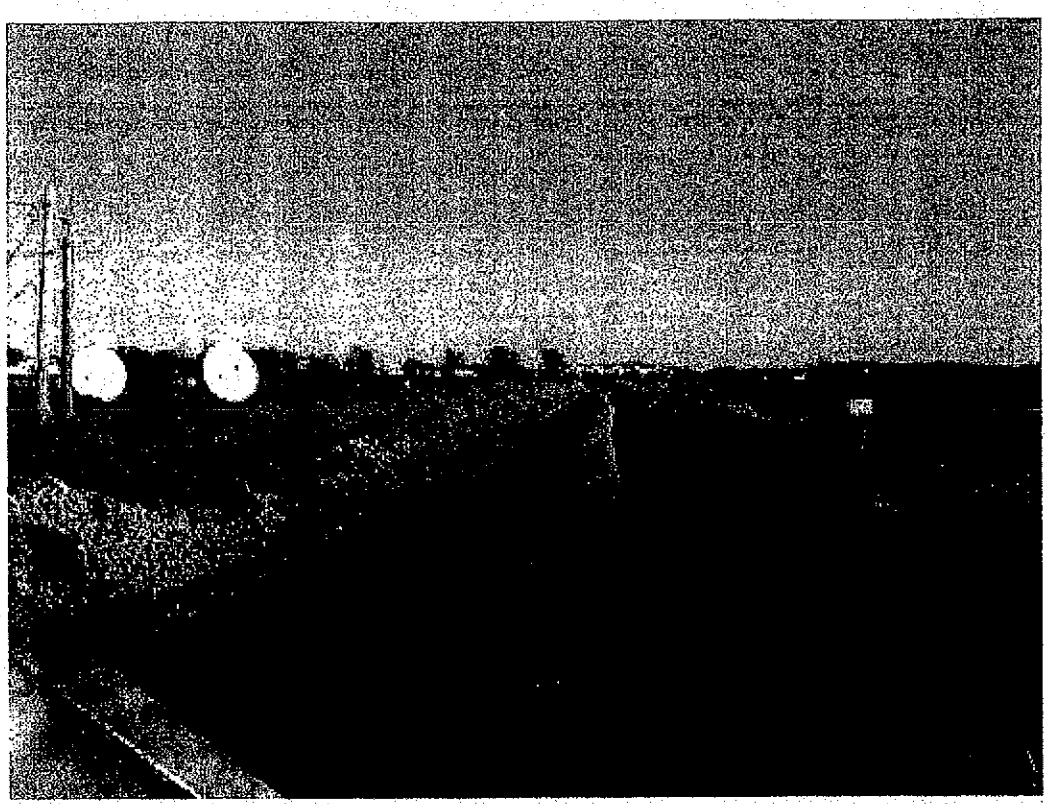
(Referenced in the text on page 2)



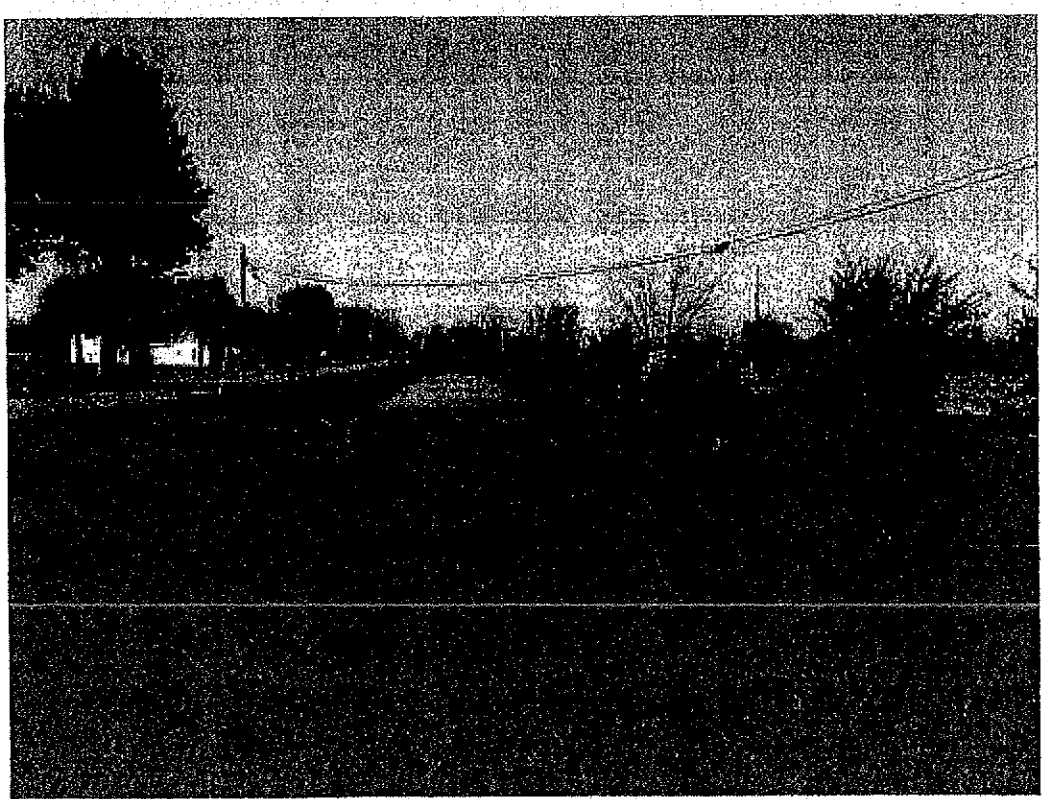
View of the western spillway and Grand Lake St. Marys (looking east).



View of Beaver Creek immediately downstream from the western spillway (looking west).



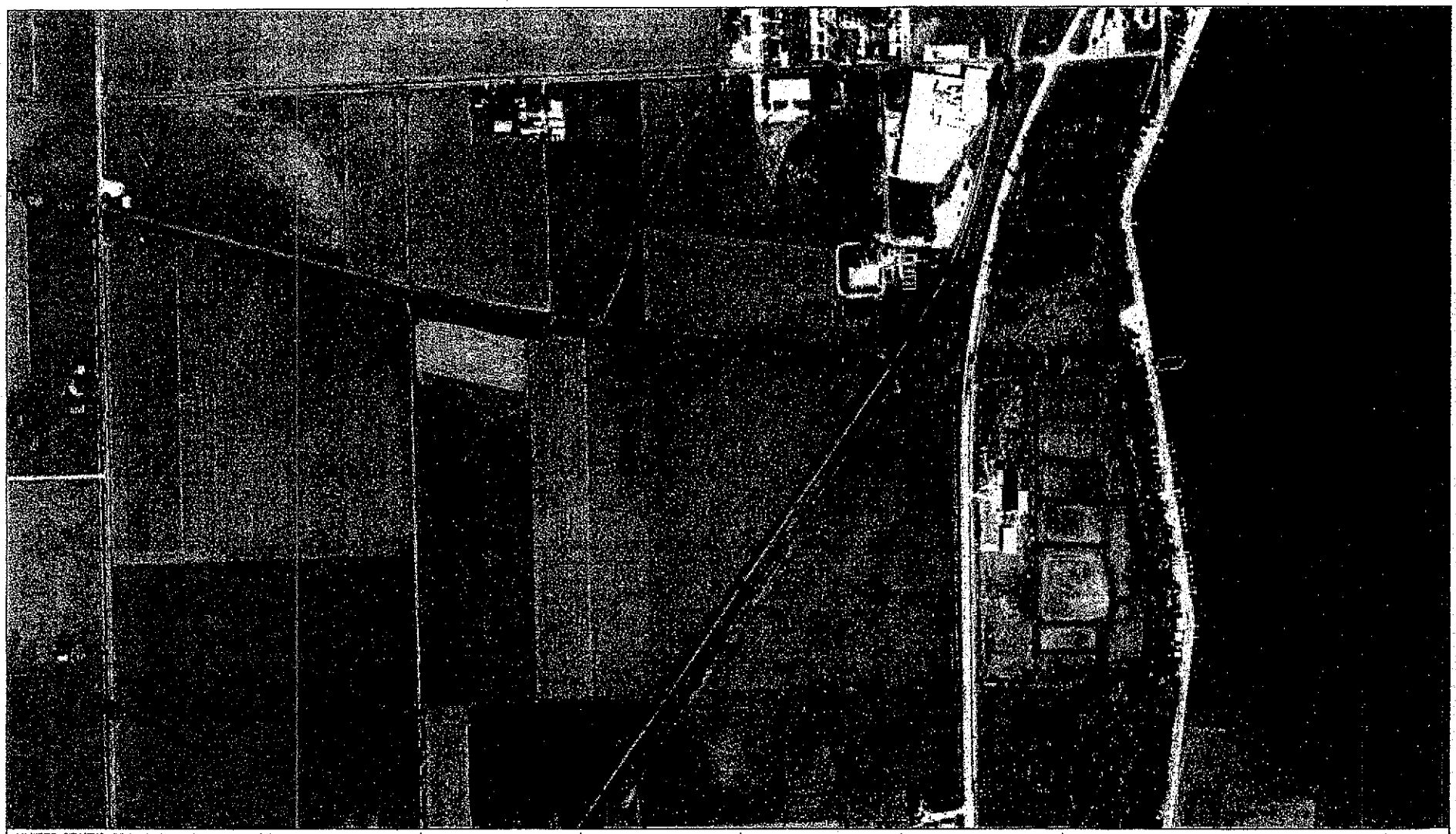
View of Beaver Creek upstream from Meyer Road (looking east, towards Grand Lake St. Marys).



View of the feeder canal downstream from the eastern outlet of Grand Lake St. Marys (looking east).

APPENDIX C

AERIAL PHOTOGRAPHS OF CASE LEASING AND RENTAL, INC.
AND SURROUNDING AREA
(Referenced in the text on page 3)



UNITED STATES GEOLOGICAL SURVEY AERIAL PHOTOGRAPH DATED OCTOBER 14, 1973.

0 200 400 Feet

1973 AERIAL PHOTOGRAPH
Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio

UNITED STATES GEOLOGICAL SURVEY AERIAL PHOTOGRAPH DATED APRIL 16, 1980.

0 200 400 Feet

1980 AERIAL PHOTOGRAPH
Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio

UNITED STATES GEOLOGICAL SURVEY AERIAL PHOTOGRAPH DATED APRIL 8, 1988.

0 200 400 Feet

1988 AERIAL PHOTOGRAPH
Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio

UNITED STATES GEOLOGICAL SURVEY AERIAL PHOTOGRAPH DATED OCTOBER 12, 2000.

0 200 400 Feet

2000 AERIAL PHOTOGRAPH
Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio

UNITED STATES DEPARTMENT OF AGRICULTURE AERIAL PHOTOGRAPH DATED JUNE 23, 2004.

0 200 400 Feet

2004 AERIAL PHOTOGRAPH
Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio

AERIAL PHOTOGRAPH BY M.A.N. MAPPING SERVICES, INC. BASED ON FLIGHT ON FEBRUARY 20, 2006.

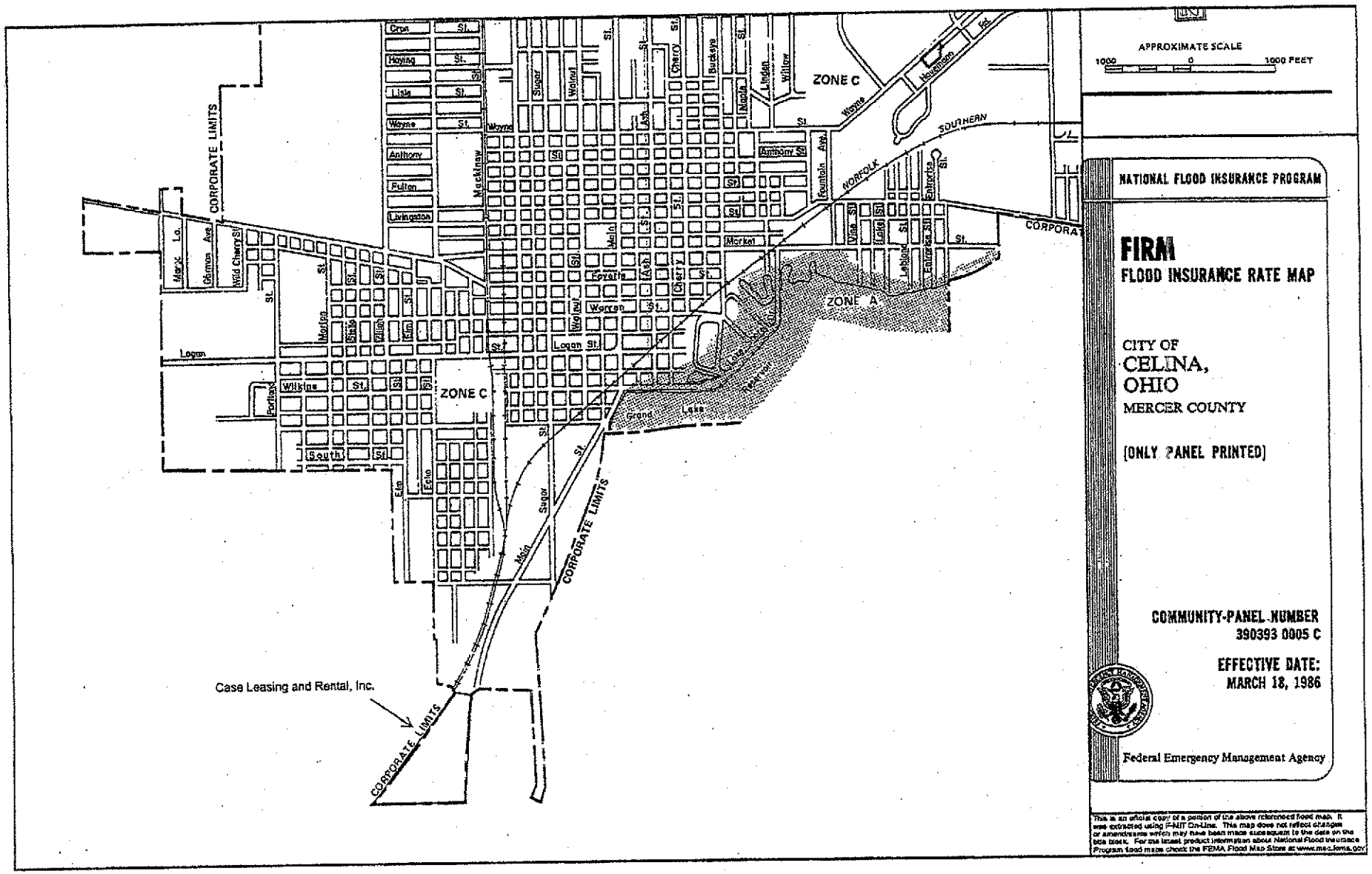
0 350ft

2006 AERIAL PHOTOGRAPH
Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio

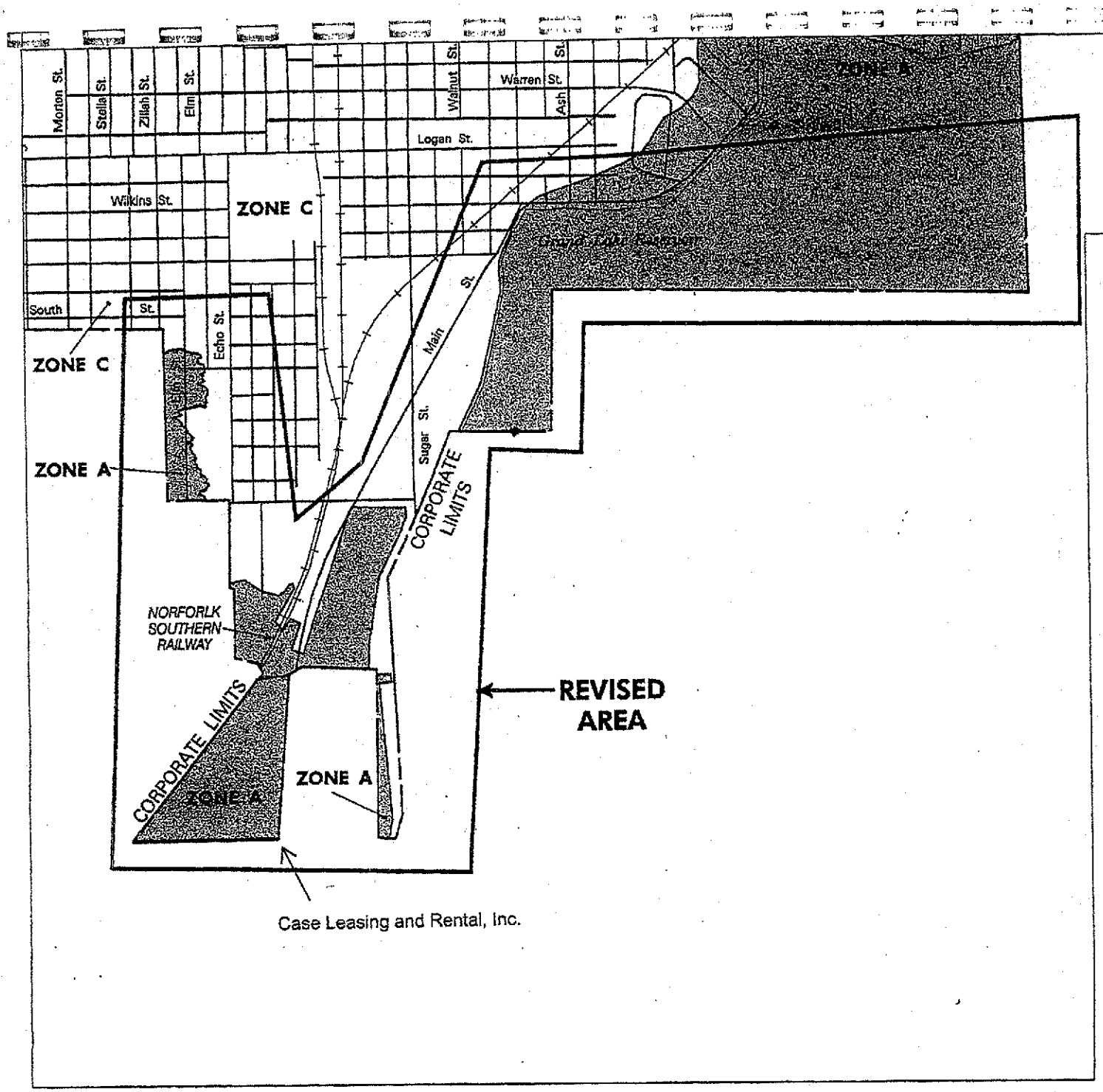
APPENDIX D

FLOOD INSURANCE RATE MAPS FOR THE CITY OF CELINA AREA

(Referenced in the text on page 11)



This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov



APPROXIMATE SCALE IN FEET

1000 0 1000

NATIONAL FLOOD INSURANCE PROGRAM

FIRM

FLOOD INSURANCE RATE MAP

CITY OF
CELINA,
OHIO
MERCER COUNTY

(ONLY PANEL PRINTED)

NOV 01 2004

COMMUNITY-PANEL NUMBER
390393 0005 C

EFFECTIVE DATE:
MARCH 18, 1986

Federal Emergency Management Agency

MITS

ZONE C

Base Flood Elevation in Feet Where Uniform Within Zone** (EL 987)

Elevation Reference Mark RM7×

Zone D Boundary

River Mile •M1.5

**Referenced to the National Geodetic Vertical Datum of 1929

*EXPLANATION OF ZONE DESIGNATIONS

ZONE	EXPLANATION
A	Areas of 100-year flood; base flood elevations and flood hazard factors not determined.
AO	Areas of 100-year shallow flooding where depths are between one (1) and three (3) feet; average depths of inundation are shown, but no flood hazard factors are determined.
AH	Areas of 100-year shallow flooding where depths are between one (1) and three (3) feet; base flood elevations are shown, but no flood hazard factors are determined.
A1-A30	Areas of 100-year flood; base flood elevations and flood hazard factors determined.
A99	Areas of 100-year flood to be protected by flood protection system under construction; base flood elevations and flood hazard factors not determined.
B	Areas between limits of the 100-year flood and 500-year flood; or certain areas subject to 100-year flooding with average depths less than one (1) foot or where the contributing drainage area is less than one square mile; or areas protected by levees from the base flood. (Medium shading)
C	Areas of minimal flooding. (No shading)
D	Areas of undetermined, but possible, flood hazards.
V	Areas of 100-year coastal flood with velocity (wave action); base flood elevations and flood hazard factors not determined.
V1-V30	Areas of 100-year coastal flood with velocity (wave action); base flood elevations and flood hazard factors determined.

NOTES TO USER

Certain areas not in the special flood hazard areas (zones A and V) may be protected by flood control structures.

This map is for flood insurance purposes only; it does not necessarily show all areas subject to flooding in the community or all planimetric features outside special flood hazard areas.

For adjoining map panels, see separately printed Map Index.

APPROXIMATE SCALE

1000 0 1000 FEET

NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP

CITY OF
CELINA,
OHIO
MERCER COUNTY

(ONLY PANEL PRINTED)

COMMUNITY-PANEL NUMBER
390393 0005 C

EFFECTIVE DATE:
MARCH 18, 1986

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov

APPENDIX E

CORRESPONDENCE FROM REVIEWING AGENCIES

(Referenced in the text on page 13)

MERC
SOIL & WATER CO

717 W. Logan Stre

Telephor

Bob -
OFBF mtg is 12/3 & 4
Zumberge is a high ranker in OFBF & this may come up.
What are your thoughts on the Mercer SWCD letter.
Please advise -

Kevin -
Are these concerns valid.
If so, I think action should happen.
I'll copy to Sally for my trip to Lima.

RECEIVED
NOV 14 1991
SOIL & WATER CONSERVATION

Notified by Jim & Not a problem with our Department.

Larry Vance
Ohio Department of Natural Resour
Fountain Square Building E.
Columbus, OH 43224

Dear Mr. Vance:

Larry, there is much heated discussion on the proposed west bank spillway. Much of the heat comes from the fact that the Division of Water has not had a good answer or any answer to questions the landowners along Beaver have. The Mercer SWCD office was not informed of the public meeting held in the county by the Division of Water. Many to be affected landowners also were unaware of the meeting.

Div of Water was also not made aware and had certainly expected to be aware

Div of Water was informed of meeting in County office where this was discussed

Concerns about Proposed Spillway

1. Data from the Division of Water indicated higher flows in Beaver Creek with proposed spillway but only out of bank flow at one place. This is not reasonable to anyone who sees Beaver Creek flow out of bank every year.

2. A study needs to be done showing what will happen to flood levels when spillway is operating and when the tributaries downstream of the lake are also contributing water to Beaver Creek.

Can hydraulic modeling be used to answer this.

3. The proposed spillway will remove water from the lake faster than the present spillway. How will existing road bridges be affected by this increase flow?

What is opinion of Co. Engineer on this?

4. How will the existing road bridges affect flood levels and duration?

5. The Wabash River is the outlet for Beaver Creek. How will the increase flow affect the flooding at this bottleneck?

6. What effect will the increase flow from the proposed spillway have on crops, bridges, roads and buildings? Will damage be more or less, with numbers to back up the statements?

RECEIVED
DEC 2 1991
Dept. of Natural Resources
Division of Water

7. The landowners in the Beaver Creek watershed downstream of the lake did pay construction assessments and an paying maintenance assessments. They have a right to know what will happen - not just someone's best guess.

8. What does it take to have the state pay their share toward maintenance?

9. A management plan for drawdown of the lake needs to be developed. This would seem the best way of solving the varied interests between farmers and recreationists.

Your assistance in this matter is greatly appreciated.

Roger Knapke

Roger Knapke
Mercer SWCD Board Chairman

dw

Enclosure

KEITH G. EARLEY, P.E., P.S.
MERCER COUNTY ENGINEER
101 N. MAIN ST. - COURT HOUSE - ROOM 205
CELINA, OHIO 45822
PHONE 419-586-7759

RECEIVED
NOV 26 1991
Dept. of Natural Resources
Division of Water

RECEIVED
ODNR - DIRECTOR'S OFFICE
NOV 2 1991

November 19, 1991

Francis Buchholzer
Director, Ohio Department of Natural Resources
Building 3D
Fountain Square
Columbus, Ohio 43224

RE: Grand Lake West Spillway Replacement

Dear Ms. Buchholzer,

The replacement of the west spillway is an important safety related project. I have reviewed information supplied by O.D.N.R., and I have reviewed the 1981 "Survey Report for Flood Control and Allied Purposes" prepared by the Louisville, Kentucky District of the Army Corps of Engineers. There are wide discrepancies between the two sources of data and I believe additional detailed analysis should be performed.

The Corps Report indicates an observed bankful flow of the Beaver Creek outlet being about 250 c.f.s. O.D.N.R. indicates a capacity of over 700 c.f.s. The Corps report indicates peak stage lake levels for the ten year through 100 year storms being approximately one foot higher than O.D.N.R. based on 51 years of record measurements. If the Corps report is correct, larger outflow will pass uncontrolled for long periods over the proposed 40 percent enlarged spillway to an outletting stream of very limited capacity. This situation could cause very costly damages especially to structures such as the Lakefront Racket and Health Club.

It appears to me that enlarging the spillway crest would cause more damage than good, even if O.D.N.R. figures are correct. Outlet graphs supplied by O.D.N.R. indicate no reduction in lake peak stage elevations for storms smaller than a 50 year storm. Even the 100 year storm only shows a 0.2 foot peak stage reduction. It appears that this minute rarely occurring reduction would be more than offset by increased damages along the Beaver Creek outlet. According to O.D.N.R. charts, the peak discharge is quadrupled for all storms larger than a ten year event and smaller storms were not analyzed.

It appears desirable for a lake regulation policy which balances the value and probability of attaining the desired recreation pool during desired periods with the cost of flood damages likely to occur around the lake and along the Beaver Creek

outlet. Perhaps the Beaver Creek outlet could economically be improved to safely handle increased outflows. Perhaps combining this increased capacity with a lake regulation policy, that includes the benefits of weather forecasting, could allow routing of peak flows through the Beaver Creek outlet at times when the outlet can handle the flow, and allow holding back flows during short periods while the peak from local storms subsides. Widening the upper three miles by approximately six feet is one alternative I believe should be studied.

A detailed study such as those designed by the Corps of Engineers Hydraulic Engineering Center (HEC) would be time consuming and expensive, but valuable. It is quite possible that such a study could not only provide much improved results, but even reduce construction cost. The study should include detailed damage analysis around the lake and along the outlet including acres inundated, crop damage, structure damage, transportation and utility damage, along with benefit analysis for different alternatives along with an optimization procedure.

Mercer County maintains ten bridges over the Beaver Creek outlet and has long range plans to replace six of these structures. We intend to utilize federal highway off system funds known as BRZ funds. Perhaps enlarging those structures should also be studied.

I sincerely hope that O.D.N.R. gives these items adequate consideration.

Sincerely,

Keith Earley

Keith Earley, P.E., P.S.
Mercer County Engineer

KGE/arn

cc: Mercer County Commissioners
Senator Robert Cupp
Representative Jim Davis

KEITH G. EARLEY, P.E., P.S.
MERCER COUNTY ENGINEER
101 N. MAIN ST. - COURT HOUSE - ROOM 205
CELINA, OHIO 45822
PHONE 419-586-7759

February 12, 1992

RECEIVED
FEB 14 1992
Dept. of Natural Resources
Division of Water

Bob Goetemoeller
Ohio Department of Natural Resources
Building 3D
Fountain Square
Columbus, Ohio 43224

RE: Grand Lake West Spillway Replacement

Dear Mr. Goetemoeller,

The additional information which you provided to me was helpful and the meeting was also helpful. The improved lakeside flood relief of the proposed spillway is quite valuable and evidently the dam safety requirements do not allow any reduction in outlet capacity. It also appears that any additional flooding along the Beaver Creek is negligible in the lower portions of the Beaver Creek. However, I still have concerns regarding flooding near the spillway especially at the Lakefront Racquet and Health Club. The ground floor elevation at that facility is 858.8 and the lowest floor elevation is about three feet lower, where there are two racquet ball courts, locker rooms, saunas, whirlpools, tanning beds, baby sitting room, laundry room, and a furnace room, much of which is carpeted. If flood elevations get above 859 there could be some very expensive damage.

It appears certain that the new spillway will increase the likelihood of very damaging flooding to this facility. Perhaps this increased flooding could be eliminated by removing bottlenecks in the upper three miles of the Beaver Creek without any damage to the downstream owners. Perhaps a capacity equal to a twenty-six foot wide bottom width could be obtained at a reasonable price. I believe that floodplain elevations should be determined for the proposed spillway with the existing channel and for the proposed spillway with an enlarged channel. Those elevations should then be compared to the existing floodplain elevations.

The proposed spillway without the enlarged outlet stream will probably be a benefit to many people, but a detriment to a few. With the enlarged outlet stream, it could be a benefit to all. Since FEMA evaluated the current floodplain in 1989, it should be revised for any significant changes in the watershed. It shouldn't take that much additional work to elevate an enlarged channel condition at the same time. If it is relatively certain that the effects of this study would not change the spillway design, then this would not delay that project and could prevent future delays.

We appreciate the work and commitment that you have devoted to this project. It is to our mutual benefit that all aspects are adequately studied.

Sincerely,

Keith Earley

Keith G. Earley, P.E., P.S.
Mercer County Engineer

KGE/an

cc: file

MERCER COUNTY
SOIL & WATER CONSERVATION DISTRICT

717 W. Logan Street • Celina, Ohio 45822

Telephone: (419) 586-2548

3/9/92

February 28, 1992

Ohio Dept. of Natural Resources
Division of Water
Fountain Square, Bldg, E-3
Columbus, OH 43224

RECEIVED
MAR 0 2 1992
SOIL & WATER CONSERVATION

Dear Chief,

We, as a board of supervisors, feel the proposed spillway at Grand Lake St. Mary's needs several things addressed or further studied to protect the cropland along Beaver Creek.

We understand the weir is being raised by 4" to the plank, that is now across the existing weir. If this is done, we request that the lake draw down be kept at the original weir level and the plank be used as a buffer zone. We feel the management of the lake level is a very important issue. A written management plan needs to be developed before spillway is built.

We feel the Department of Natural Resources has forgotten the farmer, as the Q10 design of the spillway will put 4 feet in Beaver Creek itself. The past year we had Q25 storms which puts out additional 3 feet of water in to Beaver. The increased flood over a dam of this nature will cause higher peak flows in Beaver Creek. We have a total of 7 feet of water into Beaver without any consideration of drainage into the Beaver Creek. The charts ODNR has, does not reflect a true picture of the banks. There is a difference between spoil bank and field levels. The average dept of Beaver Creek without spoil banks is approximately 8 feet.

We as a board of supervisors requested our staff to calculate the design of Beaver Creek with drainage from farm land into Beaver at State Route 118. There are 6828.40 acres. The ditch design used was the counties as built of Beaver Creek. The design used was as follow:

(a) 2:1 side slope
(b) 24' bottom
(c) 0.0003 slope ft/ft
(d) 0.040 n' value
(e) capacity 383.14 CFS Required for 6828.40

The Beaver Creek, itself, would have 6.4 feet of water in it. The ditch itself is approximately 8' deep average. Therefore, in a peak rainfall all the drainage is going to be much greater with a 500 foot dam with a 50' weir 11" deep. Sure the spillway will handle Q10, but if not kept down below the buffer zone there will be no protection for the farmers downstream. We need to know what the new peak flood elevations will be and their duration.

Another thing we would like to address is the states water. If a landowner uses water from the lake for anything, they must have permission and pay for it. We feel, if you claim ownership of the water then you have an obligation when the water enters into Beaver Creek. There has been no maintenance money paid to the county for the permanent county maintenance as of this date. It can't be all a one way street. The state assumed 2/3 of the cost of clean out and should include in their budget on a continuing basis an amount for 2/3 of the annual maintenance. We realize their will be flooding at times, but sometimes measures can be taken to prevent these things before the get out of hand.

Sincerely,

Sam Hellwarth Jr.

Sam Hellwarth Jr.
Chairman
Mercer S.W.C.D.

cc: Jim Davis
Mercer Co. Commissioners
Bob Bash
Senator Cupp

DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
P.O. BOX 59
LOUISVILLE, KENTUCKY 40201-0059

November 23, 1992

RECEIVED
NOV 30 1992
DEPT. OF NATURAL RESOURCES
Chief Engineer

Operations and Readiness Division
Regulatory Branch (North)
ID No. 199101165-pmr

Mr. J. Bruce Pickens
Ohio Department of Natural Resources
Office of Chief Engineer
Fountain Square
Columbus, Ohio 43224

Dear Mr. Pickens:

This is in regard to your letter dated October 13, 1992, concerning a proposal to place fill material to replace an existing spillway, construct a new lake drain, and replace a bridge in Grand Lake St. Marys, in Celina, Mercer County, Ohio.

We have reviewed the hydrology and hydraulics data submitted involving the new spillway design. It has been determined that there is insufficient information to make a decision as to the effects that increasing the spillway capacity will have on flood frequencies and damages. You need to reevaluate the discharges downstream of the dam for the full range of events and use those discharges in the HEC-2 and evaluate the starting elevation used in the HEC-2 analysis. Further, it has been determined that the Ordinary High Water (OHW) elevation on the lake would be 871.0 rather than 874.5 shown on the application drawings. Our point of contact regarding the additional information requested is Mr. Ron Holmberg. Mr. Holmberg can be reached at (502) 582-5513.

If you have any questions concerning this matter, please contact this office at the above address, ATTN: CEORL-OR-FN or call Mrs. Rucker at (502) 582-5607.

Sincerely,

Doug Shelton
Chief, North Section
Regulatory Branch

Grand Lake St. Marys, Mercer County, #0444-001

CONVERSATION/SITE VISIT RECORD

Time 9:15 a.m. **Date** 7/20/95

TYPE

Visit _ **Conference** _ **Telephone** X **Incoming** _ **Outgoing**

Name of Person(s) Contacted or in Contact with you **Organization (Ofc., Dept., Bureau)** **Telephone No.**

Pat Rucker & Ron Holmberg, Louisville District, Corps of Engineers
(502)582-5607

Summary

Ms. Rucker & Mr. Holmberg called to discuss the issue of flooding in Beaver Creek downstream of the proposed Grand Lake spillway. Mr. Holmberg indicated that the Corps needed either calculations to show that there would be no additional flooding in Beaver Creek or agreements from the property owners along the creek saying they accept the additional flooding. He stated that the calculations he would need are models showing the existing vs. proposed spillway flows into the creek along with d/s inflows into Beaver Creek and backwater effects from the Wabash River. I told him I have models showing the effects of the increased spillway flows routed with inflow local to Beaver Creek for the 5, 10, 25, 50 and 100-year floods. I told him the models show no significant increase in peak water levels. I also stated that the models do not take into account backwater conditions from the Wabash, but that adding additional backwater from the Wabash would only further drown the increased spillway effects. He indicated he would like to see models for floods less than the 5-year. I explained that I do not have that information, but that since the 50-foot notch is designed to handle flows up to the 10-year flood, the impact should be minimal. He agreed that the floods above the 10-year when the full 500-foot width of the spillway would flow would be the most critical.

I told them that I had submitted most of this information previously and that during my conversation with Mr. Holmberg from 12/18/92 he had indicated they would study what we had submitted and call us if additional information was needed. I told them that I had not received a request for information since that time. Mr. Holmberg indicated that he had moved twice since that time and had lost some of what I had sent to them. I said that it was my understanding that everything else involved with the 404 was complete and I asked how quickly they could review the modeling information. Mr. Holmberg said he could look at the information the same day he received it. I told them I would send the information today and asked that they call me right away if there are any questions. I told them I would be on vacation from July 28, 1995 and asked that this all be resolved before then if possible.

Name of Person Documenting Conversation **Date**

MBO

Mark B. Ogden, P.E. July 20, 1995

Action Taken

Sent flood studies to Pat Rucker. Call Ms. Rucker by 7/26/95 if I have not heard from them.

c: Gary Harsanye, Div. Of Engineering

ADDENDUM TO THE

HYDROLOGIC AND HYDRAULIC ANALYSIS
GRAND LAKE ST. MARYS DISCHARGE TO BEAVER CREEK
MERCER AND AUGLAIZE COUNTIES, OHIO

Case Leasing and Rental, Inc. Property
Celina, Ohio

Prepared for:

Schottenstein Zox & Dunn Co., LPA
250 West Street
Columbus, Ohio 43215

NOVEMBER 2006

CONESTOGA-ROVERS & ASSOCIATES
4915 S. Sherwood Forest Blvd.
Baton Rouge, LA 70816

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EXECUTIVE SUMMARY

This addendum report was prepared as a supplement to the May, 2006 report, *Hydrologic and Hydraulic Analysis Grand Lake St. Marys Discharge to Beaver Creek, Mercer and Auglaize Counties, Ohio* prepared by Conestoga-Rovers & Associates (CRA).

The CRA May 2006 Report evaluated the impact of the replacement of the spillway at Grand Lake St. Marys (GLSM) on flooding along Beaver Creek and analyzed nine severe historical storm events between 1913 and 2006. The modeling of these storm events was conducted using the historical rainfall data in the GLSM area. The discharge of water over the 39.4-foot spillway was compared to the discharge of water over the 500-foot spillway installed in 1997. The purpose of this analysis was to determine whether and to what extent the design and construction of the 1997 spillway affected the frequency and severity of flooding on properties (and specifically the Case property) along Beaver Creek.

After the trial of this matter was continued on August 29, 2006, CRA was finally able to obtain accurate GLSM lake level data from 1927 to 2006. Using this information, CRA was able to complete a more accurate analysis of historical storm events. A total of sixteen severe storm events were analyzed to determine the potential for flooding along Beaver Creek. The additional analysis by CRA, using the best available data, demonstrates that never during the entire period of record did the 39.4-foot spillway cause the Case sports complex to flood. However, the 500-foot spillway would have caused the Case property, and numerous other properties, to flood ten (10) times.

Contrary to accepted engineering practice, ODNR did not consider and/or model actual historical rainfall data <u>or</u> historical lake elevations during the development and implementation of its plan to manage the probable maximum flood through GLSM. Had ODNR completed such an evaluation, they would have known that their decision to replace the 39.4-foot spillway with their 500-foot spillway would cause - indeed, has now four times since its installation caused (July and December, 2003; January 2005; and June 2006)[1] – severe flooding in Beaver Creek and the nearby properties. ODNR's design and installation of the existing 500-foot spillway is indefensible. Feasible alternatives were and are available to ODNR, but these alternatives were not employed. If ODNR does not take action to correct its mistake, flooding along Beaver Creek will continue to occur.

[1] Refer to Table I and Figures 7a and 7b through 10a and 10b.

BACKGROUND

A. The CRA May 2006 Report and Efforts to Obtain Lake Level Data Prior to August 28, 2006

The CRA May 2006 Report analyzed ODNR lake level data (reported in feet above mean sea level, msl) between 1927 and 1978, that was provided to CRA by the Louisville District Army Corps of Engineers (USACE). In addition, ODNR directly provided to CRA lake level measurements (reported as ± inches above an ambiguously described elevation[2]) that it had collected between 1972 and 2006, as well as some field notes that purported to explain how to translate ODNR's measurements into a standard elevation (i.e., feet msl). Prior to the August 28, 2006 trial, Case (both through its counsel and CRA) repeatedly contacted ODNR in an attempt to obtain clarification of the ODNR measurement technique and field notes, but was never able to obtain this clarification. As a result, CRA did not have accurate lake elevations and completed its historical storm modeling for the May 2006 Report using historical recorded rainfall data.

B. The August 28-29, 2006 Trial

On August 28, 2006, Dr. Pressley Campbell testified on behalf of Case regarding the impact of the replacement of the western spillway at GLSM on flooding along Beaver Creek. During the testimony of ODNR's witness, Doyle Hartman, it was learned that Hartman was relying on lake level data—provided to him only a couple of days before trial—that was never provided and/or explained to Case's counsel or CRA prior to trial. On the basis of this data, Hartman criticized the CRA modeling of historical storms because CRA's modeling was not performed using GLSM lake levels. As a result, the trial was postponed to allow Case to take necessary steps to obtain accurate lake level data. CRA traveled to GLSM on August 29th and met Mr. Steven Dorsten of ODNR to observe and photograph the GLSM gauge located on the eastern

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[2] During the deposition of Steve Dorsten on September 8, 2006, ODNR's lake measurement practices were revealed. According to Dorsten—whose understanding of the mathematics involved is based solely on the oral history provided him by his long-departed supervisor—ODNR collects measurements at one of three lake gauges, not all of which are at the same elevation, in ± inches of the "0" marking on the gauge. For readings collected prior to July 1988, 3 inches were to be added to the reading. For readings collected after July 1998, 7 inches were to be added to the reading. The basis for the addition of 3 inches to the measurement was that when the eastern outlet structure gauge was installed in approximately 1940, it was reportedly installed 2.78 inches below the crest of the 39.4-foot spillway and since the elevation of the spillway crest was known, one could back-calculate the lake elevation. The measurements began adding 7 inches because in July 1988 the crest of the 39.4-foot spillway was raised by approximately 4 inches, so 7 inches were needed in the back-calculation procedure.

outlet structure. Dorsten was personally responsible for recording measurements from the GLSM gauges since 1976.

C. Survey of the Lake Gauges

On September 8, 2006, Mr. Dorsten was deposed and testified that there are three different gauges at GLSM. Dorsten also testified that the elevation of the gauges was not known by ODNR; specifically, that no survey of any of the existing gauges (to determine if they were accurately measuring the elevation of the lake) was to be found in ODNR's files. Accordingly, ODNR and Case jointly arranged for the completion of a survey of the elevation of the three gauges by a licensed professional land surveyor. On September 19, 2006 Lee Surveying, Inc., of Bellefontaine, Ohio, completed this survey, the results of which are attached as Appendix A. The survey revealed that the gauges were not at the elevations ascribed to them by ODNR, meaning that the GLSM lake levels have been consistently under-reported by ODNR.

ADDITIONAL ANALYSIS PERFORMED BY CRA

In order to accurately determine the lake levels between 1927 and 2006 and complete an accurate analysis of the impact of the spillway replacement, CRA completed the following tasks:

(1) CRA calculated the GLSM lake levels for the period April 1, 1927 to August 21, 2006 based upon the actual elevation of the three lake gauges at GLSM, as determined by the survey. The survey demonstrates that the lake elevations reported by ODNR for the last seventy-nine years were less than the actual lake elevations. The lake elevation data are attached in Appendix B.

(2) Using the correct historical lake levels, CRA calculated the actual discharge of water that flowed (or would have flowed) over the 39.4-foot spillway and the 500-foot spillway, respectively, into Beaver Creek between April 1927 and August 2006. The results of the calculations are illustrated on Revised Figure 3 attached as Appendix C. Using the accurate lake levels, this analysis reveals that, had the ODNR-designed 500-foot spillway been constructed 70 years earlier (in 1927), fifteen storm events between 1927 and 2006 would have resulted in flow that exceeds the capacity of Beaver Creek, resulting in flooding; an average of approximately once every five years.

(3) CRA evaluated the rainfall record from 1913 to 2006 and the accurate historical lake levels from 1927 to 2006 to identify the historical periods where rainfall resulted in high lake elevations, the factors that can cause severe runoff and flooding in the GLSM area. The evaluation identified sixteen storm events that had such an impact:

March/April	1913	June/July	1993
January	1930	February/March	1997
April	1938	July/August	1998
May	1943	May	2002
February	1950	June/July	2003
April/May	1972	December	2003
May	1981	January	2005
July	1992	June	2006

(4) Using the HEC-2 computer model employed by ODNR, CRA determined the water surface elevation along Beaver Creek that had (or would have) occurred from the discharge over the 39.4 and 500-foot spillways for the sixteen most significant storm events that occurred between 1913 and 2006. These results demonstrate that, **with the 39.4-foot spillway, the Case sports complex would not have flooded during a single event. However, with the 500-foot spillway, water in Beaver Creek overflows the channel banks and inundates the Case property ten times**: in 1913, 1930, 1943, 1981, 1992, 1993, July 2003, December 2003, 2005, and 2006. The results of this modeling are presented on Table 1 and illustrated on Figures 1a and 1b through 10a and 10b.

(5) CRA completed an analysis of the lake levels from 1927 through 1997—when ODNR ceased managing lake levels—and 1997 through 2006, when ODNR no longer managed lake levels. The results of the lake level analysis are presented on Table 2. The results follow:

- Since 1997, 73.3 percent of the measurements taken reflect lake level elevations above 870.6 feet msl, the elevation at which water overflows the 50-foot long notch in the spillway and enters Beaver Creek. Before 1997, the lake level was above 870.6 feet for only 21.4 percent of the measurements.
- Since 1997, 26.3 percent of the measurements collected reflect lake level elevations above 871.5 feet msl, the elevation at which water overflows the entire 500-foot length of the spillway. Before 1997, the lake level was above 871.5 feet for only 2.4 percent of the measurements.
- Since 1997, 10 percent of the measurements taken reflect lake level elevations above 871.8 feet msl, the lake elevation at which the 500-foot spillway discharges a quantity of water that will overflow the Beaver Creek channel banks at the Case property. Before 1997, the lake level exceeded 871.8 feet for only 1 percent of the measurements.

As evident above, since the construction of the 500-foot spillway in 1997, the lake levels of GLSM are consistently and significantly higher than historically. When the lake level of GLSM is above 870.6 feet msl, water is discharging into Beaver Creek. If the lake is at or above that

elevation when a storm event occurs, the storm is more likely to cause flooding in Beaver Creek, regardless of the size of the event; and the higher the initial lake elevation, the more dramatic the impact will be. The combination of the 500-foot spillway and the ODNR policy of not managing the lake levels drastically increases the risk of flooding for downstream property owners. This risk has become reality four times since the construction of the 500-foot spillway, (July and December, 2003; January 2005; and June 2006)[3].

For example, on July 2, 2003, three days before the storm began that inundated Case, the elevation of the lake was 871.2 feet msl, more than seven (7) inches above the notch (870.6 feet). For the December, 2003 event, the initial lake elevation was 871.7 feet msl, more than one foot above the notch and two inches higher than the remaining 450 feet of the spillway (871.5 feet).

ANALYSIS OF DOYLE HARTMAN'S REPORT AND METHODOLOGY

During his testimony on August 28, 2006 and in his report dated July 14, 2006, Mr. Hartman implied that the frequency and severity of flooding in Beaver Creek resulting form the 1997 spillway replacement are minimal. However, when CRA evaluated the new lake elevations, in conjunction with the historical rainfall information, the analysis disclosed that Hartman's conclusions are not supported by the data. (Indeed, the potential for flooding in Beaver Creek as a result of the 500-foot spillway installation is far more severe than initially reported in the May 2006 CRA report.) CRA examined Hartman's methodology to determine why his calculations of the frequency and severity of flooding in Beaver Creek underestimated the problem. To that end, CRA obtained and evaluated the HEC-HMS and HEC-RAS models used by Hartman.

A. Hartman's Use of a 24-Hour Duration Storm Event

Hartman used a 24-hour duration storm event in his modeling and analysis to predict the magnitude of flooding that would be caused by ODNR's 500-foot spillway. However, Hartman did not examine the historical record to determine if his selection of the 24-hour duration event corresponded with recorded storm durations of the past. It does not. The storm event durations that have historically resulted in the most severe flow in Beaver Creek were 72-hour, and longer events. Hartman's selection and use of the 24-hour duration event misleadingly suggests that the severity of flooding in Beaver Creek caused by the 1997 spillway is significantly less than what the Creek and adjoining properties experience during the numerous storm events that exceed 24 hours. His model does not accurately reflect the conditions of the GLSM area.

[3] Refer to Table 1 and Figures 7a and 7b through 10a and 10b.

B. The Flaws in Hartman's Model

The models used by Hartman, HEC-HMS and HEC-RAS, were developed by the U.S. Army Corps of Engineers, which also promulgated guidance for the proper use of the models. Hartman's modeling deviated from the Army Corps of Engineers guidance in, at least, two key respects:

(1) Hartman modeled the 2003 storm event to determine the potential flooding along Beaver Creek. However, during modeling, Hartman used the precipitation data from only one meteorological station (Coldwater), rather than using the HEC-recommended method that prescribes the use of all available records at multiple stations. Hartman states in his July 14, 2006 report, "there were not enough detailed data to accurately determine the actual amount and distribution of rainfall in the various segments of the overall watershed." This is not true. Seven National Oceanic & Atmospheric Administration (NOAA) meteorological stations are located within a 35-mile radius of the western spillway at GLSM with precipitation data dating back to 1910. Hartman did not input the publicly available rainfall data at the six other stations, including stations at Celina and St. Marys. Instead Hartman assumed, in constructing his model, that the amount of rainfall recorded at the Coldwater station was the amount of rainfall that fell over the entire 296 square mile drainage basin he used in his model. That is not what happened. The distribution of rainfall, as recorded by the seven stations, was not similar to the distribution used by Hartman in his modeling.

Standard modeling practice is to collect the available data including rainfall, streamflow, and lake levels, and input this known recorded data into the model. Once the model is set up with the known data, unknown variables, such as soil conditions and antecedent moisture conditions, can be adjusted in an attempt to match actual recorded conditions such as, in this instance, the flood elevations measured during the 2003 flood. It violates standard practice and common sense to adjust the known, recorded data such as rainfall, as Hartman did. For his model, Hartman admits that he selected a rainfall amount from one location and assumed it was distributed uniformly over 296 square miles, "Although the actual rainfall distribution varied widely across the entire watershed, a uniform distribution was assumed in the entire watershed analysis." This is a gross misuse of the modeling process. The results from a model that bases its conclusions on inaccurate depictions of known, recorded conditions, such as the amount of rainfall and rainfall distribution, is not credible.

(2) Hartman modeled the 2003 storm event using the methodology described above. His conclusion was that the flood elevations in Beaver Creek immediately downstream of GLSM were approximately 861 feet msl for the 500-foot spillway and approximately 857.5 feet msl for the 39.4-foot spillway. This is approximately a 3.5 foot difference in elevation as a result of the replacement of the spillway as stated by Hartman in his July 2006 Report. The Mercer County Engineers Office surveyed the 2003 flood elevation on July 9, 2003 during the flooding, directly

downstream of the 500-foot spillway and determined the flood elevation to be 861.8 feet msl. This differs from Hartman's model by approximately 0.8 feet. Therefore, the model used by Hartman underestimates the amount of flooding that occurred in 2003 at the Case property and likely also underestimates the amount of flooding caused by other storms. There is no indication that Hartman made an attempt to verify the accuracy of his model by comparing the model output to recorded flood elevations, as standard engineering practice dictates.

CONCLUSION

The use of accurate historic lake elevations in the calculations and modeling of discharge into Beaver Creek from GLSM demonstrates that the potential for flooding as a result of the installation of the 500-foot spillway is substantially worse than originally reported in the CRA May 2006 Report, which used precipitation data to predict flooding. However, because ODNR failed to consider and analyze historical lake level data or precipitation data—as is standard engineering practice—, it did not realize that the installation of the 500-foot spillway would cause, and now has repeatedly caused, frequent and severe flooding in Beaver Creek, and the surrounding properties (including the Case property).

The impact of this error has been greatly compounded by ODNR's decision to adopt a laissez faire approach towards lake level "management"; a decision that was apparently made without any consideration, or scientific analysis, of the effect that this decision would have, and has had, on Case and the people living and working in the vicinity of Beaver Creek.

As stated in CRA's earlier report and in the testimony of Dr. Campbell, ODNR had feasible alternatives available in 1997 to prevent GLSM from overtopping the embankments separating the lake from the City of Celina, without sacrificing the property and endangering the safety of the residents near Beaver Creek. ODNR failed to utilize those measures. It has also failed to take the simple measure of opening the gates in the spillways, as necessary, to avoid the risk that higher lake elevations have on flooding. ODNR's actions, omissions and practices, as described in this Report, do not comport with accepted engineering standards.

All of which is Respectfully Submitted,
CONESTOGA-ROVERS & ASSOCIATES

Pressley L. Campbell

Pressley L. Campbell, Ph.D., PE
Ohio PE 56681

ADDENDUM TO THE

HYDROLOGIC AND HYDRAULIC ANALYSIS
GRAND LAKE ST. MARYS DISCHARGE TO BEAVER CREEK
MERCER AND AUGLAIZE COUNTIES, OHIO

Case Leasing and Rental, Inc. Property
Celina, Ohio

Prepared for:

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NOVEMBER 2006

Prepared by:
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PENGAD-Bayonne, N. J.
Respondent 2A

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EXECUTIVE SUMMARY

This addendum report was prepared as a supplement to the May, 2006 report, *Hydrologic and Hydraulic Analysis Grand Lake St. Marys Discharge to Beaver Creek, Mercer and Auglaize Counties, Ohio* prepared by Conestoga-Rovers & Associates (CRA).

The CRA May 2006 Report evaluated the impact of the replacement of the spillway at Grand Lake St. Marys (GLSM) on flooding along Beaver Creek and analyzed nine severe historical storm events between 1913 and 2006. The modeling of these storm events was conducted using the historical rainfall data in the GLSM area. The discharge of water over the 39.4-foot spillway was compared to the discharge of water over the 500-foot spillway installed in 1997. The purpose of this analysis was to determine whether and to what extent the design and construction of the 1997 spillway affected the frequency and severity of flooding on properties (and specifically the Case property) along Beaver Creek.

After the trial of this matter was continued on August 29, 2006, CRA was finally able to obtain accurate GLSM lake level data from 1927 to 2006. Using this information, CRA was able to complete a more accurate analysis of historical storm events. A total of sixteen severe storm events were analyzed to determine the potential for flooding along Beaver Creek. The additional analysis by CRA, using the best available data, demonstrates that never during the entire period of record did the 39.4-foot spillway cause the Case sports complex to flood. However, the 500-foot spillway would have caused the Case property, and numerous other properties, to flood ten (10) times.

Contrary to accepted engineering practice, ODNR did not consider and/or model actual historical rainfall data <u>or</u> historical lake elevations during the development and implementation of its plan to manage the probable maximum flood through GLSM. Had ODNR completed such an evaluation, they would have known that their decision to replace the 39.4-foot spillway with their 500-foot spillway would cause - indeed, has now four times since its installation caused (July and December, 2003; January 2005; and June 2006)[1] – severe flooding in Beaver Creek and the nearby properties. ODNR's design and installation of the existing 500-foot spillway is indefensible. Feasible alternatives were and are available to ODNR, but these alternatives were not employed. If ODNR does not take action to correct its mistake, flooding along Beaver Creek will continue to occur.

[1] Refer to Table 1 and Figures 7a and 7b through 10a and 10b.

BACKGROUND

A. The CRA May 2006 Report and Efforts to Obtain Lake Level Data Prior to August 28, 2006

The CRA May 2006 Report analyzed ODNR lake level data (reported in feet above mean sea level, msl) between 1927 and 1978, that was provided to CRA by the Louisville District Army Corps of Engineers (USACE). In addition, ODNR directly provided to CRA lake level measurements (reported as + inches above an ambiguously described elevation[2]) that it had collected between 1972 and 2006, as well as some field notes that purported to explain how to translate ODNR's measurements into a standard elevation (i.e., feet msl). Prior to the August 28, 2006 trial, Case (both through its counsel and CRA) repeatedly contacted ODNR in an attempt to obtain clarification of the ODNR measurement technique and field notes, but was never able to obtain this clarification. As a result, CRA did not have accurate lake elevations and completed its historical storm modeling for the May 2006 Report using historical recorded rainfall data.

B. The August 28-29, 2006 Trial

On August 28, 2006, Dr. Pressley Campbell testified on behalf of Case regarding the impact of the replacement of the western spillway at GLSM on flooding along Beaver Creek. During the testimony of ODNR's witness, Doyle Hartman, it was learned that Hartman was relying on lake level data—provided to him only a couple of days before trial—that was never provided and/or explained to Case's counsel or CRA prior to trial. On the basis of this data, Hartman criticized the CRA modeling of historical storms because CRA's modeling was not performed using GLSM lake levels. As a result, the trial was postponed to allow Case to take necessary steps to obtain accurate lake level data. CRA traveled to GLSM on August 29th and met Mr. Steven Dorsten of ODNR to observe and photograph the GLSM gauge located on the eastern

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[2] During the deposition of Steve Dorsten on September 8, 2006, ODNR's lake measurement practices were revealed. According to Dorsten—whose understanding of the mathematics involved is based solely on the oral history provided him by his long-departed supervisor—ODNR collects measurements at one of three lake gauges, not all of which are at the same elevation, in ± inches of the "0" marking on the gauge. For readings collected prior to July 1988, 3 inches were to be added to the reading. For readings collected after July 1998, 7 inches were to be added to the reading. The basis for the addition of 3 inches to the measurement was that when the eastern outlet structure gauge was installed in approximately 1940, it was reportedly installed 2.78 inches below the crest of the 39.4-foot spillway and since the elevation of the spillway crest was known, one could back-calculate the lake elevation. The measurements began adding 7 inches because in July 1988 the crest of the 39.4-foot spillway was raised by approximately 4 inches, so 7 inches were needed in the back-calculation procedure.

outlet structure. Dorsten was personally responsible for recording measurements from the GLSM gauges since 1976.

C. Survey of the Lake Gauges

On September 8, 2006, Mr. Dorsten was deposed and testified that there are three different gauges at GLSM. Dorsten also testified that the elevation of the gauges was not known by ODNR; specifically, that no survey of any of the existing gauges (to determine if they were accurately measuring the elevation of the lake) was to be found in ODNR's files. Accordingly, ODNR and Case jointly arranged for the completion of a survey of the elevation of the three gauges by a licensed professional land surveyor. On September 19, 2006 Lee Surveying, Inc., of Bellefontaine, Ohio, completed this survey, the results of which are attached as Appendix A. The survey revealed that the gauges were not at the elevations ascribed to them by ODNR, meaning that the GLSM lake levels have been consistently under-reported by ODNR.

ADDITIONAL ANALYSIS PERFORMED BY CRA

In order to accurately determine the lake levels between 1927 and 2006 and complete an accurate analysis of the impact of the spillway replacement, CRA completed the following tasks:

(1) CRA calculated the GLSM lake levels for the period April 1, 1927 to August 21, 2006 based upon the actual elevation of the three lake gauges at GLSM, as determined by the survey. The survey demonstrates that the lake elevations reported by ODNR for the last seventy-nine years were less than the actual lake elevations. The lake elevation data are attached in Appendix B.

(2) Using the correct historical lake levels, CRA calculated the actual discharge of water that flowed (or would have flowed) over the 39.4-foot spillway and the 500-foot spillway, respectively, into Beaver Creek between April 1927 and August 2006. The results of the calculations are illustrated on Revised Figure 3 attached as Appendix C. Using the accurate lake levels, this analysis reveals that, had the ODNR-designed 500-foot spillway been constructed 70 years earlier (in 1927), fifteen storm events between 1927 and 2006 would have resulted in flow that exceeds the capacity of Beaver Creek, resulting in flooding; an average of approximately once every five years.

(3) CRA evaluated the rainfall record from 1913 to 2006 and the accurate historical lake levels from 1927 to 2006 to identify the historical periods where rainfall resulted in high lake elevations, the factors that can cause severe runoff and flooding in the GLSM area. The evaluation identified sixteen storm events that had such an impact:

March/April	1913	June/July	1993
January	1930	February/March	1997
April	1938	July/August	1998
May	1943	May	2002
February	1950	June/July	2003
April/May	1972	December	2003
May	1981	January	2005
July	1992	June	2006

(4) Using the HEC-2 computer model employed by ODNR, CRA determined the water surface elevation along Beaver Creek that had (or would have) occurred from the discharge over the 39.4 and 500-foot spillways for the sixteen most significant storm events that occurred between 1913 and 2006. These results demonstrate that, **with the 39.4-foot spillway, the Case sports complex would not have flooded during a single event. However, with the 500-foot spillway, water in Beaver Creek overflows the channel banks and inundates the Case property ten times:** in 1913, 1930, 1943, 1981, 1992, 1993, July 2003, December 2003, 2005, and 2006. The results of this modeling are presented on Table 1 and illustrated on Figures 1a and 1b through 10a and 10b.

(5) CRA completed an analysis of the lake levels from 1927 through 1997—when ODNR ceased managing lake levels—and 1997 through 2006, when ODNR no longer managed lake levels. The results of the lake level analysis are presented on Table 2. The results follow:

- Since 1997, 73.3 percent of the measurements taken reflect lake level elevations above 870.6 feet msl, the elevation at which water overflows the 50-foot long notch in the spillway and enters Beaver Creek. Before 1997, the lake level was above 870.6 feet for only 21.4 percent of the measurements.
- Since 1997, 26.3 percent of the measurements collected reflect lake level elevations above 871.5 feet msl, the elevation at which water overflows the entire 500-foot length of the spillway. Before 1997, the lake level was above 871.5 feet for only 2.4 percent of the measurements.
- Since 1997, 10 percent of the measurements taken reflect lake level elevations above 871.8 feet msl, the lake elevation at which the 500-foot spillway discharges a quantity of water that will overflow the Beaver Creek channel banks at the Case property. Before 1997, the lake level exceeded 871.8 feet for only 1 percent of the measurements.

As evident above, since the construction of the 500-foot spillway in 1997, the lake levels of GLSM are consistently and significantly higher than historically. When the lake level of GLSM is above 870.6 feet msl, water is discharging into Beaver Creek. If the lake is at or above that

elevation when a storm event occurs, the storm is more likely to cause flooding in Beaver Creek, regardless of the size of the event; and the higher the initial lake elevation, the more dramatic the impact will be. The combination of the 500-foot spillway and the ODNR policy of not managing the lake levels drastically increases the risk of flooding for downstream property owners. This risk has become reality four times since the construction of the 500-foot spillway, (July and December, 2003; January 2005; and June 2006)[3].

For example, on July 2, 2003, three days before the storm began that inundated Case, the elevation of the lake was 871.2 feet msl, more than seven (7) inches above the notch (870.6 feet). For the December, 2003 event, the initial lake elevation was 871.7 feet msl, more than one foot above the notch and two inches higher than the remaining 450 feet of the spillway (871.5 feet).

ANALYSIS OF DOYLE HARTMAN'S REPORT AND METHODOLOGY

During his testimony on August 28, 2006 and in his report dated July 14, 2006, Mr. Hartman implied that the frequency and severity of flooding in Beaver Creek resulting form the 1997 spillway replacement are minimal. However, when CRA evaluated the new lake elevations, in conjunction with the historical rainfall information, the analysis disclosed that Hartman's conclusions are not supported by the data. (Indeed, the potential for flooding in Beaver Creek as a result of the 500-foot spillway installation is far more severe than initially reported in the May 2006 CRA report.) CRA examined Hartman's methodology to determine why his calculations of the frequency and severity of flooding in Beaver Creek underestimated the problem. To that end, CRA obtained and evaluated the HEC-HMS and HEC-RAS models used by Hartman.

A. Hartman's Use of a 24-Hour Duration Storm Event

Hartman used a 24-hour duration storm event in his modeling and analysis to predict the magnitude of flooding that would be caused by ODNR's 500-foot spillway. However, Hartman did not examine the historical record to determine if his selection of the 24-hour duration event corresponded with recorded storm durations of the past. It does not. The storm event durations that have historically resulted in the most severe flow in Beaver Creek were 72-hour, and longer events. Hartman's selection and use of the 24-hour duration event misleadingly suggests that the severity of flooding in Beaver Creek caused by the 1997 spillway is significantly less than what the Creek and adjoining properties experience during the numerous storm events that exceed 24 hours. His model does not accurately reflect the conditions of the GLSM area.

[3] Refer to Table 1 and Figures 7a and 7b through 10a and 10b.

B. The Flaws in Hartman's Model

The models used by Hartman, HEC-HMS and HEC-RAS, were developed by the U.S. Army Corps of Engineers, which also promulgated guidance for the proper use of the models. Hartman's modeling deviated from the Army Corps of Engineers guidance in, at least, two key respects:

(1) Hartman modeled the 2003 storm event to determine the potential flooding along Beaver Creek. However, during modeling, Hartman used the precipitation data from only one meteorological station (Coldwater), rather than using the HEC-recommended method that prescribes the use of all available records at multiple stations. Hartman states in his July 14, 2006 report, "there were not enough detailed data to accurately determine the actual amount and distribution of rainfall in the various segments of the overall watershed." This is not true. Seven National Oceanic & Atmospheric Administration (NOAA) meteorological stations are located within a 35-mile radius of the western spillway at GLSM with precipitation data dating back to 1910. Hartman did not input the publicly available rainfall data at the six other stations, including stations at Celina and St. Marys. Instead Hartman assumed, in constructing his model, that the amount of rainfall recorded at the Coldwater station was the amount of rainfall that fell over the entire 296 square mile drainage basin he used in his model. That is not what happened. The distribution of rainfall, as recorded by the seven stations, was not similar to the distribution used by Hartman in his modeling.

Standard modeling practice is to collect the available data including rainfall, streamflow, and lake levels, and input this known recorded data into the model. Once the model is set up with the known data, unknown variables, such as soil conditions and antecedent moisture conditions, can be adjusted in an attempt to match actual recorded conditions such as, in this instance, the flood elevations measured during the 2003 flood. It violates standard practice and common sense to adjust the known, recorded data such as rainfall, as Hartman did. For his model, Hartman admits that he selected a rainfall amount from one location and assumed it was distributed uniformly over 296 square miles, "Although the actual rainfall distribution varied widely across the entire watershed, a uniform distribution was assumed in the entire watershed analysis." This is a gross misuse of the modeling process. The results from a model that bases its conclusions on inaccurate depictions of known, recorded conditions, such as the amount of rainfall and rainfall distribution, is not credible.

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CONCLUSION

The use of accurate historic lake elevations in the calculations and modeling of discharge into Beaver Creek from GLSM demonstrates that the potential for flooding as a result of the installation of the 500-foot spillway is substantially worse than originally reported in the CRA May 2006 Report, which used precipitation data to predict flooding. However, because ODNR failed to consider and analyze historical lake level data or precipitation data—as is standard engineering practice—, it did not realize that the installation of the 500-foot spillway would cause, and now has repeatedly caused, frequent and severe flooding in Beaver Creek, and the surrounding properties (including the Case property).

The impact of this error has been greatly compounded by ODNR's decision to adopt a laissez faire approach towards lake level "management"; a decision that was apparently made without any consideration, or scientific analysis, of the effect that this decision would have, and has had, on Case and the people living and working in the vicinity of Beaver Creek.

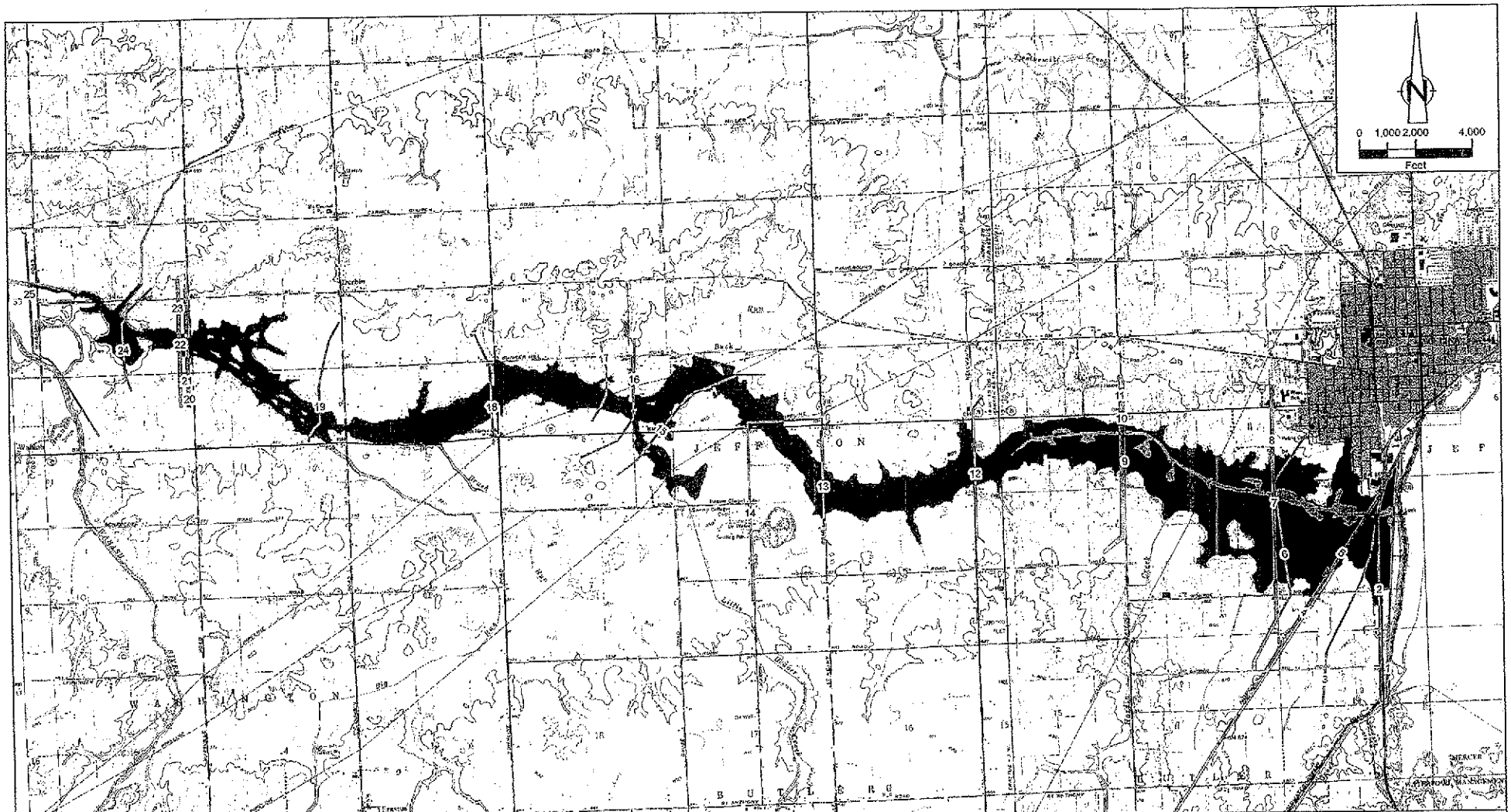
As stated in CRA's earlier report and in the testimony of Dr. Campbell, ODNR had feasible alternatives available in 1997 to prevent GLSM from overtopping the embankments separating the lake from the City of Celina, without sacrificing the property and endangering the safety of the residents near Beaver Creek. ODNR failed to utilize those measures. It has also failed to take the simple measure of opening the gates in the spillways, as necessary, to avoid the risk that higher lake elevations have on flooding. ODNR's actions, omissions and practices, as described in this Report, do not comport with accepted engineering standards.

All of which is Respectfully Submitted,
CONESTOGA-ROVERS & ASSOCIATES

Pressley L. Campbell

Pressley L. Campbell, Ph.D., PE
Ohio PE 56681

FIGURES



CROSS SECTIONS OF BEAVER CREEK USED IN HEC-2 MODEL WERE OBTAINED FROM THE FINAL REPORT HYDROLOGIC AND HYDRAULIC ANALYSES, GRAND LAKE ST. MARYS, AUGLAIZE AND MERCER COUNTIES, OHIO, FEBRUARY 2, 1990, BBC&M ENGINEERING, INC.

UNITED STATES GEOLOGICAL SURVEY DIGITAL RASTER GRAPHICS (CELINA & ERASTUS) DOWNLOADED FROM THE OHIO OFFICE OF INFORMATION TECHNOLOGY WEBSITE

GROUND SURFACE ELEVATIONS USED WERE OBTAINED FROM THE OHIO 10 METER DIGITAL ELEVATION MODEL, PUBLISHED BY THE OHIO ENVIRONMENTAL PROTECTION AGENCY DIVISION OF EMERGENCY AND REMEDIAL RESPONSE, 2004

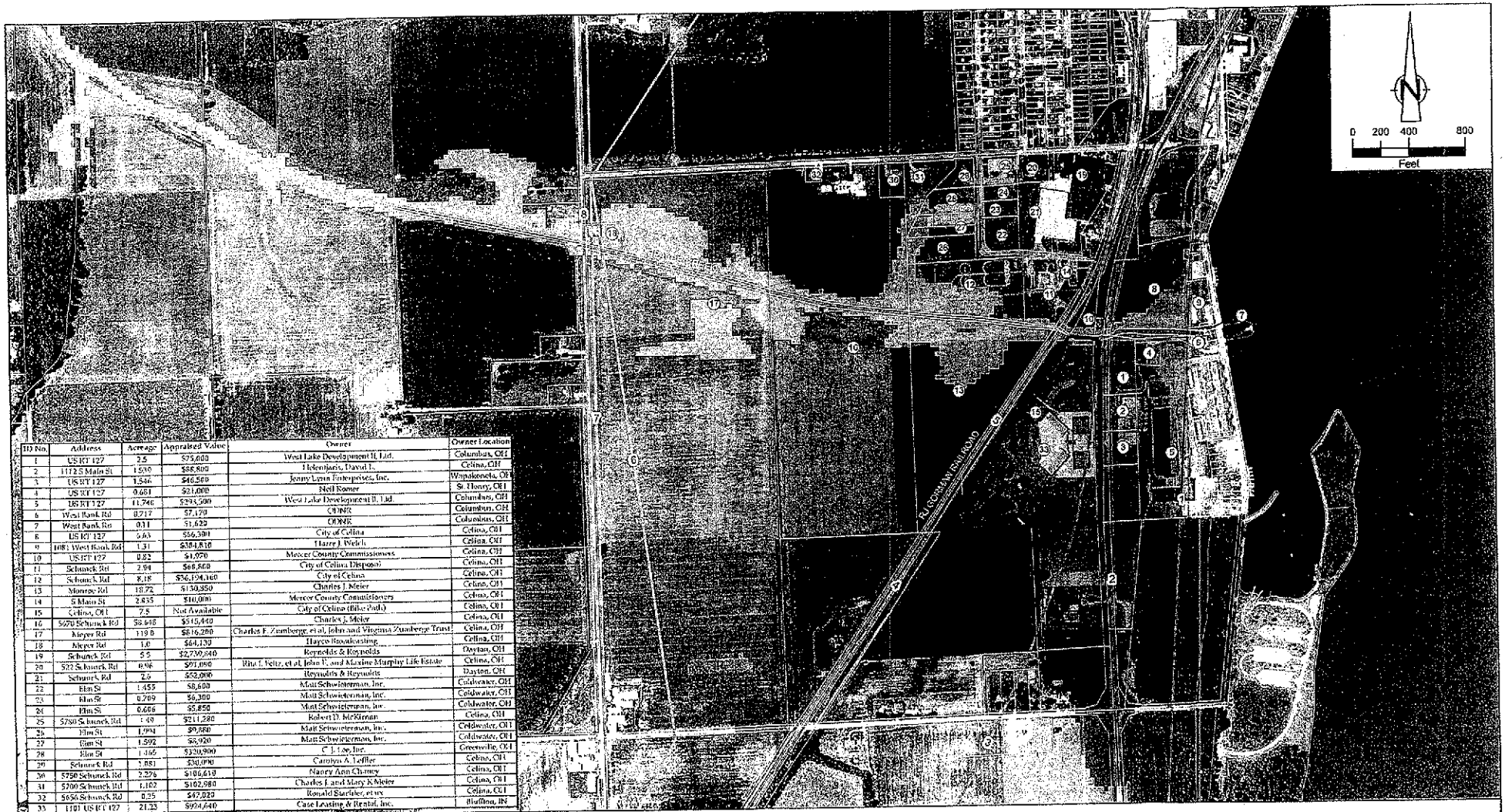
THIS FIGURE ILLUSTRATES MODELING COMPLETED FOR THE CRA MAY 2006 REPORT AND IS IDENTICAL TO FIGURE 4a IN THE CRA MAY 2006 REPORT.

LEGEND

- CASE LEASING AND RENTAL, INC. PROPERTY BOUNDARY
- CROSS SECTION NUMBER AND LOCATIONS USED IN HEC-2 COMPUTER PROGRAM
- INUNDATED AREA AS THE RESULT OF THE 500-FOOT SPILLWAY
- INUNDATED AREA AS THE RESULT OF THE 39.4-FOOT SPILLWAY

Figure 1a
MARCH/APRIL 1913 STORM EVENT FLOOD INUNDATION MAP

Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio



ID No.	Address	Acreage	Appraised Value	Owner	Owner Location
1	US RT 127	3.5	$75,600	West Lake Development II, Ltd.	Columbus, OH
2	1172 S Main St	1.530	$66,800	Helentjaris, David L.	Celina, OH
3	US RT 127	1.546	$46,560	Jenny Lynn Enterprises, Inc.	Wapakoneta, OH
4	US RT 127	0.681	$21,000	Neil Romer	St. Henry, OH
5	US RT 127	11.746	$295,500	West Lake Development II, Ltd.	Columbus, OH
6	West Bank Rd	0.717	$7,170	ODNR	Columbus, OH
7	West Bank Rd	0.11	$1,622	ODNR	Columbus, OH
8	US RT 127	5.63	$56,300	City of Celina	Celina, OH
9	1081 West Bank Rd	1.31	$384,810	Harry J. Welch	Celina, OH
10	US RT 127	0.82	$1,950	Mercer County Commissioners	Celina, OH
11	Schunck Rd	2.94	$68,860	City of Celina Disposal	Celina, OH
12	Schunck Rd	8.18	$36,194,160	City of Celina	Celina, OH
13	Monroe Rd	18.72	$130,950	Charles J. Meier	Celina, OH
14	S Main St	2.835	$10,000	Mercer County Commissioners	Celina, OH
15	Celina, OH	7.5	Not Available	City of Celina (Bike Path)	Celina, OH
16	5670 Schunck Rd	56.448	$515,440	Charles J. Meier	Celina, OH
17	Meyer Rd	119.8	$816,200	Charles F. Zumberge, et al, John and Virginia Zumberge Trust	Celina, OH
18	Meyer Rd	1.0	$64,130	Hayco Broadcasting	Celina, OH
19	Schunck Rd	5.5	$2,700,940	Reynolds & Reynolds	Dayton, OH
20	532 Schunck Rd	0.98	$91,000	Rita L. Feltz, et al, John E. and Maxine Murphy Life Estate	Celina, OH
21	Schunck Rd	2.6	$52,000	Reynolds & Reynolds	Dayton, OH
22	Elm St	1.455	$8,600	Matt Schweisterman, Inc.	Coldwater, OH
23	Elm St	0.769	$6,300	Matt Schweisterman, Inc.	Coldwater, OH
24	Elm St	0.686	$5,850	Matt Schweisterman, Inc.	Coldwater, OH
25	5780 Schunck Rd	1.49	$211,280	Robert D. McKinnan	Celina, OH
26	Elm St	1.994	$9,880	Matt Schweisterman, Inc.	Coldwater, OH
27	Elm St	1.592	$8,920	Matt Schweisterman, Inc.	Coldwater, OH
28	Elm St	1.165	$320,900	C.J. Law, Inc.	Greenville, OH
29	Schunck Rd	1.881	$30,090	Carolyn A. Leffler	Celina, OH
30	5750 Schunck Rd	2.276	$106,610	Nancy Ann Chaney	Celina, OH
31	5700 Schunck Rd	1.102	$102,080	Charles J. and Mary K Meier	Celina, OH
32	5656 Schunck Rd	0.25	$47,020	Ronald Starkler, et ux.	Celina, OH
33	1101 US RT 127	21.23	$924,640	Case Leasing & Rental, Inc.	Bluffton, IN

CROSS SECTIONS OF BEAVER CREEK USED IN HEC-2 MODEL WERE OBTAINED FROM THE FINAL REPORT HYDROLOGIC AND HYDRAULIC ANALYSES, GRAND LAKE ST. MARYS, AUGLAIZE AND MERCER COUNTIES, OHIO, FEBRUARY 2, 1980, BBC&M ENGINEERING, INC.

UNITED STATES DEPARTMENT OF AGRICULTURE AERIAL PHOTOGRAPH DATED JUNE 23, 2004

INFORMATION SHOWN IN THE TABLE AND PROPERTY BOUNDARIES SHOWN ON THE FIGURE WERE OBTAINED FROM THE MERCER COUNTY, OHIO REAL ESTATE SEARCH RESULTS, UNOFFICIAL REAL PROPERTY RECORD CARDS, COMPLETED ON DECEMBER 21, 2005

GROUND SURFACE ELEVATIONS USED WERE OBTAINED FROM THE OHIO 10 METER DIGITAL ELEVATION MODEL, PUBLISHED BY THE OHIO ENVIRONMENTAL PROTECTION AGENCY DIVISION OF EMERGENCY AND REMEDIAL RESPONSE, 2004

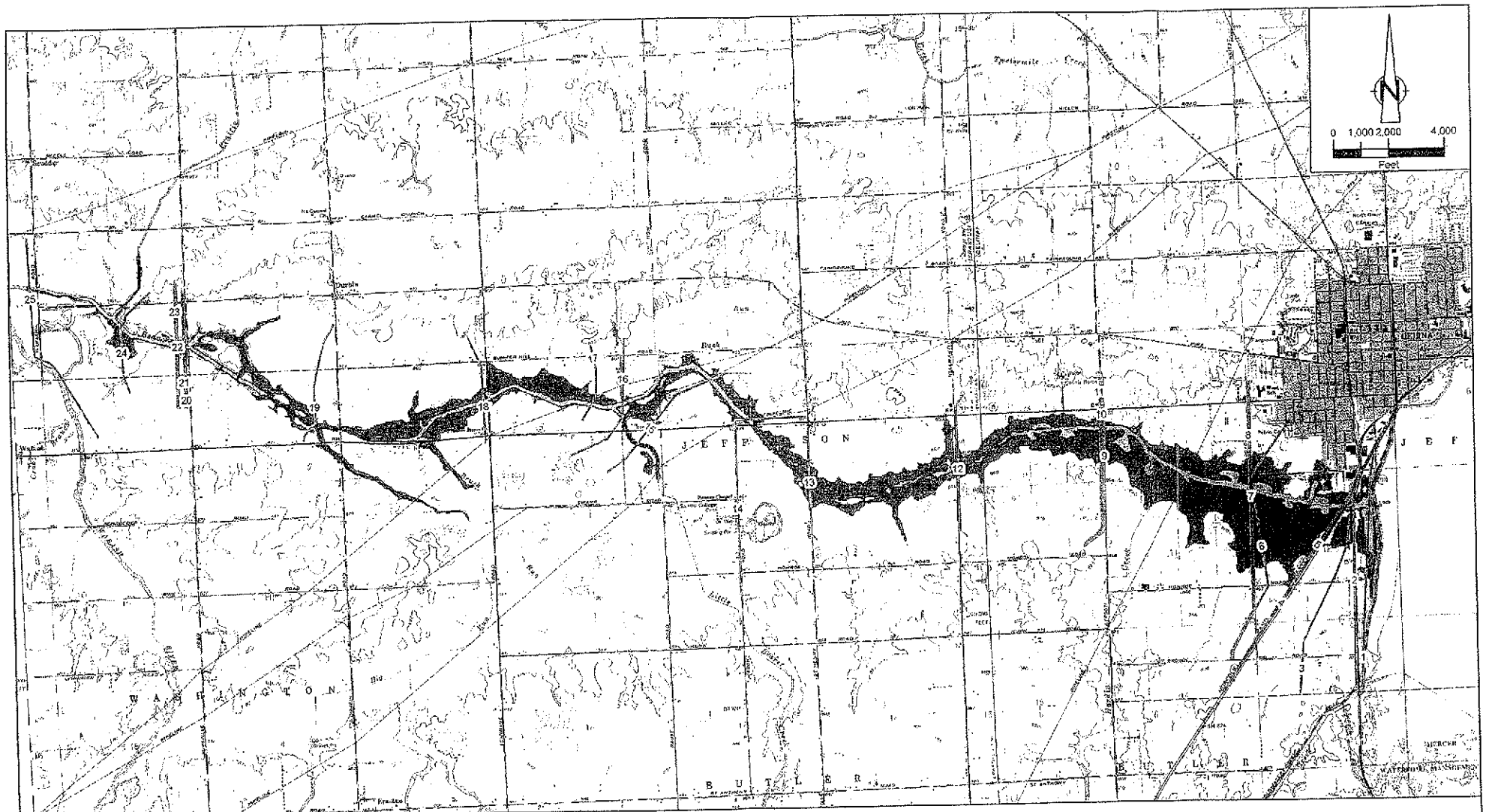
THIS FIGURE ILLUSTRATES MODELING COMPLETED FOR THE CRA MAY 2006 REPORT AND IS IDENTICAL TO FIGURE 4b IN THE CRA MAY 2006 REPORT.

CRA

LEGEND

- CASE LEASING AND RENTAL, INC. PROPERTY BOUNDARY
- CROSS SECTION NUMBER AND LOCATIONS USED IN HEC-2 COMPUTER PROGRAM
- PROPERTY BOUNDARIES
- INUNDATED AREA AS THE RESULT OF THE 39.4-FOOT SPILLWAY
- INUNDATED AREA AS THE RESULT OF THE 500-FOOT SPILLWAY
- (17) PROPERTY IDENTIFICATION NUMBER

Figure 1b
MARCH/APRIL 1913 STORM EVENT
FLOOD INUNDATION MAP
Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio



CROSS SECTIONS OF BEAVER CREEK USED IN HEC-2 MODEL WERE OBTAINED FROM THE FINAL REPORT HYDROLOGIC AND HYDRAULIC ANALYSES, GRAND LAKE ST. MARYS, AUGLAIZE AND MERCER COUNTIES, OHIO, FEBRUARY 2, 1993, BBCSM ENGINEERING, INC.

UNITED STATES GEOLOGICAL SURVEY DIGITAL RASTER GRAPHICS (DELINA & ERASTUS) DOWNLOADED FROM THE OHIO OFFICE OF INFORMATION TECHNOLOGY WEBSITE

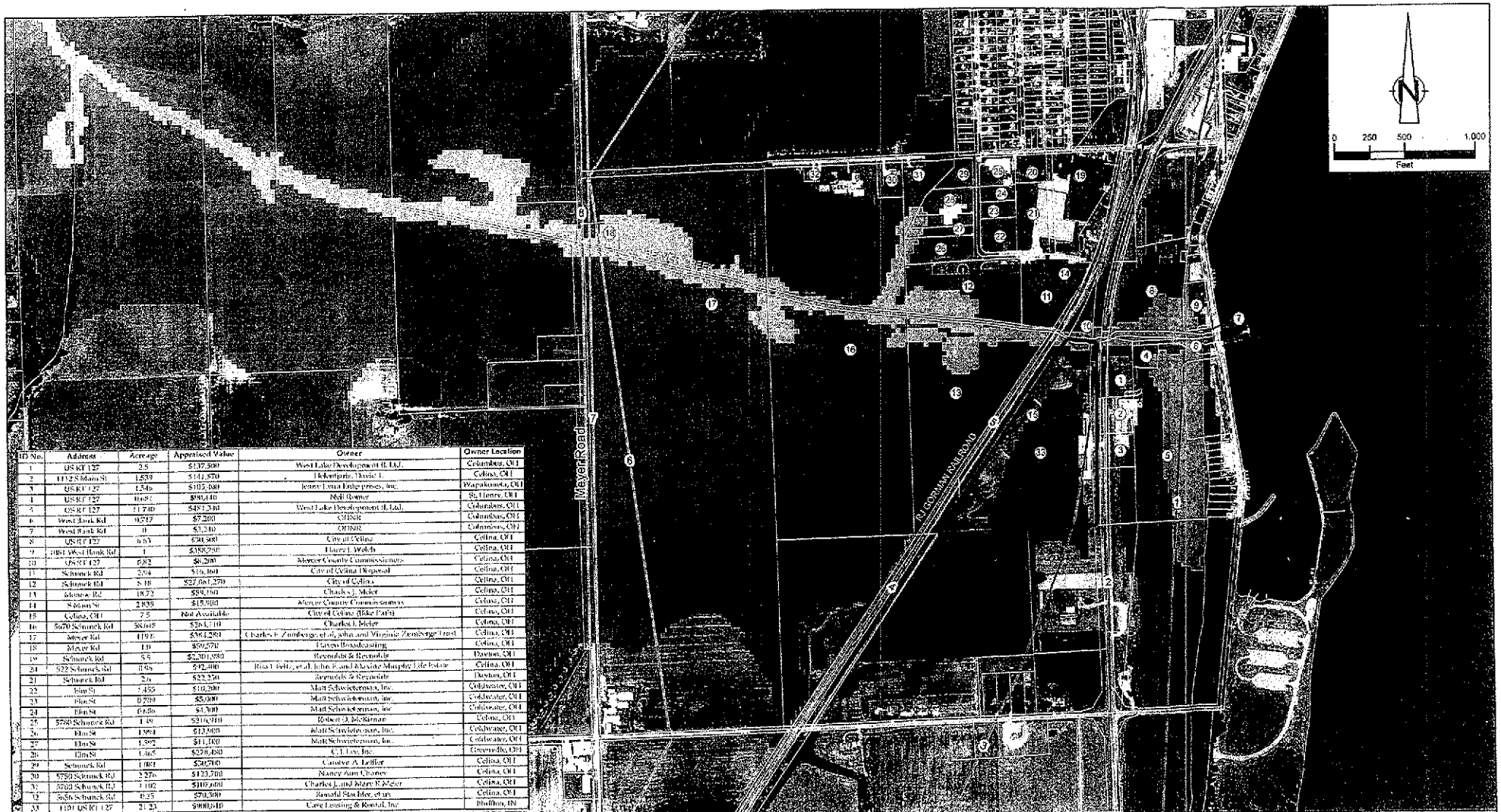
GROUND SURFACE ELEVATIONS USED WERE OBTAINED FROM THE OHIO 10 METER DIGITAL ELEVATION MODEL, PUBLISHED BY THE OHIO ENVIRONMENTAL PROTECTION AGENCY DIVISION OF EMERGENCY AND REMEDIAL RESPONSE, 2004

LEGEND

- CASE LEASING AND RENTAL, INC. PROPERTY BOUNDARY
- CROSS SECTION NUMBER AND LOCATIONS USED IN HEC-2 COMPUTER PROGRAM
- INUNDATED AREA AS THE RESULT OF THE 39.4 FOOT SPILLWAY
- INUNDATED AREA AS THE RESULT OF THE 500 FOOT SPILLWAY

Figure 2a
DECEMBER / JANUARY 1930 STORM EVENT FLOOD INUNDATION MAP

Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio



ID No.	Address	Acreage	Appraised Value	Owner	Owner Location
1	US RT 127	2.5	$137,300	West Lake Development II, Ltd.	Columbus, OH
2	1112 S Main St	1.539	$141,870	Holenfiatis, David L.	Celina, OH
3	US RT 127	1.546	$105,080	Jenny Lynn Enterprises, Inc.	Wapakoneta, OH
4	US RT 127	0.697	$90,140	Neil Romer	St. Henry, OH
5	US RT 127	11.749	$451,230	West Lake Development II, Ltd.	Columbus, OH
6	West Bank Rd	0.717	$7,200	OHNR	Columbus, OH
7	West Bank Rd	0	$1,240	OHNR	Columbus, OH
8	US RT 127	6.63	$30,500	City of Celina	Celina, OH
9	1081 West Bank Rd	1	$358,250	Harry L. Welch	Celina, OH
10	US RT 127	0.82	$6,200	Mercer County Commissioners	Celina, OH
11	Schunck Rd	2.04	$16,160	City of Celina Disposal	Celina, OH
12	Schunck Rd	5.18	$27,067,270	City of Celina	Celina, OH
13	Meyer Rd	18.72	$59,150	Charles J. Meier	Celina, OH
14	S Main St	2.835	$15,900	Mercer County Commissioners	Celina, OH
15	Celina, OH	7.5	Not Available	City of Celina (Bike Path)	Celina, OH
16	5670 Schunck Rd	58.668	$264,710	Charles J. Meier	Celina, OH
17	Meyer Rd	119.5	$584,280	Charles F. Zumbrunge, et al, John and Virginia Zumbrunge Trust	Celina, OH
18	Meyer Rd	1.0	$59,570	Davies Broadcasting	Celina, OH
19	Schunck Rd	5.5	$2,201,980	Reynolds & Reynolds	Davion, OH
20	522 Schunck Rd	0.96	$92,400	Rita T. Fehl, et al, John E. and Maxine Murphy Life Estate	Celina, OH
21	Schunck Rd	2.6	$22,250	Reynolds & Reynolds	Davion, OH
22	Elm St	1.455	$10,200	Matt Schwieterman, Inc.	Coldwater, OH
23	Elm St	0.709	$5,000	Matt Schwieterman, inc.	Coldwater, OH
24	Elm St	0.686	$1,700	Matt Schwieterman, inc	Celina, OH
25	5780 Schunck Rd	1.46	$210,910	Robert G. McGarnar	Coldwater, OH
26	Elm St	1.991	$13,900	Matt Schwieterman, Inc.	Coldwater, OH
27	Elm St	1.592	$11,100	Matt Schwieterman, Inc.	Coldwater, OH
28	Elm St	1.605	$220,480	C.T. Lee, Inc.	Greenville, OH
29	Schunck Rd	1.001	$70,700	Caroline A. Leffler	Celina, OH
30	5750 Schunck Rd	2.276	$123,700	Nancy Ann Chaney	Celina, OH
31	5700 Schunck Rd	1.102	$109,600	Charles J. and Mary F. Meier	Celina, OH
32	5656 Schunck Rd	0.25	$70,300	Ronald Stephen, et ux	Bluffton, IN
33	1101 US RT 127	21.23	$900,410	Care Leasing & Rental, Inc.	

CROSS SECTIONS OF BEAVER CREEK USED IN HEC-2 MODEL WERE OBTAINED FROM THE FINAL REPORT HYDROLOGIC AND HYDRAULIC ANALYSES, GRAND LAKE ST MARYS AUGLAIZE AND MERCER COUNTIES, OHIO FEBRUARY 7, 1980, BOCKM ENGINEERING, INC.

UNITED STATES DEPARTMENT OF AGRICULTURAL AERIAL PHOTOGRAPH, DATED JUNE 23 2004

INFORMATION SHOWN IN THE TABLE AND PROPERTY BOUNDARIES SHOWN ON THIS FIGURE WERE OBTAINED FROM THE MERCER COUNTY OHIO REAL ESTATE SEARCH RESULTS UNOFFICIAL REAL PROPERTY RECORD CARDS COMPLETED ON DECEMBER 31 2005

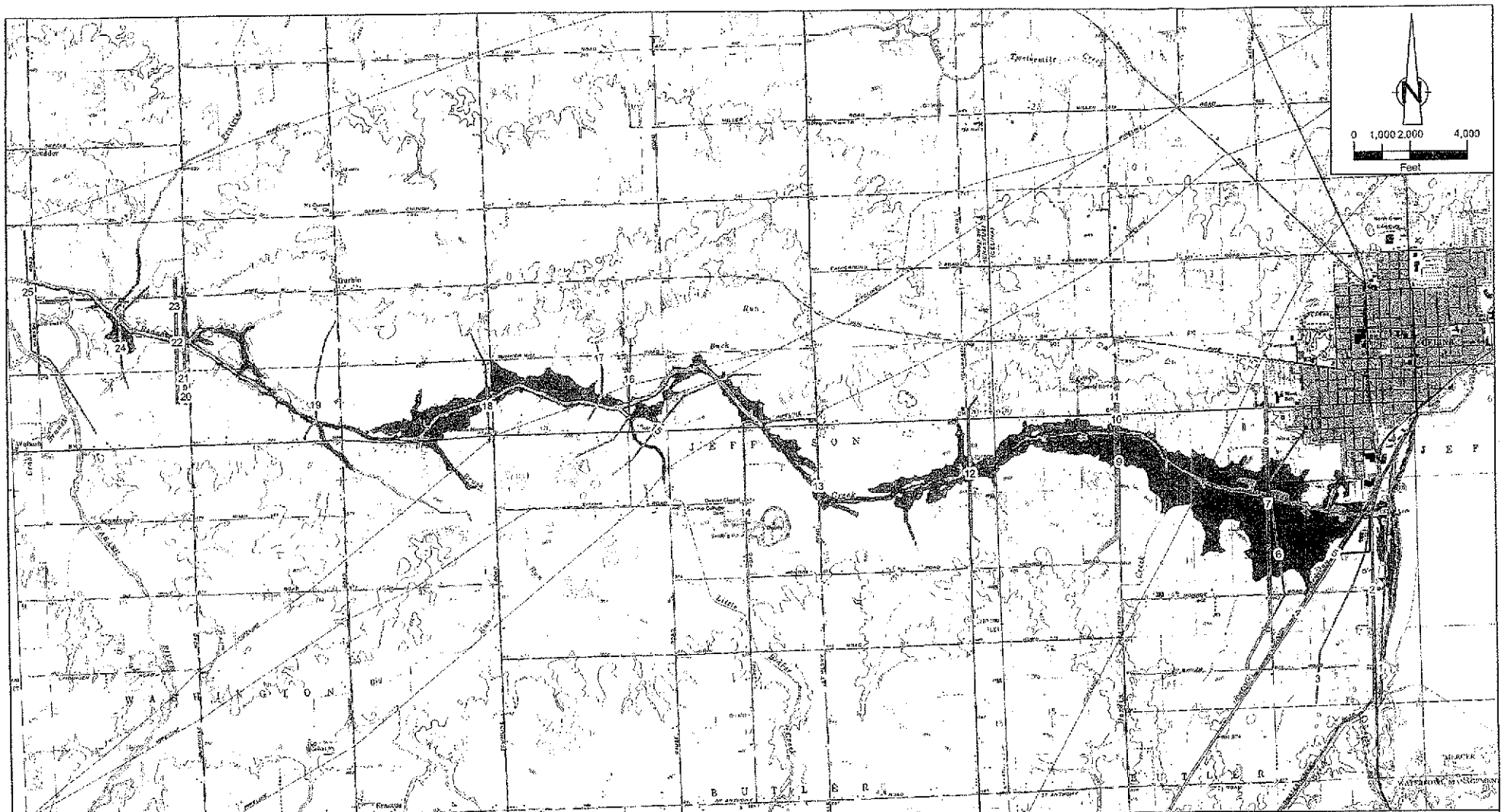
GROUND SURFACE ELEVATIONS USED WERE OBTAINED FROM THE OHIO 10 METER DIGITAL ELEVATION MODEL, PUBLISHED BY THE OHIO ENVIRONMENTAL PROTECTION AGENCY DIVISION OF EMERGENCY AND REMEDIAL RESPONSE 2004

LEGEND

- CASE LEASING AND RENTAL, INC. PROPERTY BOUNDARY
- CROSS SECTION NUMBER AND LOCATIONS USED IN HEC-2 COMPUTER PROGRAM
- PROPERTY BOUNDARIES
- INUNDATED AREA AS THE RESULT OF THE 39.4 FOOT SPILLWAY
- INUNDATED AREA AS THE RESULT OF THE 500 FOOT SPILLWAY
- 17 PROPERTY IDENTIFICATION NUMBER

Figure 2b
DECEMBER / JANUARY 1930 STORM EVENT FLOOD INUNDATION MAP

Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio



CROSS SECTIONS OF BEAVER CREEK USED IN HEC-2 MODEL WERE OBTAINED FROM THE FINAL REPORT HYDROLOGIC AND HYDRAULIC ANALYSES, GRAND LAKE ST. MARYS, AUGLAIZE AND MERCER COUNTIES, OHIO, FEBRUARY 2, 1990, BECAM ENGINEERING, INC.

UNITED STATES GEOLOGICAL SURVEY DIGITAL RASTER GRAPHICS (CELINA & GRASTUS) DOWNLOADED FROM THE OHIO OFFICE OF INFORMATION TECHNOLOGY WEBSITE

GROUND SURFACE ELEVATIONS USED WERE OBTAINED FROM THE OHIO 10 METER DIGITAL ELEVATION MODEL, PUBLISHED BY THE OHIO ENVIRONMENTAL PROTECTION AGENCY DIVISION OF EMERGENCY AND REMEDIAL RESPONSE, 2004

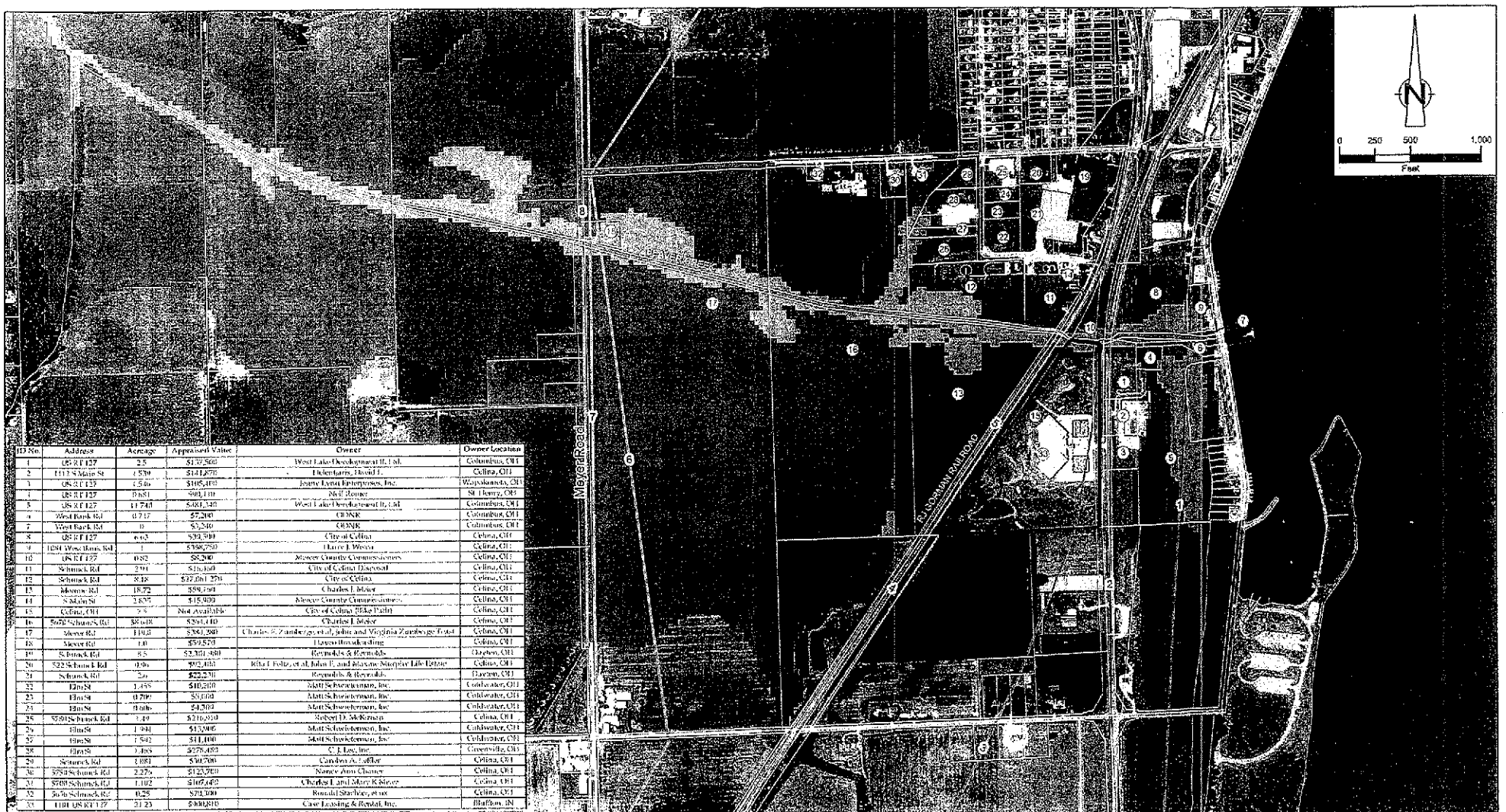
THE MODEL OUTPUT FOR THE 1943 EVENT INDICATES THAT THE WATER SURFACE ELEVATION IN BEAVER CREEK AT THE UPSTREAM LIMIT OF THE CASE PROPERTY WOULD BE 956.8 FEET MSL. THE CASE SPORTS COMPLEX FINISHED FLOOR ELEVATION IS 958.74 FEET MSL. THE LEVEL OF DETAIL OF THE GROUND SURFACE TOPOGRAPHY USED TO DEVELOP THIS FIGURE, ALTHOUGH THE BEST AVAILABLE DATA, IS NOT SUFFICIENTLY PRECISE TO SHOW THE 0.06 FEET OF FLOODING AT THE SPORTS COMPLEX.

LEGEND

- CASE LEASING AND RENTAL, INC. PROPERTY BOUNDARY
- CROSS SECTION NUMBER AND LOCATIONS USED IN HEC-2 COMPUTER PROGRAM
- INUNDATED AREA AS THE RESULT OF THE 39.4 FOOT SPILLWAY
- INUNDATED AREA AS THE RESULT OF THE 500 FOOT SPILLWAY

Figure 3a
MAY 1943 STORM EVENT
FLOOD INUNDATION MAP

Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio



ID No.	Address	Acreage	Appraised Value	Owner	Owner Location
1	US RT 127	2.5	$139,500	West Lake Development II, Ltd.	Columbus, OH
2	1113 S Main St	1.530	$141,970	Dilenburg, David L.	Celina, OH
3	US RT 127	1.546	$105,400	Jenny Lynn Enterprises, Inc.	Wapakoneta, OH
4	US RT 127	0.681	$68,110	Neil Zumer	St. Henry, OH
5	US RT 127	11.740	$301,345	West Lake Development II, Ltd.	Columbus, OH
6	West Bank Rd	0.717	$7,200	CSX	Columbus, OH
7	West Bank Rd	0	$5,500	CSX	Columbus, OH
8	US RT 127	6.63	$39,500	City of Celina	Celina, OH
9	1001 West Bank Rd	1	$398,750	Harry L. Weiss	Celina, OH
10	US RT 127	0.82	$8,200	Mercer County Commissioners	Celina, OH
11	Schmick Rd	2.91	$16,160	City of Celina Disposal	Celina, OH
12	Schmick Rd	8.18	$37,061,270	City of Celina	Celina, OH
13	Mercer Rd	18.72	$59,250	Charles L. Moor	Celina, OH
14	S Main St	2.637	$15,900	Mercer County Commissioners	Celina, OH
15	Celina, OH	3.5	Not Available	City of Celina (Bike Path)	Celina, OH
16	5670 Schmick Rd	38.610	$394,140	Charles L. Moor	Celina, OH
17	Mercer Rd	114.8	$381,280	Charles E. Zumbrunnen et al, John and Virginia Zumbrunnen Estate	Celina, OH
18	Mercer Rd	1.0	$59,570	Liquor Distributing	Celina, OH
19	Schmick Rd	8.5	$2,301,980	Reynolds & Reynolds	Dayton, OH
20	522 Schmick Rd	0.96	$92,400	Rita L. Fritz, et al, John E. and Marvin Murphy Life Estate	Celina, OH
21	Schmick Rd	2.6	$22,270	Reynolds & Reynolds	Dayton, OH
22	Elm St	1.455	$40,800	Matt Schweickerman, Inc.	Coldwater, OH
23	Elm St	0.790	$5,000	Matt Schweickerman, Inc.	Coldwater, OH
24	Elm St	0.686	$4,500	Matt Schweickerman, Inc.	Coldwater, OH
25	5800 S Branch Rd	1.49	$216,930	Robert D. McKinnon	Celina, OH
26	Elm St	1.941	$13,900	Matt Schweickerman, Inc.	Coldwater, OH
27	Elm St	1.542	$11,100	Matt Schweickerman, Inc.	Coldwater, OH
28	Elm St	1.165	$27,400	C.J. Lee, Inc.	Greenville, OH
29	Schmick Rd	1.081	$30,700	Candace A. Leffler	Celina, OH
30	5753 Schmick Rd	2.276	$123,700	Nancy Ann Chaney	Celina, OH
31	5708 Schmick Rd	1.102	$107,640	Charles L and Mary K Moor	Celina, OH
32	5676 Schmick Rd	0.25	$71,100	Ronald Starbuck, et ux	Celina, OH
33	1101 US RT 127	31.23	$300,000	Case Leasing & Rental, Inc.	Bluffton, IN

CROSS SECTIONS OF BEAVER CREEK USED IN HEC-2 MODEL WERE OBTAINED FROM THE FINAL REPORT HYDROLOGIC AND HYDRAULIC ANALYSES GRAND LAKE ST. MARY'S, AUGLAIZE AND MERCER COUNTIES, OHIO FEBRUARY 2, 1978, BROWN ENGINEERING, INC

UNITED STATES DEPARTMENT OF AGRICULTURAL AERIAL PHOTOGRAPH DATED JUNE 23, 2004

INFORMATION SHOWN IN THE TABLE AND PROPERTY BOUNDARIES SHOWN ON THE FIGURE WERE OBTAINED FROM THE MERCER COUNTY OHIO REAL ESTATE SEARCH RESULTS, UNOFFICIAL REAL PROPERTY RECORD CARDS, COMPLETED ON DECEMBER 21, 2005

GROUND SURFACE ELEVATIONS USED WERE OBTAINED FROM THE OHIO 10 METER DIGITAL ELEVATION MODEL, PUBLISHED BY THE OHIO ENVIRONMENTAL PROTECTION AGENCY DIVISION OF EMERGENCY AND REMEDIAL RESPONSE 2004

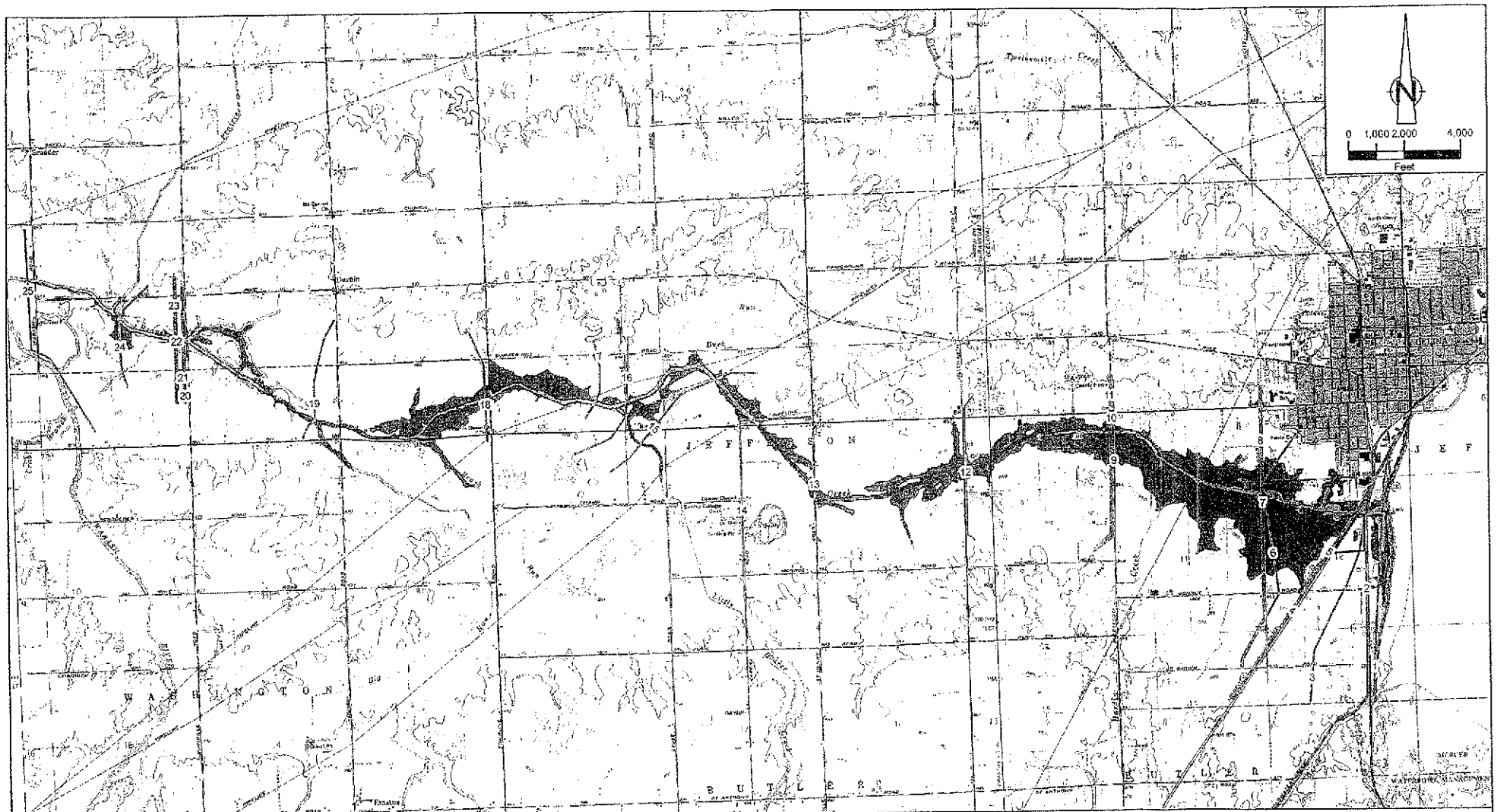
THE MODEL OUTPUT FOR THE 1943 EVENT INDICATES THAT THE WATER SURFACE ELEVATION IN BEAVER CREEK AT THE UPSTREAM LIMIT OF THE CASE PROPERTY WOULD BE 858.8 FEET MSL. THE CASE SPORTS COMPLEX FINISHED FLOOR ELEVATION IS 858.74 FEET MSL. THE LEVEL OF DETAIL OF THE GROUND SURFACE TOPOGRAPHY USED TO DEVELOP THIS MODEL, ALTHOUGH THE BEST AVAILABLE DATA, IS NOT SUFFICIENTLY PRECISE TO SHOW THE 0.04 FEET OF FLOODING AT THE SPORTS COMPLEX

LEGEND

- CASE LEASING AND RENTAL, INC. PROPERTY BOUNDARY
- CROSS SECTION NUMBER AND LOCATIONS USED IN HEC-2 COMPUTER PROGRAM
- PROPERTY BOUNDARIES
- INUNDATED AREA AS THE RESULT OF THE 39.4 FOOT SPILLWAY
- INUNDATED AREA AS THE RESULT OF THE 500 FOOT SPILLWAY
- 117 PROPERTY IDENTIFICATION NUMBER

Figure 3b
MAY 1943 STORM EVENT
FLOOD INUNDATION MAP

Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio



CROSS SECTIONS OF BEAVER CREEK USED IN HEC-2 MODEL WERE OBTAINED FROM THE FINAL REPORT HYDROLOGIC AND HYDRAULIC ANALYSES, GRAND LAKE ST. MARYS, AUGLAIZE AND MERCER COUNTIES, OHIO, FEBRUARY 2, 1990, BECAM ENGINEERING, INC.

UNITED STATES GEOLOGICAL SURVEY DIGITAL RASTER GRAPHICS (DELSHA & ERASTUS) DOWNLOADED FROM THE OHIO OFFICE OF INFORMATION TECHNOLOGY WEBSITE

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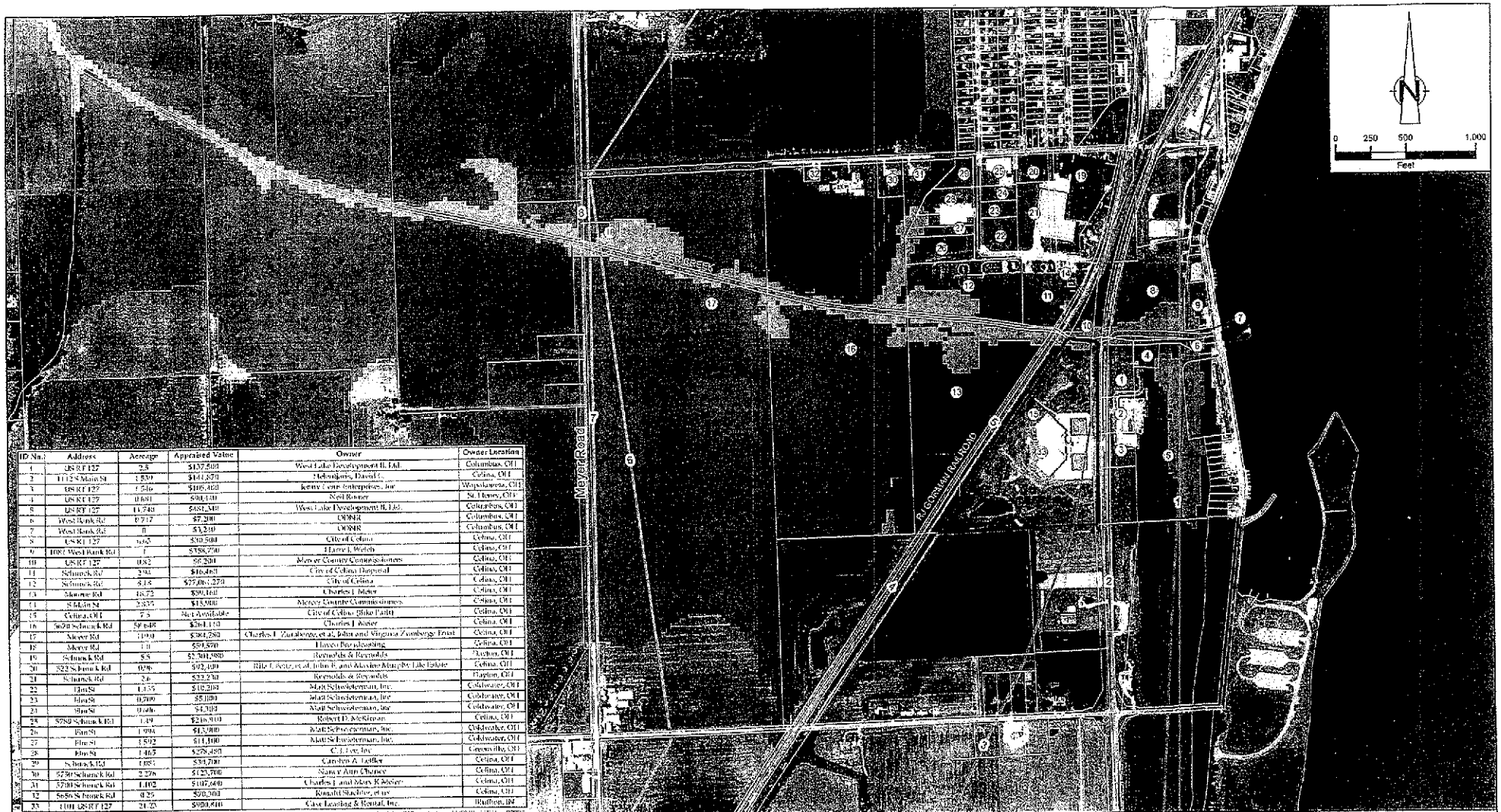
THE MODEL OUTPUT FOR THE 1981 EVENT INDICATES THAT THE WATER SURFACE ELEVATION IN BEAVER CREEK AT THE UPSTREAM LIMIT OF THE CASE PROPERTY WOULD BE 168.8 FEET MSL. THE CASE SPORTS COMPLEX FINISHED FLOOR ELEVATION IS 168.74 FEET MSL. THE LEVEL OF DETAIL OF THE GROUND SURFACE TOPOGRAPHY USED TO DEVELOP THIS FIGURE, ALTHOUGH THE BEST AVAILABLE DATA, IS NOT SUFFICIENTLY PRECISE TO SHOW THE 0.06 FEET OF FLOODING AT THE SPORTS COMPLEX.

LEGEND

- CASE LEASING AND RENTAL, INC. PROPERTY BOUNDARY
- CROSS SECTION NUMBER AND LOCATIONS USED IN HEC-2 COMPUTER PROGRAM
- INUNDATED AREA AS THE RESULT OF THE 39.4 FOOT SPILLWAY
- INUNDATED AREA AS THE RESULT OF THE 500 FOOT SPILLWAY

Figure 4a
MAY 1981 STORM EVENT FLOOD INUNDATION MAP

Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio



ID No.	Address	Acreage	Appraised Value	Owner	Owner Location
1	US RT 127	2.5	$137,500	West Lake Development II, Ltd.	Columbus, OH
2	1112 S Main St	1.530	$141,670	Helmkjens, David C.	Celina, OH
3	US RT 127	1.546	$105,400	Kenny Cone Enterprises, Inc	Wapakoneta, OH
4	US RT 127	0.601	$90,100	Neil Rosner	St. Henry, OH
5	US RT 127	11.740	$651,300	West Lake Development II, Ltd.	Columbus, OH
6	West Bank Rd	0.717	$7,200	OWNR	Columbus, OH
7	West Bank Rd	0	$13,200	OWNR	Columbus, OH
8	US RT 127	3.05	$30,500	City of Celina	Celina, OH
9	1082 West Bank Rd	1	$358,750	Harry L. Welch	Celina, OH
10	US RT 127	0.82	$8,200	Mercer County Commissioners	Celina, OH
11	Schunck Rd	3.93	$16,463	City of Celina Disposal	Celina, OH
12	Schunck Rd	8.18	$27,06[illegible],229	City of Celina	Celina, OH
13	Meyer Rd	16.72	$39,168	Charles L Meier	Celina, OH
14	S Main St	2.535	$15,900	Mercer County Commissioners	Celina, OH
15	Celina, OH	7.5	Not Available	City of Celina, Mike Farfal	Celina, OH
16	5620 Schunck Rd	59.648	$261,110	Charles L Meier	Celina, OH
17	Meyer Rd	19.00	$304,280	Charles L. Zumberge, et al, John and Virginia Zumberge Trust	Celina, OH
18	Meyer Rd	1.0	$91,500	Hunt Development	Celina, OH
19	Schunck Rd	5.5	$2,301,900	Reynolds & Reynolds	Dayton, OH
20	522 Schunck Rd	0.96	$92,100	Ritz Electric, et al, John B. and Alexine Ritz, Life Estate	Celina, OH
21	Schunck Rd	2.6	$32,230	Reynolds & Reynolds	Dayton, OH
22	Elm St	1.135	$10,200	Matt Schwiebertmann, Inc	Coldwater, OH
23	Elm St	0.200	$5,100	Matt Schwiebertmann, Inc	Coldwater, OH
24	Elm St	0.686	$4,300	Matt Schwiebertmann, Inc	Coldwater, OH
25	5280 Schunck Rd	1.49	$216,900	Robert D. McKinnon	Celina, OH
26	Elm St	1.990	$13,900	Matt Schwiebertmann, Inc	Coldwater, OH
27	Elm St	1.592	$11,100	Matt Schwiebertmann, Inc	Coldwater, OH
28	Elm St	1.463	$276,400	C.L.Live, Inc	Greenville, OH
29	Schunck Rd	0.085	$34,700	Carolyn A. Leffler	Celina, OH
30	5730 Schunck Rd	2.276	$123,700	Nancy Ann Chaney	Celina, OH
31	5700 Schunck Rd	1.102	$107,600	Charles L and Mary K Meier	Celina, OH
32	5656 Schunck Rd	0.25	$20,300	Ronald Shadley, et ux	Celina, OH
33	1101 US RT 127	21.25	$900,400	Case Leasing & Rental, Inc	Bluffton, IN

CROSS SECTIONS OF BEAVER CREEK USED IN HEC-2 MODEL WERE OBTAINED FROM THE FINAL REPORT HYDROLOGIC AND HYDRAULIC ANALYSES, GRAND LAKE ST. MARYS, AUGLAIZE AND MERCER COUNTIES, OHIO, FEBRUARY 7, 1990, BOOM ENGINEERING, INC.

UNITED STATES DEPARTMENT OF AGRICULTURAL AERIAL PHOTOGRAPH DATED JUNE 23, 2004

INFORMATION SHOWN IN THE TABLE AND PROPERTY BOUNDARIES SHOWN ON THE FIGURE WERE OBTAINED FROM THE MERCER COUNTY, OHIO REAL ESTATE SEARCH RESULTS, UNOFFICIAL REAL PROPERTY RECORD CARDS, COMPLETED ON DECEMBER 21, 2005

GROUND SURFACE ELEVATIONS USED WERE OBTAINED FROM THE OHIO 10 METER DIGITAL ELEVATION MODEL, PUBLISHED BY THE OHIO ENVIRONMENTAL PROTECTION AGENCY DIVISION OF EMERGENCY AND REMEDIAL RESPONSE, 2004

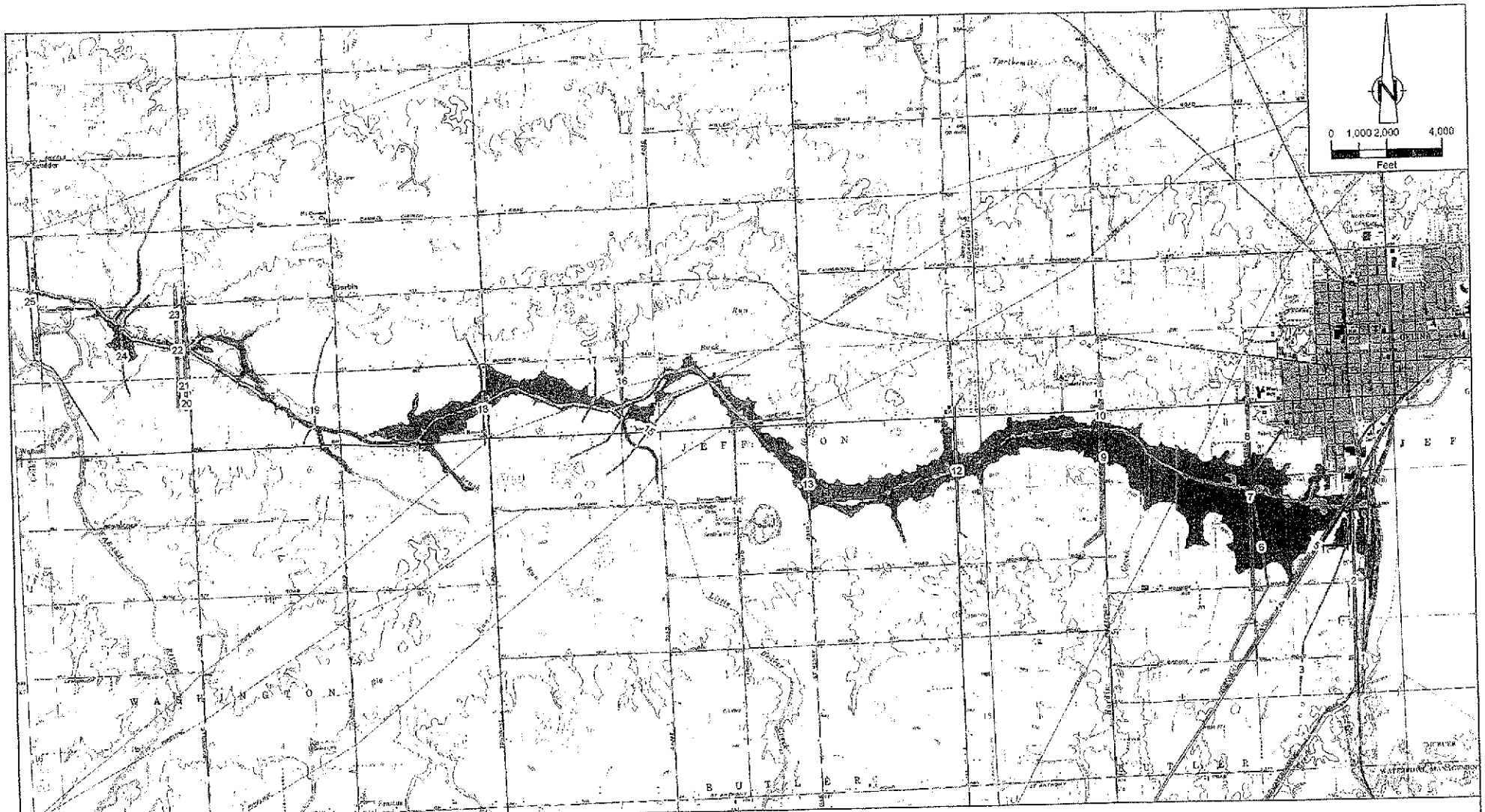
THE MODEL OUTPUT FOR THE 1981 EVENT INDICATES THAT THE WATER SURFACE ELEVATION IN BEAVER CREEK AT THE UPSTREAM LIMIT OF THE CASE PROPERTY WOULD BE 858.3 FEET MSL. THE CASE SPORTS COMPLEX FINISHED FLOOR ELEVATION IS 856.74 FEET MSL. THE LEVEL OF DETAIL OF THE GROUND SURFACE TOPOGRAPHY USED TO DEVELOP THIS FIGURE, ALTHOUGH THE BEST AVAILABLE DATA, IS NOT SUFFICIENTLY PRECISE TO SHOW THE 0.80 FEET OF FLOODING AT THE SPORTS COMPLEX.

LEGEND

- CASE LEASING AND RENTAL, INC. PROPERTY BOUNDARY
- CROSS SECTION NUMBER AND LOCATIONS USED IN HEC-2 COMPUTER PROGRAM
- PROPERTY BOUNDARIES
- INUNDATED AREA AS THE RESULT OF THE 39.4 FOOT SPILLWAY
- INUNDATED AREA AS THE RESULT OF THE 500 FOOT SPILLWAY
- 17 PROPERTY IDENTIFICATION NUMBER

Figure 4b
MAY 1981 STORM EVENT
FLOOD INUNDATION MAP

Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio



CROSS SECTIONS OF BEAVER CREEK USED IN HEC-2 MODEL WERE OBTAINED FROM THE FINAL REPORT HYDROLOGIC AND HYDRAULIC ANALYSES, GRAND LAKE ST. MARYS, AUGLAIZE AND MERCER COUNTIES, OHIO, FEBRUARY 2, 1996, BECAM ENGINEERING, INC.

UNITED STATES GEOLOGICAL SURVEY DIGITAL RASTER GRAPHICS (ECLINA & ERASTRIB) DOWNLOADED FROM THE OHIO OFFICE OF INFORMATION TECHNOLOGY WEBSITE

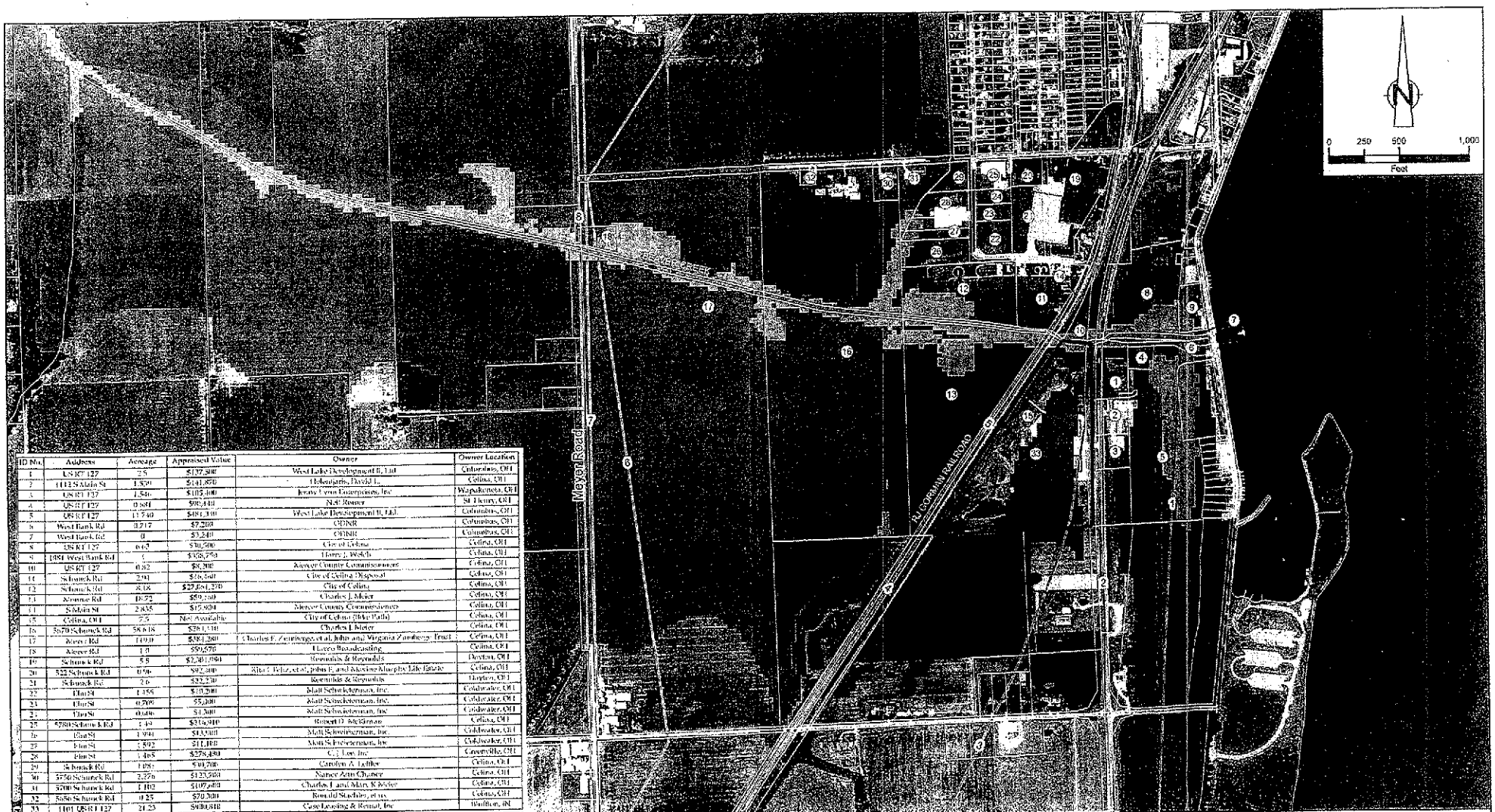
GROUND SURFACE ELEVATIONS USED WERE OBTAINED FROM THE OHIO 10 METER DIGITAL ELEVATION MODEL, PUBLISHED BY THE OHIO ENVIRONMENTAL PROTECTION AGENCY DIVISION OF EMERGENCY AND REMEDIAL RESPONSE, 2004

LEGEND

- CASE LEASING AND RENTAL, INC. PROPERTY BOUNDARY
- CROSS SECTION NUMBER AND LOCATIONS USED IN HEC-2 COMPUTER PROGRAM
- INUNDATED AREA AS THE RESULT OF THE 39.4 FOOT SPILLWAY
- INUNDATED AREA AS THE RESULT OF THE 500 FOOT SPILLWAY

Figure 5a
JULY 1992 STORM EVENT FLOOD INUNDATION MAP

Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio



ID No.	Address	Acreage	Appraised Value	Owner	Owner Location
1	US RT 127	2.5	$137,500	West Lake Development II, Ltd	Columbus, OH
2	1113 S Main St	1.500	$141,850	Hohenfeldt, David L.	Celina, OH
3	US RT 127	1.546	$103,400	Jenny Lynn Enterprises, Inc	Wapakoneta, OH
4	US RT 127	0.681	$90,440	Neil Romer	St Henry, OH
5	US RT 127	11.740	$391,100	West Lake Development II, Ltd	Columbus, OH
6	West Bank Rd	3.717	$7,200	ODNR	Columbus, OH
7	West Bank Rd	0	$3,240	ODNR	Columbus, OH
8	US RT 127	0.63	$10,500	City of Celina	Celina, OH
9	1981 West Bank Rd	1	$108,750	Henry J. Welch	Celina, OH
10	US RT 127	0.02	$8,200	Mercer County Commissioners	Celina, OH
11	Schunck Rd	2.91	$16,340	City of Celina Disposal	Celina, OH
12	Schunck Rd	8.18	$27,861,270	City of Celina	Celina, OH
13	Monroe Rd	10.72	$59,240	Charles J. Meier	Celina, OH
14	S Main St	2.655	$15,904	Mercer County Commissioners	Celina, OH
15	Celina, OH	7.2	Not Available	City of Celina (Bike Path)	Celina, OH
16	5670 Schunck Rd	56.618	$261,110	Charles J. Meier	Celina, OH
17	Meyer Rd	14.0	$381,200	Charles F. Cummings, et al, John and Virginia Cummings Trust	Celina, OH
18	Meyer Rd	1.8	$59,570	Huron Broadcasting	Celina, OH
19	Schunck Rd	5.8	$2,301,960	Reynolds & Reynolds	Dayton, OH
20	522 Schunck Rd	0.96	$92,300	Rita C Fritz, et al, John F. and Adeline Murphy Life Estate	Celina, OH
21	Schunck Rd	2.6	$32,230	Reynolds & Reynolds	Dayton, OH
22	Elm St	1.155	$10,200	Matt Schnickelmann, Inc.	Coldwater, OH
23	Elm St	0.709	$5,300	Matt Schnickelmann, Inc.	Coldwater, OH
24	Elm St	0.046	$1,300	Matt Schnickelmann, Inc	Coldwater, OH
25	5780 Schunck Rd	1.49	$316,910	Robert D. McKinnan	Celina, OH
26	Elm St	1.994	$13,500	Matt Schnickelmann, Inc.	Coldwater, OH
27	Elm St	1.892	$11,100	Matt Schnickelmann, Inc	Coldwater, OH
28	Elm St	1.465	$278,430	C.J. Lee, Inc	Covington, OH
29	Schunck Rd	1.091	$10,200	Carolyn A. Lightfoot	Celina, OH
30	5756 Schunck Rd	2.276	$123,960	Nancy Ann Chaney	Celina, OH
31	5700 Schunck Rd	1.102	$107,960	Charles J and Mary K Meier	Celina, OH
32	5656 Schunck Rd	0.23	$70,300	Rosedal Studios, et ux	Celina, OH
33	1101 US RT 127	21.23	$980,840	Case Leasing & Rental, Inc	Bluffton, IN

CROSS SECTIONS OF BEAVER CREEK USED IN HEC-2 MODEL WERE OBTAINED FROM THE FINAL REPORT HYDROLOGIC AND HYDRAULIC ANALYSES, GRAND LAKE ST. MARYS, AUGLAIZE AND MERCER COUNTIES, OHIO, FEBRUARY 2, 1998 BECAM ENGINEERING, INC

UNITED STATES DEPARTMENT OF AGRICULTURAL AERIAL PHOTOGRAPH DATED JUNE 22, 2004

INFORMATION SHOWN IN THE TABLE AND PROPERTY BOUNDARIES SHOWN ON THE FIGURE WERE OBTAINED FROM THE MERCER COUNTY, OHIO REAL ESTATE SEARCH RESULTS, UNOFFICIAL REAL PROPERTY RECORD CARDS, COMPLETED ON DECEMBER 21, 2005

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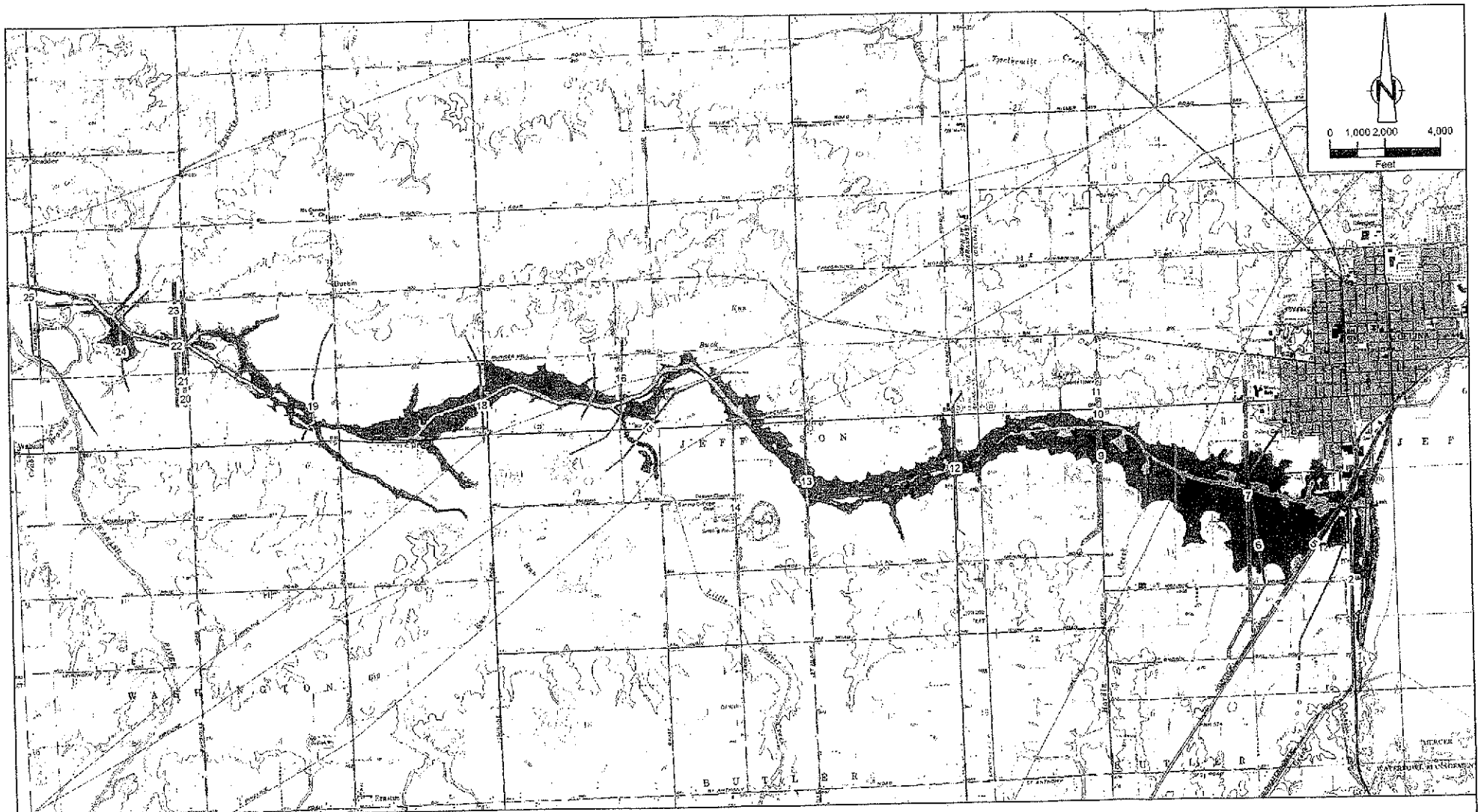
LEGEND

- CASE LEASING AND RENTAL, INC. PROPERTY BOUNDARY
- CROSS SECTION NUMBER AND LOCATIONS USED IN HEC-2 COMPUTER PROGRAM
- PROPERTY BOUNDARIES
- INUNDATED AREA AS THE RESULT OF THE 39.4 FOOT SPILLWAY
- INUNDATED AREA AS THE RESULT OF THE 500 FOOT SPILLWAY
- PROPERTY IDENTIFICATION NUMBER

Figure 5b
JULY 1992 STORM EVENT
FLOOD INUNDATION MAP

Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio



CROSS SECTIONS OF BEAVER CREEK USED IN HEC-2 MODEL WERE OBTAINED FROM THE FINAL REPORT HYDROLOGIC AND HYDRAULIC ANALYSES, GRAND LAKE ST. MARYS, AUGLAIZE AND MERCER COUNTIES, OHIO, FEBRUARY 2, 1990, BROWN ENGINEERING, INC.

UNITED STATES GEOLOGICAL SURVEY DIGITAL RASTER GRAPHICS (CD LINA & ERASTUS) DOWNLOADED FROM THE OHIO OFFICE OF INFORMATION TECHNOLOGY WEBSITE

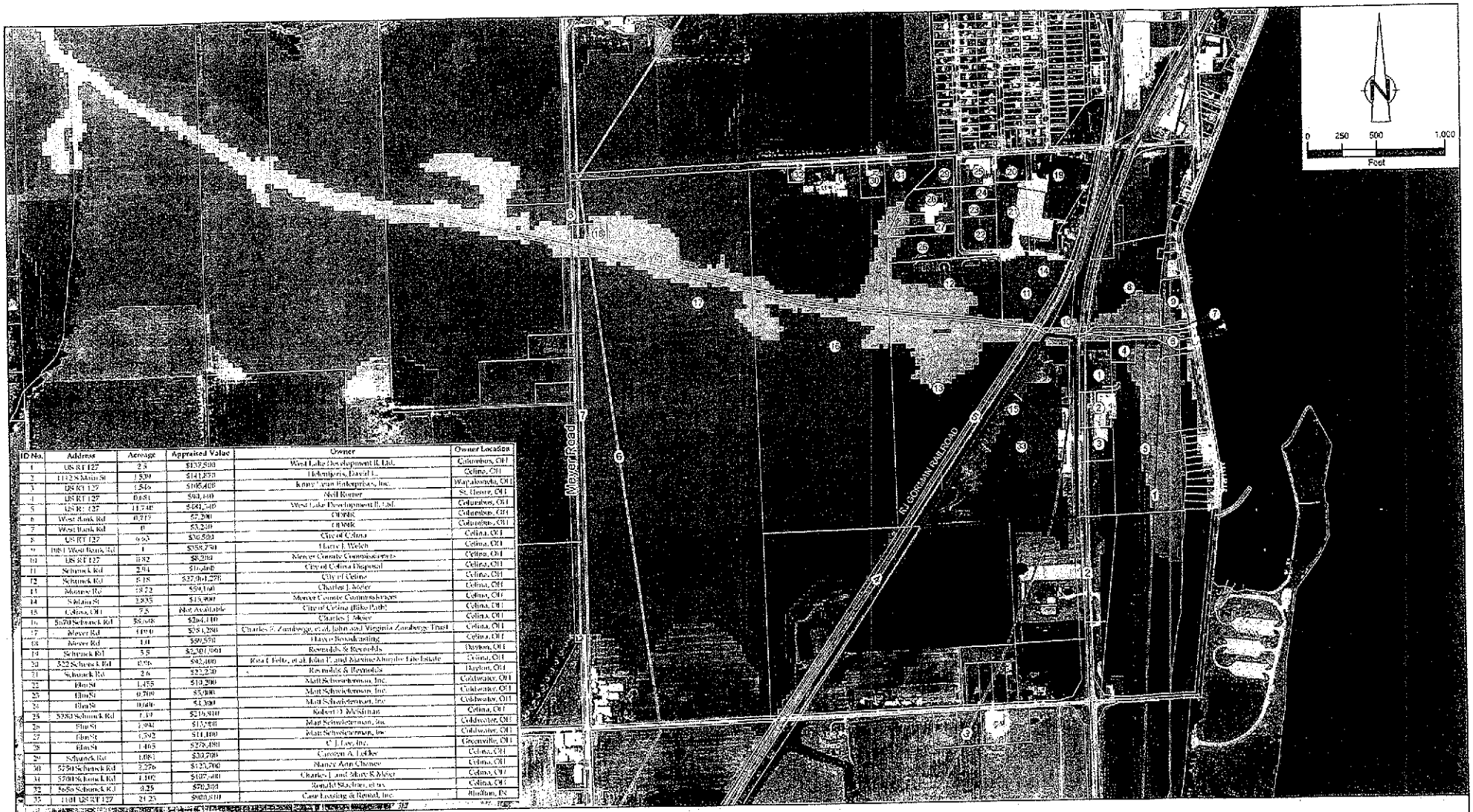
GROUND SURFACE ELEVATIONS USED WERE OBTAINED FROM THE OHIO 10 METER DIGITAL ELEVATION MODEL, PUBLISHED BY THE OHIO ENVIRONMENTAL PROTECTION AGENCY DIVISION OF EMERGENCY AND REMEDIAL RESPONSE, 2001

LEGEND

- CASE LEASING AND RENTAL, INC. PROPERTY BOUNDARY
- CROSS SECTION NUMBER AND LOCATIONS USED IN HEC-2 COMPUTER PROGRAM
- INUNDATED AREA AS THE RESULT OF THE 39.4 FOOT SPILLWAY
- INUNDATED AREA AS THE RESULT OF THE 500 FOOT SPILLWAY

Figure 6a
JUNE / JULY 1993 STORM EVENT FLOOD INUNDATION MAP

Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio



ID No.	Address	Acreage	Appraised Value	Owner	Owner Location
1	US RT 127	2.3	$132,500	West Lake Development II, Ltd.	Columbus, OH
2	1112 S Main St	1.539	$141,870	Heleniparis, David L.	Celina, OH
3	US RT 127	1.546	$105,400	Kenny Cavan Enterprises, Inc.	Wapakoneta, OH
4	US RT 127	0.681	$93,140	Neil Rorner	St. Henry, OH
5	US RT 127	11.748	$493,540	West Lake Development II, Ltd.	Columbus, OH
6	West Bank Rd	0.717	$7,200	CH Wilk	Columbus, OH
7	West Bank Rd	0	$3,200	CH Wilk	Columbus, OH
8	US RT 127	0.63	$36,500	City of Celina	Celina, OH
9	1081 West Bank Rd	1	$358,750	Harry L. Welch	Celina, OH
10	US RT 127	0.82	$8,200	Mercer County Commissioners	Celina, OH
11	Schunck Rd	2.94	$16,400	City of Celina Disposal	Celina, OH
12	Schunck Rd	5.18	$327,047,275	City of Celina	Celina, OH
13	Monroe Dr	0.72	$59,100	Charles J. Meier	Celina, OH
14	Sylvania St	2.805	$15,900	Mercer County Commissioners	Celina, OH
15	Celina, OH	7.5	Not Available	City of Celina (Bike Path)	Celina, OH
16	5070 Schunck Rd	58.608	$264,100	Charles J. Meier	Celina, OH
17	Mayer Rd	149.0	$581,280	Charles S. Zumbrunge, et al, John and Virginia Zumbrunge Trust	Celina, OH
18	Mayer Rd	1.11	$90,570	Hayes Broadcasting	Celina, OH
19	Schunck Rd	5.5	$2,301,061	Reynolds & Reynolds	Dayton, OH
20	522 Schunck Rd	0.96	$92,400	Rita C. Holtz, et al, John T. and Marsine Murphy Estate	Celina, OH
21	Schunck Rd	2.6	$22,220	Reynolds & Reynolds	Dayton, OH
22	Elm St	1.455	$19,200	Matt Schwiderman, Inc.	Coldwater, OH
23	Elm St	0.709	$5,900	Matt Schwiderman, Inc.	Coldwater, OH
24	Elm St	0.646	$4,300	Matt Schwiderman, Inc.	Coldwater, OH
25	5393 Schunck Rd	1.19	$216,900	Robert D. McSlinnan	Celina, OH
26	Elm St	1.992	$13,900	Matt Schwiderman, Inc.	Coldwater, OH
27	Elm St	1.592	$11,100	Matt Schwiderman, Inc.	Coldwater, OH
28	Elm St	1.465	$278,400	C. J. Lay, Inc.	Greenville, OH
29	Schunck Rd	1.083	$30,700	Carolyn A. Lodder	Celina, OH
30	5250 Schunck Rd	2.276	$125,700	Nancy Ann Chaney	Celina, OH
31	5200 Schunck Rd	1.102	$107,400	Charles L. and Mary K. Meier	Celina, OH
32	5056 Schunck Rd	4.25	$70,300	Ronald Stachler, et ux.	Celina, OH
33	1101 US RT 127	21.25	$600,000	Case Leasing & Rental, Inc.	Bluffton, IN

CROSS SECTIONS OF BEAVER CREEK USED IN HEC-2 MODEL WERE OBTAINED FROM THE FINAL REPORT HYDROLOGIC AND HYDRAULIC ANALYSIS, GRAND LAKE ST. MARYS, AUGLAIZE AND MERCER COUNTIES, OHIO, FEBRUARY 2, 1993, BROAM ENGINEERING, INC

UNITED STATES DEPARTMENT OF AGRICULTURAL AERIAL PHOTOGRAPH DATED JUNE 23, 2001

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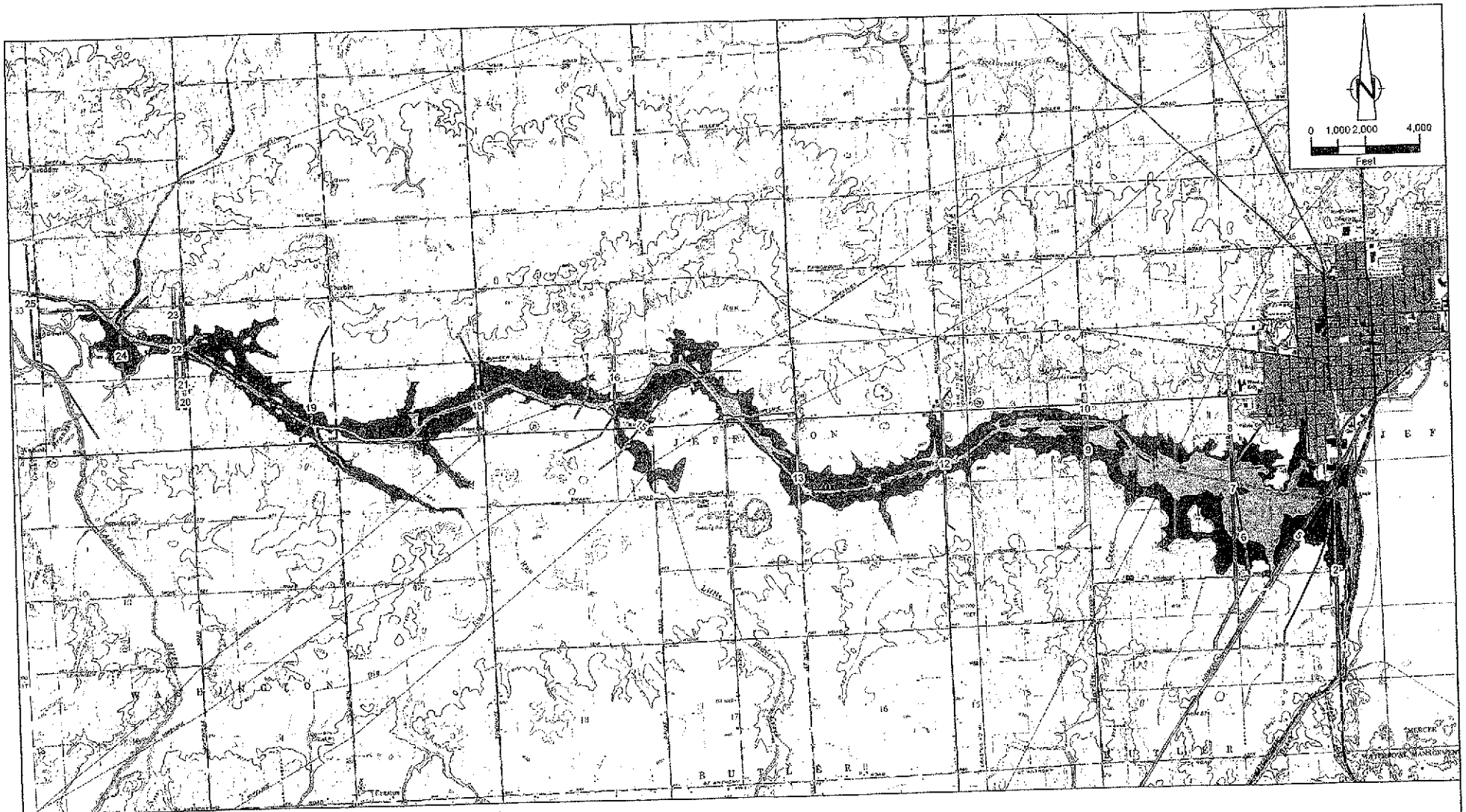
- CASE LEASING AND RENTAL, INC. PROPERTY BOUNDARY
- CROSS SECTION NUMBER AND LOCATIONS USED IN HEC-2 COMPUTER PROGRAM
- PROPERTY BOUNDARIES
- INUNDATED AREA AS THE RESULT OF THE 39.4 FOOT SPILLWAY
- INUNDATED AREA AS THE RESULT OF THE 500 FOOT SPILLWAY
- .17 PROPERTY IDENTIFICATION NUMBER

Figure 6b
JUNE / JULY 1993 STORM EVENT FLOOD INUNDATION MAP

Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio



CROSS SECTIONS OF BEAVER CREEK USED IN HEC-2 MODEL WERE OBTAINED FROM THE FINAL REPORT HYDROLOGIC AND HYDRAULIC ANALYSES, GRAND LAKE ST. MARYS, AUGLAIZE AND MERCER COUNTIES, OHIO, FEBRUARY 2, 1990, BBCEM ENGINEERING, INC.

UNITED STATES GEOLOGICAL SURVEY DIGITAL RASTER GRAPHICS (CELINA & ERASTUS) DOWNLOADED FROM THE OHIO OFFICE OF INFORMATION TECHNOLOGY WEBSITE

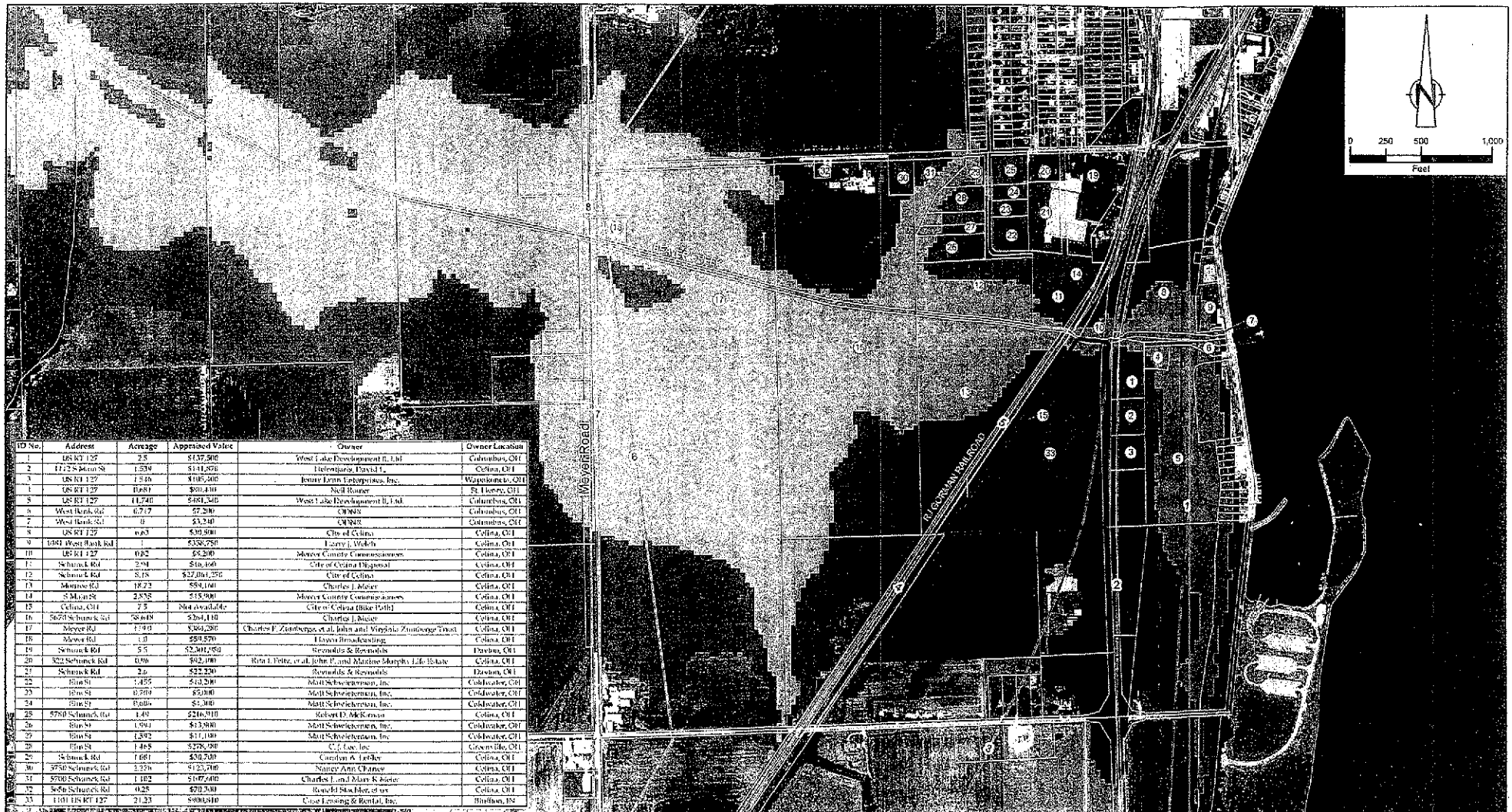
GROUND SURFACE ELEVATIONS USED WERE OBTAINED FROM THE OHIO 10 METER DIGITAL ELEVATION MODEL, PUBLISHED BY THE OHIO ENVIRONMENTAL PROTECTION AGENCY DIVISION OF EMERGENCY AND REMEDIAL RESPONSE, 2004

LEGEND

- CASE LEASING AND RENTAL, INC. PROPERTY BOUNDARY
- CROSS SECTION NUMBER AND LOCATIONS USED IN HEC-2 COMPUTER PROGRAM
- INUNDATED AREA AS THE RESULT OF THE 39.4 FOOT SPILLWAY
- INUNDATED AREA AS THE RESULT OF THE 500 FOOT SPILLWAY

Figure 7a
JUNE / JULY 2003 STORM EVENT FLOOD INUNDATION MAP

Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio



ID No.	Address	Acreage	Appraised Value	Owner	Owner Location
1	US RT 127	2.5	$137,500	West Lake Development II, Ltd	Columbus, OH
2	6725 Meyer St	1.539	$141,978	Hofenjaer, David L.	Celina, OH
3	US RT 127	1.546	$105,500	Jenny Lynn Enterprises, Inc.	Wapakoneta, OH
4	US RT 127	0.681	$90,430	Neil Rauer	St. Henry, OH
5	US RT 127	11.748	$481,340	West Lake Development II, Ltd	Columbus, OH
6	West Bank Rd	0.717	57,200	ODNR	Columbus, OH
7	West Bank Rd	0	$3,240	ODNR	Columbus, OH
8	US RT 127	0.63	$30,800	City of Celina	Celina, OH
9	1081 West Bank Rd	1	$350,750	Larry J. Welch	Celina, OH
10	US RT 127	0.82	$5,200	Mercer County Commissioners	Celina, OH
11	Schunck Rd	2.94	$46,600	City of Celina Disposal	Celina, OH
12	Schunck Rd	8.18	$27,061,250	City of Celina	Celina, OH
13	Monroe Rd	18.72	$594,160	Charles J. Meier	Celina, OH
14	S Main St	2.875	$15,900	Mercer County Commissioners	Celina, OH
15	Celina, OH	7.5	Not available	City of Celina (Bike Path)	Celina, OH
16	5670 Schunck Rd	58.649	$264,110	Charles J. Meier	Celina, OH
17	Meyer Rd	1.940	$384,280	Charles F. Zumberge, et al, John and Virginia Zumberge Trust	Celina, OH
18	Meyer Rd	1.0	$59,570	Hayes Broadcasting	Celina, OH
19	Schunck Rd	9.5	$2,301,950	Reynolds & Reynolds	Dayton, OH
20	322 Schunck Rd	0.06	$92,100	Rita L. Fritz, et al, John F. and Maxine Murphy Life Estate	Celina, OH
21	Schunck Rd	2.6	$22,230	Reynolds & Reynolds	Dayton, OH
22	Elm St	1.455	$43,200	Matt Schweikerman, Inc.	Coldwater, OH
23	Elm St	0.709	$5,000	Matt Schweikerman, Inc.	Coldwater, OH
24	Elm St	0.606	$4,300	Matt Schweikerman, Inc.	Coldwater, OH
25	5780 Schunck Rd	1.49	$216,910	Robert D. McKinnon	Celina, OH
26	Elm St	1.941	$13,900	Matt Schweikerman, Inc.	Coldwater, OH
27	Elm St	1.592	$11,100	Matt Schweikerman, Inc.	Coldwater, OH
28	Elm St	1.465	$278,900	C. J. Coe, Inc.	Green Hill, OH
29	Schunck Rd	1.681	$30,700	Carolyn A. Liddle	Celina, OH
30	5750 Schunck Rd	2.276	$123,700	Nancy Ann Chaney	Celina, OH
31	5700 Schunck Rd	1.102	$107,600	Charles L. and Mary K. Meier	Celina, OH
32	5650 Schunck Rd	0.25	$70,300	Ronald Stuckey, et ux	Celina, OH
33	1101 US RT 127	21.23	$900,610	Case Leasing & Rental, Inc.	Bluffton, IN

CROSS SECTIONS OF BEAVER CREEK USED IN HEC-2 MODEL WERE OBTAINED FROM THE FINAL REPORT HYDROLOGIC AND HYDRAULIC ANALYSES, GRAND LAKE ST. MARYS, AUGLAIZE AND MERCER COUNTIES, OHIO, FEBRUARY 2, 1990, BROSM ENGINEERING, INC.

UNITED STATES DEPARTMENT OF AGRICULTURAL AERIAL PHOTOGRAPH DATED JUNE 23, 2001

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LEGEND

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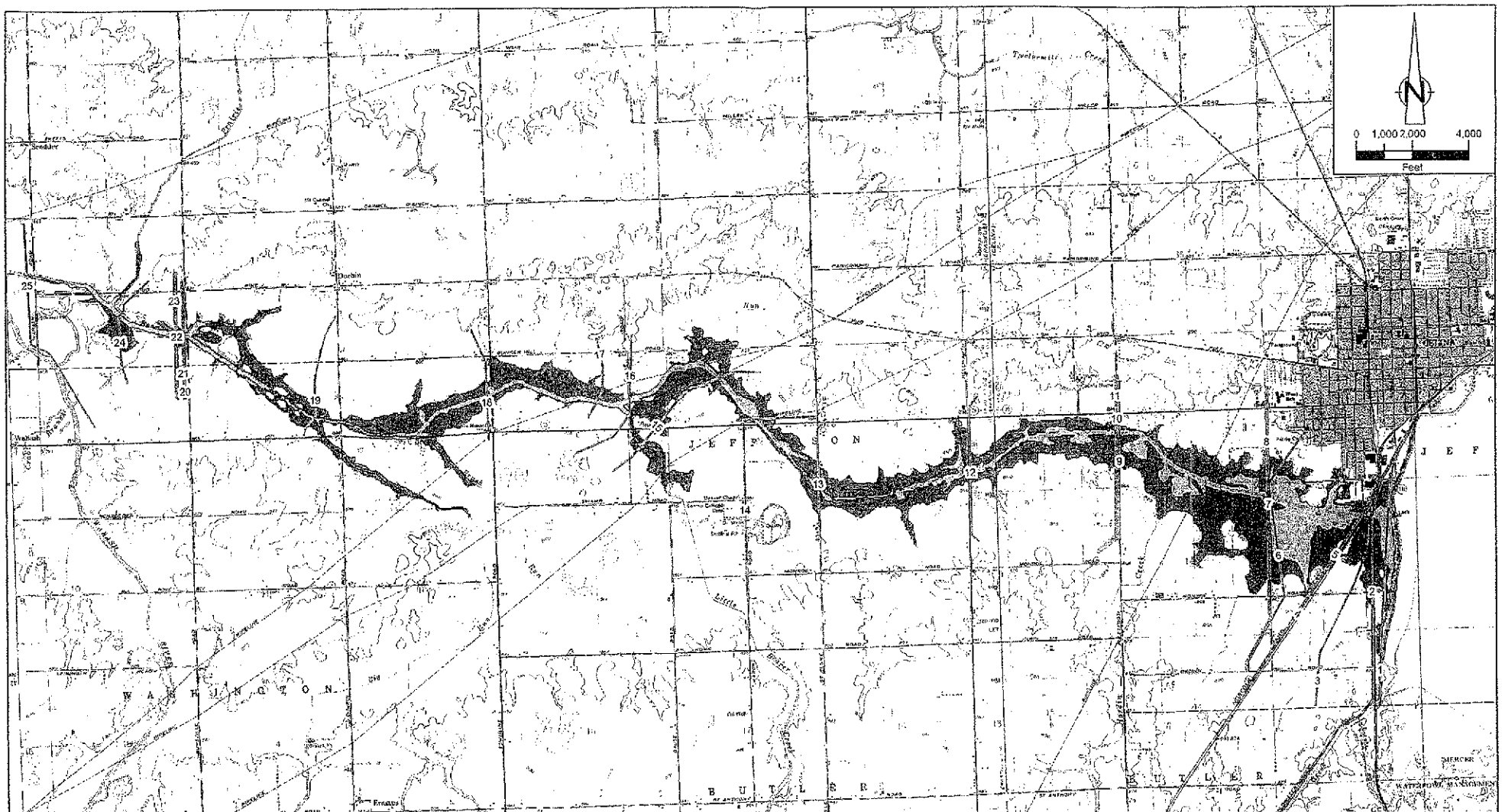
- PROPERTY BOUNDARIES
- INUNDATED AREA AS THE RESULT OF THE 39.4 FOOT SPILLWAY
- INUNDATED AREA AS THE RESULT OF THE 500 FOOT SPILLWAY
- 17 PROPERTY IDENTIFICATION NUMBER

Figure 7b
JUNE / JULY 2003 STORM EVENT
FLOOD INUNDATION MAP

Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio



CROSS SECTIONS OF BEAVER CREEK USED IN HEC-2 MODEL WERE OBTAINED FROM THE FINAL REPORT HYDROLOGIC AND HYDRAULIC ANALYSES, GRAND LAKE ST. MARYS, AUGLAIZE AND MERCER COUNTIES, OHIO, FEBRUARY 2, 1999, BIRCHAM ENGINEERING, INC.

UNITED STATES GEOLOGICAL SURVEY DIGITAL RASTER GRAPHICS (CELINA & ERASTUS) DOWNLOADED FROM THE OHIO OFFICE OF INFORMATION TECHNOLOGY WEBSITE

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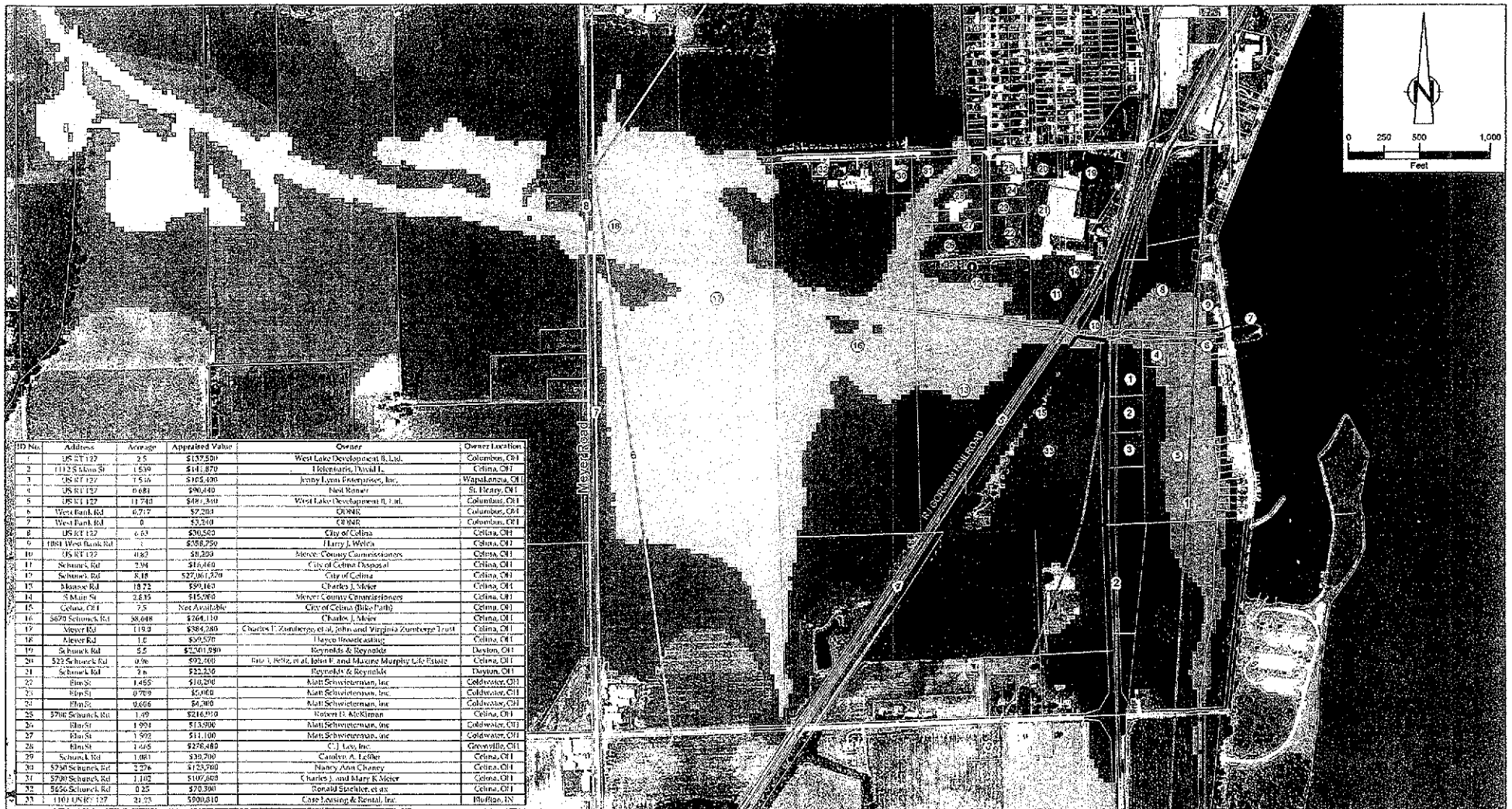
- CASE LEASING AND RENTAL, INC. PROPERTY BOUNDARY
- CROSS SECTION NUMBER AND LOCATIONS USED IN HEC-2 COMPUTER PROGRAM
- INUNDATED AREA AS THE RESULT OF THE 39.4 FOOT SPILLWAY
- INUNDATED AREA AS THE RESULT OF THE 500 FOOT SPILLWAY

Figure 8a
DECEMBER 2003 STORM EVENT FLOOD INUNDATION MAP

Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio



ID No.	Address	Acreage	Appraised Value	Owner	Owner Location
1	US RT 127	2.5	$137,500	West Lake Development II, Ltd.	Columbus, OH
2	1112 S Main St	1.539	$141,870	Heleniaris, David L.	Celina, OH
3	US RT 127	7.516	$105,400	Jenny Lynn Enterprises, Inc.	Wapakoneta, OH
4	US RT 127	0.681	$90,440	Neil Remer	St. Henry, OH
5	US RT 127	11.740	$481,340	West Lake Development II, Ltd.	Columbus, OH
6	West Bank Rd	6.717	$7,200	ODNR	Columbus, OH
7	West Bank Rd	0	$3,240	ODNR	Columbus, OH
8	US RT 127	6.63	$30,500	City of Celina	Celina, OH
9	1061 West Bank Rd	1	$358,750	Harry J. Welch	Celina, OH
10	US RT 127	4.83	$8,200	Mercer County Commissioners	Celina, OH
11	Schunck Rd	2.94	$16,460	City of Celina Disposal	Celina, OH
12	Schunck Rd	8.18	$27,061,970	City of Celina	Celina, OH
13	Monroe Rd	18.72	$59,160	Charles J. Meier	Celina, OH
14	S Main St	2.635	$15,060	Mercer County Commissioners	Celina, OH
15	Celina, OH	7.5	Not Available	City of Celina (Bike Path)	Celina, OH
16	5670 Schunck Rd	58.648	$264,110	Charles J. Meier	Celina, OH
17	Meyer Rd	119.9	$384,280	Charles T. Zumberge, et al, John and Virginia Zumberge Trust	Celina, OH
18	Meyer Rd	1.6	$59,570	Hayco Broadcasting	Celina, OH
19	Schunck Rd	5.5	$2,501,990	Reynolds & Reynolds	Dayton, OH
20	523 Schunck Rd	0.96	$92,500	Eric J. Bellz, et al, John F. and Maxine Murphy Life Estate	Celina, OH
21	Schunck Rd	2.6	$22,320	Reynolds & Reynolds	Dayton, OH
22	Elm St	1.455	$10,290	Matt Schwieterman, Inc	Coldwater, OH
23	Elm St	0.789	$5,000	Matt Schwieterman, Inc	Coldwater, OH
24	Elm St	0.606	$6,900	Matt Schwieterman, Inc	Coldwater, OH
25	5700 Schunck Rd	1.69	$216,910	Robert D. McKleman	Celina, OH
26	Elm St	1.954	$13,900	Matt Schwieterman, Inc	Coldwater, OH
27	Elm St	1.592	$11,100	Matt Schwieterman, Inc	Coldwater, OH
28	Elm St	1.645	$276,480	C.J. Lee, Inc.	Greenville, OH
29	Schunck Rd	1.003	$30,700	Carolyn A. Leffler	Celina, OH
30	5790 Schunck Rd	2.276	$123,700	Nancy Ann Cheney	Celina, OH
31	5790 Schunck Rd	1.102	$109,600	Charles J. and Mary K Meier	Celina, OH
32	5656 Schunck Rd	0.25	$70,300	Ronald Stechler, et ux	Celina, OH
33	1101 US RT 127	30.23	$900,810	Case Leasing & Rental, Inc.	Bluffton, IN

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UNITED STATES DEPARTMENT OF AGRICULTURAL AERIAL PHOTOGRAPH DATED JUNE 23, 2004

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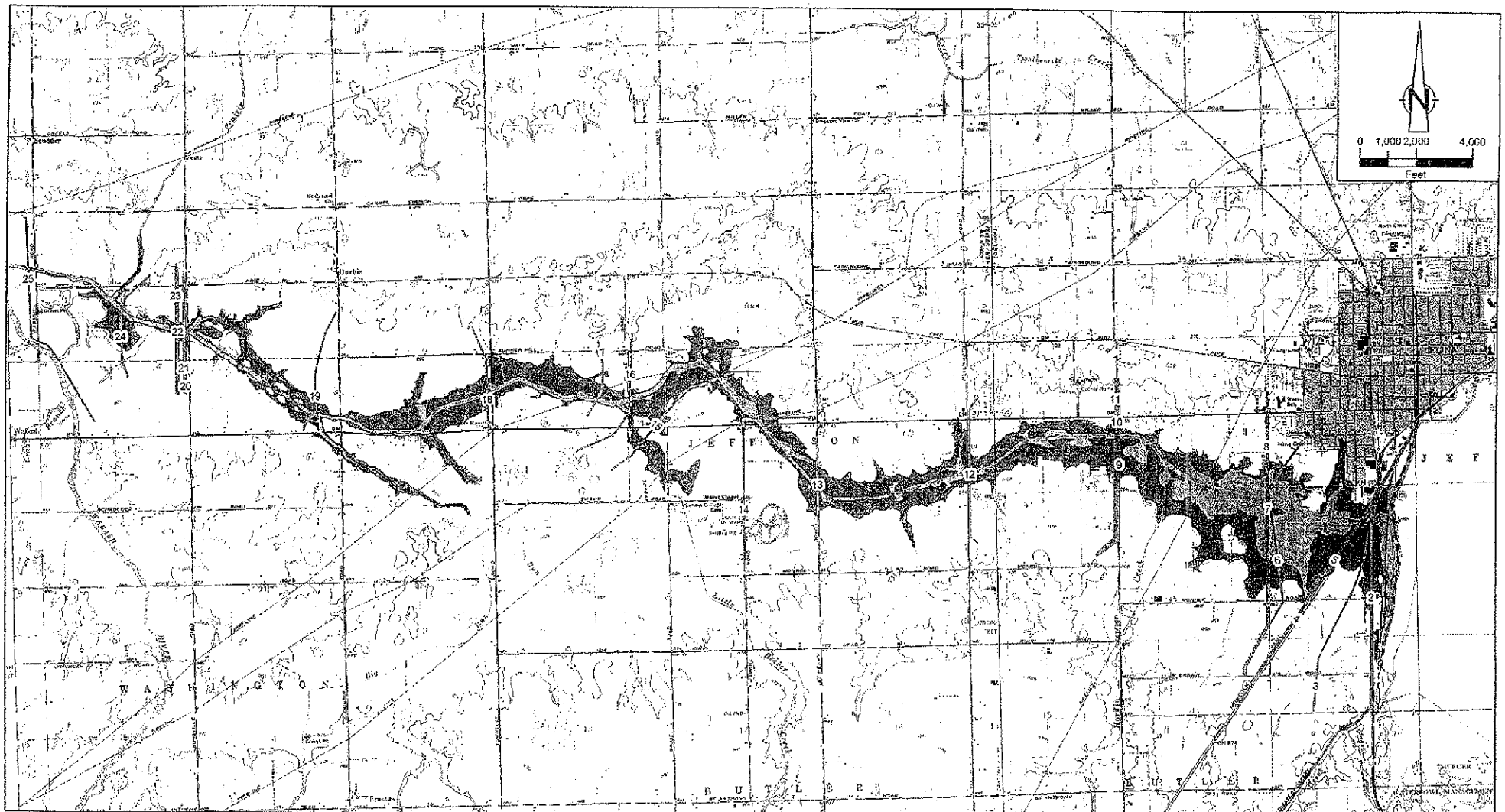
LEGEND

- CASE LEASING AND RENTAL, INC. PROPERTY BOUNDARY
- CROSS SECTION NUMBER AND LOCATIONS USED IN HEC-2 COMPUTER PROGRAM
- PROPERTY BOUNDARIES
- INUNDATED AREA AS THE RESULT OF THE 39.4 FOOT SPILLWAY
- INUNDATED AREA AS THE RESULT OF THE 500 FOOT SPILLWAY
- (17) PROPERTY IDENTIFICATION NUMBER

Figure 8b
DECEMBER 2003 STORM EVENT FLOOD INUNDATION MAP

Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio



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UNITED STATES GEOLOGICAL SURVEY DIGITAL RASTER GRAPHICS (DRG NA & ERASTUS) DOWNLOADED FROM THE OHIO OFFICE OF INFORMATION TECHNOLOGY WEBSITE

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- CROSS SECTION NUMBER AND LOCATIONS USED IN HEC-2 COMPUTER PROGRAM
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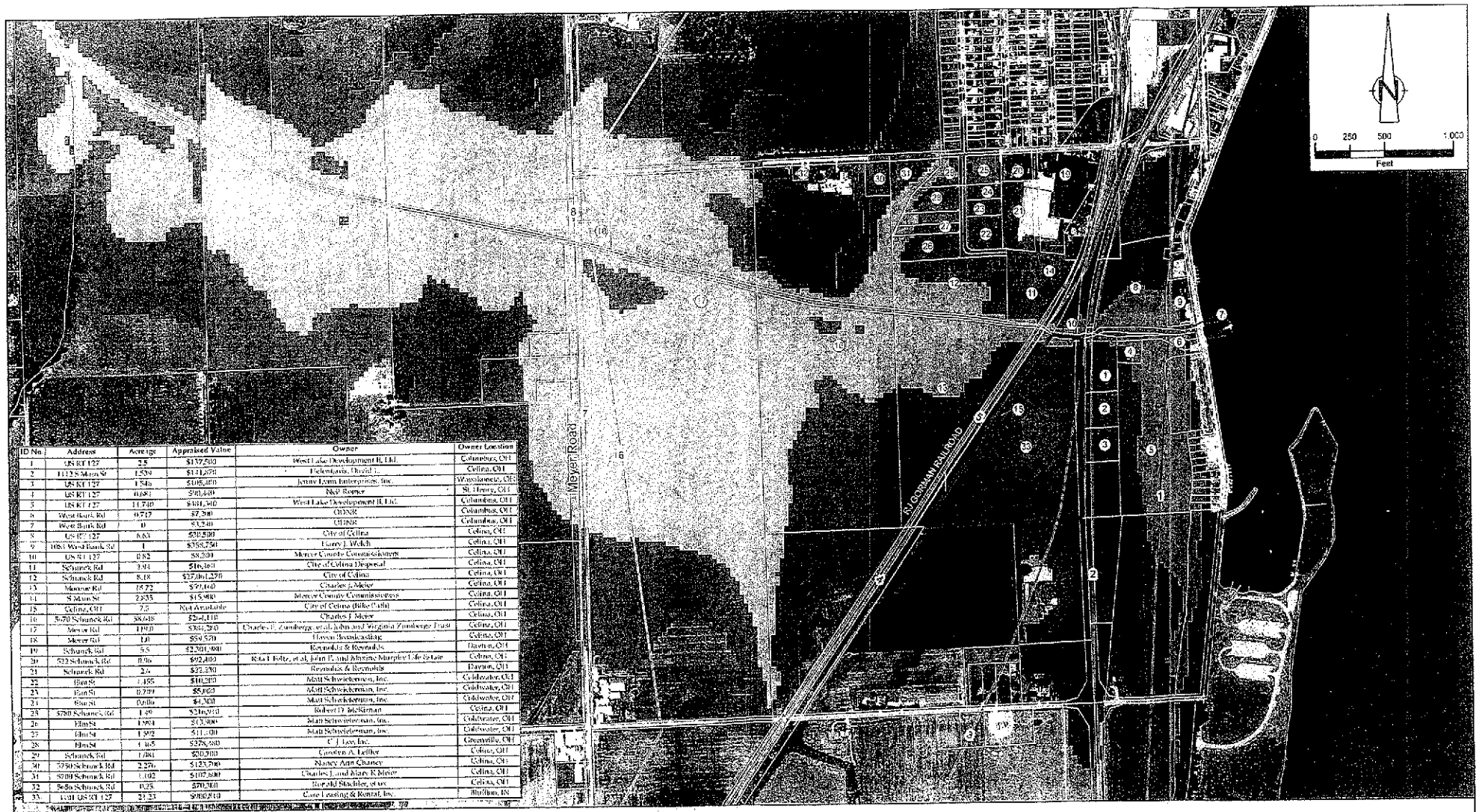
- INUNDATED AREA AS THE RESULT OF THE 500 FOOT SPILLWAY

Figure 9a
JANUARY 2005 STORM EVENT FLOOD INUNDATION MAP

Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio



ID No.	Address	Acreage	Appraised Value	Owner	Owner Location
1	US RT 127	3.5	$137,500	West Lake Development II, Ltd.	Columbus, OH
2	1123 S Main St	1.539	$111,070	Helentanis, David L.	Celina, OH
3	US RT 127	1.546	$105,400	Jenny Lynn Enterprises, Inc.	Wapakoneta, OH
4	US RT 127	0.682	$90,440	Nick Berner	St. Henry, OH
5	US RT 127	11.740	$101,340	West Lake Development II, Ltd.	Columbus, OH
6	West Bank Rd	0.717	$7,200	ODNR	Columbus, OH
7	West Bank Rd	10	$33,240	ODNR	Columbus, OH
8	US RT 127	8.63	$30,500	City of Celina	Celina, OH
9	1063 West Bank St	1	$358,750	Larry J. Welch	Celina, OH
10	US RT 127	0.82	$8,200	Mercer County Commissioners	Celina, OH
11	Schunck Rd	3.94	$16,360	City of Celina Disposal	Celina, OH
12	Schunck Rd	8.08	$27,061,270	City of Celina	Celina, OH
13	Monroe Rd	18.72	$79,040	Charles J. Meier	Celina, OH
14	S Main St	2.935	$15,900	Mercer County Commissioners	Celina, OH
15	Celina, OH	7.5	Not Available	City of Celina (Bike Path)	Celina, OH
16	5670 Schunck Rd	38.648	$261,110	Charles J. Meier	Celina, OH
17	Meyer Rd	19.08	$304,200	Charles E. Zumberge, et al, John and Virginia Zumberge Trust	Celina, OH
18	Meyer Rd	1.01	$59,570	Hoven Broadcasting	Celina, OH
19	Schunck Rd	5.5	$2,301,000	Reynolds & Reynolds	Dayton, OH
20	523 Schunck Rd	0.96	$92,400	Rita F. Foltz, et al, John F. and Johnine Murphy Life Estate	Celina, OH
21	Schunck Rd	2.6	$22,200	Reynolds & Reynolds	Dayton, OH
22	Elm St	1.455	$40,200	Matt Schwiebermann, Inc.	Coldwater, OH
23	Elm St	0.739	$5,900	Matt Schwiebermann, Inc.	Coldwater, OH
24	Elm St	0.086	$4,300	Matt Schwiebermann, Inc.	Coldwater, OH
25	5700 Schunck Rd	1.49	$246,930	Robert D. McKiernan	Celina, OH
26	Elm St	1.904	$52,000	Matt Schwiebermann, Inc.	Coldwater, OH
27	Elm St	1.992	$11,100	Matt Schwiebermann, Inc.	Coldwater, OH
28	Elm St	1.165	$278,560	C. J. Lee, Inc.	Greenville, OH
29	Schunck Rd	1.061	$20,700	Carolyn A. Leffler	Celina, OH
30	5750 Schunck Rd	2.276	$123,700	Nancy Ann Chaney	Celina, OH
31	5700 Schunck Rd	1.102	$102,600	Charles L. and Mary K Meier	Celina, OH
32	5650 Schunck Rd	0.25	$70,300	Ronald Stechler, et ux	Celina, OH
33A	1101 US RT 127	23.23	$980,910	Case Leasing & Rental, Inc.	Bluffton, IN

CROSS SECTIONS OF BEAVER CREEK USED IN HEC-2 MODEL WERE OBTAINED FROM THE FINAL REPORT HYDROLOGIC AND HYDRAULIC ANALYSES, GRAND LAKE ST MARYS, AUGLAIZE AND MERCER COUNTIES, OHIO, FEBRUARY 2, 1990, BECAM ENGINEERING, INC

UNITED STATES DEPARTMENT OF AGRICULTURAL AERIAL PHOTOGRAPH DATED JUNE 23, 2004

INFORMATION SHOWN IN THE TABLE AND PROPERTY BOUNDARIES SHOWN ON THE FIGURE WERE OBTAINED FROM THE MERCER COUNTY OHIO REAL ESTATE SEARCH RESULTS, UNOFFICIAL REAL PROPERTY RECORD CARDS COMPLETED ON DECEMBER 21, 2005

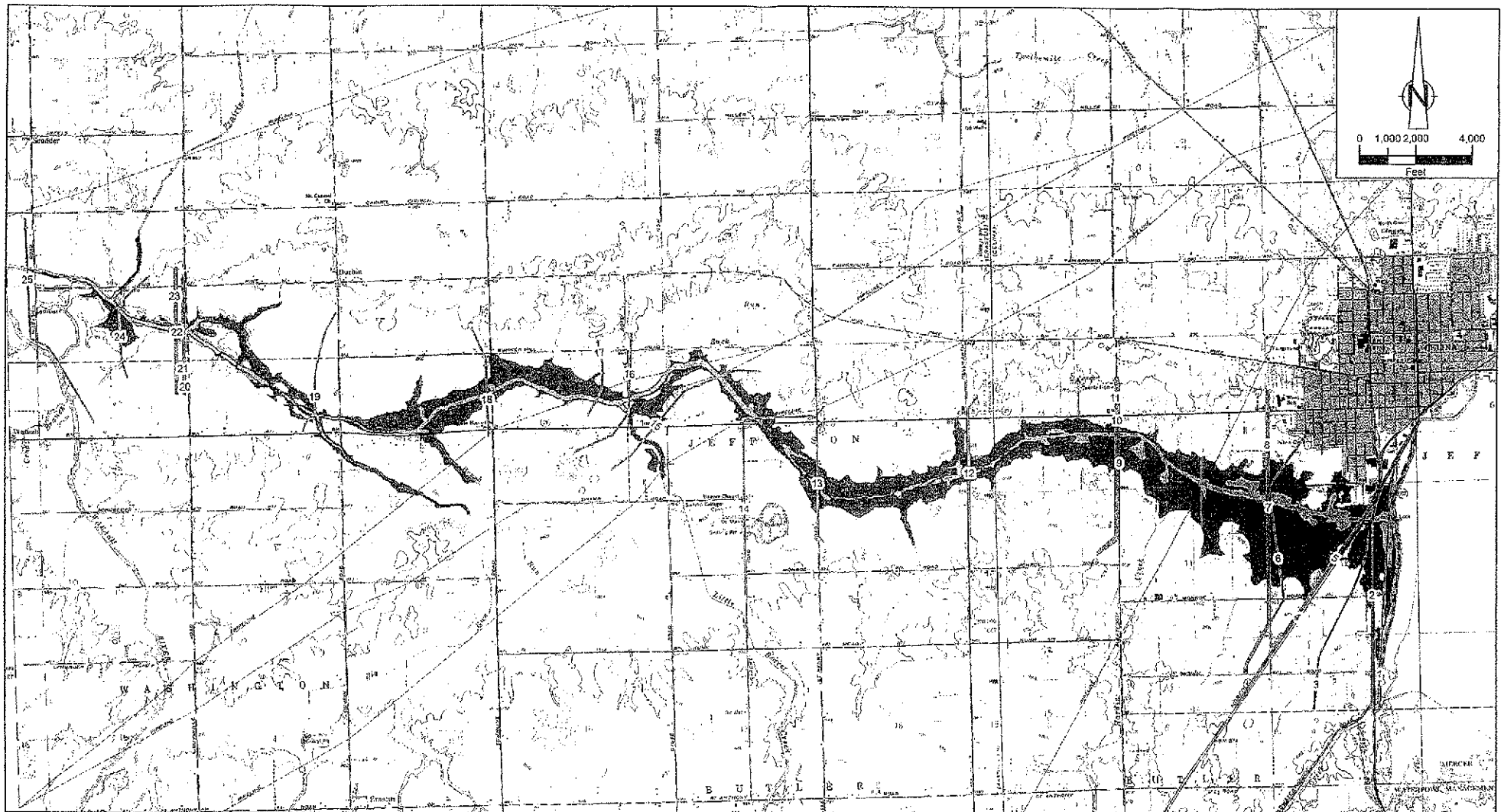
GROUND SURFACE ELEVATIONS USED WERE OBTAINED FROM THE OHIO 10 METER DIGITAL ELEVATION MODEL, PUBLISHED BY THE OHIO ENVIRONMENTAL PROTECTION AGENCY DIVISION OF EMERGENCY AND REMEDIAL RESPONSE, 2004

LEGEND

- CASE LEASING AND RENTAL, INC. PROPERTY BOUNDARY
- CROSS SECTION NUMBER AND LOCATIONS USED IN HEC-2 COMPUTER PROGRAM
- PROPERTY BOUNDARIES
- INUNDATED AREA AS THE RESULT OF THE 39.4 FOOT SPILLWAY
- INUNDATED AREA AS THE RESULT OF THE 500 FOOT SPILLWAY
- 17 PROPERTY IDENTIFICATION NUMBER

Figure 9b
JANUARY 2005 STORM EVENT FLOOD INUNDATION MAP

Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio



CROSS SECTIONS OF BEAVER CREEK USED IN HEC-2 MODEL WERE OBTAINED FROM THE FINAL REPORT HYDROLOGIC AND HYDRAULIC ANALYSES, GRAND LAKE ST. MARYS, AUGLAIZE AND MERCER COUNTIES, OHIO, FEBRUARY 2, 1990, BDC&M ENGINEERING, INC.

UNITED STATES GEOLOGICAL SURVEY DIGITAL RASTER GRAPHICS (CELINA & ERASTUS) DOWNLOADED FROM THE OHIO OFFICE OF INFORMATION TECHNOLOGY WEBSITE

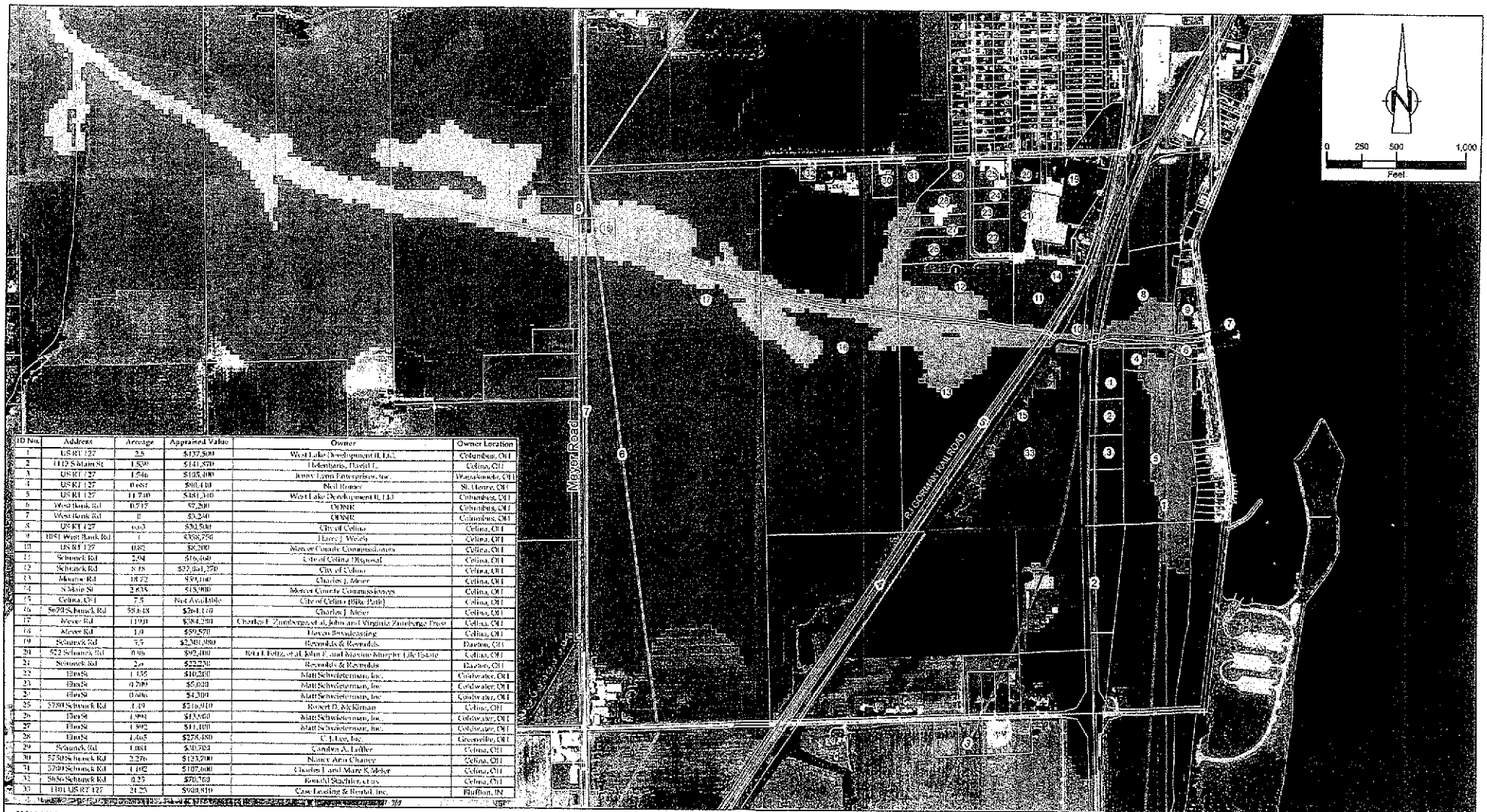
GROUND SURFACE ELEVATIONS USED WERE OBTAINED FROM THE OHIO 10 METER DIGITAL ELEVATION MODEL, PUBLISHED BY THE OHIO ENVIRONMENTAL PROTECTION AGENCY, DIVISION OF EMERGENCY AND REMEDIAL RESPONSE, 2004

LEGEND

- CASE LEASING AND RENTAL, INC. PROPERTY BOUNDARY
- CROSS SECTION NUMBER AND LOCATIONS USED IN HEC-2 COMPUTER PROGRAM
- INUNDATED AREA AS THE RESULT OF THE 39.4 FOOT SPILLWAY
- INUNDATED AREA AS THE RESULT OF THE 500 FOOT SPILLWAY

Figure 10a
JUNE 2006 STORM EVENT
FLOOD INUNDATION MAP

Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio



ID No.	Address	Acreage	Appraised Value	Owner	Owner Location
1	US RT 127	2.5	$137,500	West Lake Development II, LLC	Columbus, OH
2	1172 S Main St	1.530	$141,570	Lolentaris, David L.	Celina, OH
3	US RT 127	1.546	$105,400	Jenny Lynn Enterprises, Inc.	Wapakoneta, OH
4	US RT 127	0.687	$90,410	Neil Renner	St. Henry, OH
5	US RT 127	11.740	$481,340	West Lake Development II, LLC	Columbus, OH
6	West Bank Rd	0.717	57,200	ODNR	Columbus, OH
7	West Bank Rd	8	$3,240	ODNR	Columbus, OH
8	US RT 127	0.03	$30,500	City of Celina	Celina, OH
9	1051 West Bank Rd	1	$358,750	Harry J. Woerly	Celina, OH
10	US RT 127	0.02	$8,200	Mercer County Commissioners	Celina, OH
11	Schunck Rd	2.94	$16,600	City of Celina Disposal	Celina, OH
12	Schunck Rd	8.18	$32,861,270	City of Celina	Celina, OH
13	Mercer Rd	18.72	$59,100	Charles J. Meier	Celina, OH
14	S Main St	2.635	$15,900	Mercer County Commissioners	Celina, OH
15	Celina, OH	7.5	Not Available	City of Celina (Bike Path)	Celina, OH
16	5629 Schunck Rd	58.63	$264,110	Charles J. Meier	Celina, OH
17	Mayer Rd	11.93	$384,290	Charles E. Zumberge, et al, John and Virginia Zumberge Prop	Celina, OH
18	Mayer Rd	1.0	$59,570	Dayton Broadcasting	Celina, OH
19	Schunck Rd	7.5	$2,300,980	Reynolds & Reynolds	Dayton, OH
20	522 Schunck Rd	0.96	$92,400	Rita L. Heitz, et al, John F. and Marlene Murphy Life Estate	Celina, OH
21	Schunck Rd	2.0	$32,230	Reynolds & Reynolds	Dayton, OH
22	Elm St	1.135	$10,200	Matt Schwieterman, Inc.	Coldwater, OH
23	Elm St	0.709	$6,600	Matt Schwieterman, Inc.	Coldwater, OH
24	Elm St	0.686	$4,300	Matt Schwieterman, Inc.	Coldwater, OH
25	5280 Schunck Rd	1.49	$316,910	Robert D. McKiman	Celina, OH
26	Elm St	1.994	$13,900	Matt Schwieterman, Inc.	Coldwater, OH
27	Elm St	1.992	$11,100	Matt Schwieterman, Inc.	Coldwater, OH
28	Elm St	1.665	$278,980	C.L. Lee, Inc.	Greenville, OH
29	Schunck Rd	0.861	$30,700	Carolyn A. Leffler	Celina, OH
30	5750 Schunck Rd	2.276	$123,200	Nancy Ann Chaney	Celina, OH
31	5790 Schunck Rd	1.492	$107,600	Charles J. and Mary K Meier	Celina, OH
32	5650 Schunck Rd	0.25	$70,700	Ronald Stechler, et ux	Celina, OH
33	1101 US RT 127	21.23	$908,810	Case Leasing & Rental, Inc.	Huffton, IN
34	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

CROSS SECTIONS OF BEAVER CREEK USED IN HEC-2 MODEL WERE OBTAINED FROM THE FINAL REPORT HYDROLOGIC AND HYDRAULIC ANALYSES GRAND LAKE ST. MARYS, AUGLAIZE AND MERCER COUNTIES, OHIO, FEBRUARY 2, 1990, BBCM ENGINEERING, INC.

UNITED STATES DEPARTMENT OF AGRICULTURAL AERIAL PHOTOGRAPH DATED JUNE 20, 2004

INFORMATION SHOWN IN THE TABLE AND PROPERTY BOUNDARIES SHOWN ON THE FIGURE WERE OBTAINED FROM THE MERCER COUNTY OHIO REAL ESTATE SEARCH RESULTS, UNOFFICIAL REAL PROPERTY RECORD CARDS COMPLETED ON DECEMBER 21, 2005.

GROUND SURFACE ELEVATIONS USED WERE OBTAINED FROM THE OHIO 10 METER DIGITAL ELEVATION MODEL, PUBLISHED BY THE OHIO ENVIRONMENTAL PROTECTION AGENCY DIVISION OF EMERGENCY AND REMEDIAL RESPONSE, 2004

LEGEND

- CASE LEASING AND RENTAL, INC. PROPERTY BOUNDARY
- CROSS SECTION NUMBER AND LOCATIONS USED IN HEC-2 COMPUTER PROGRAM
- PROPERTY BOUNDARIES
- INUNDATED AREA AS THE RESULT OF THE 39.4 FOOT SPILLWAY
- INUNDATED AREA AS THE RESULT OF THE 500 FOOT SPILLWAY
- 17 PROPERTY IDENTIFICATION NUMBER

Figure 10b
JUNE 2006 STORM EVENT
FLOOD INUNDATION MAP

Schottenstein Zox & Dunn Co., LPA
Columbus, Ohio

TABLE 1

MODEL RESULTS FOR HISTORICAL STORM EVENTS
GRAND LAKE ST. MARYS
MERCER AND AUGLAIZE COUNTIES, OHIO

Rainfall/Runoff event	Rainfall Amount [1]	Rainfall Duration [2]	39.4-Foot Spillway	500-Foot Spillway	Difference [3]	39.4-Foot Spillway	500-Foot Spillway	Difference [4]	39.4-Foot Spillway	500-Foot Spillway	Difference [11]	39.4-Foot Spillway	500-Foot Spillway	Difference [17]
			Maximum lake elevation	Maximum lake elevation		Maximum Discharge [5]	Maximum Discharge [6]		Upstream Case Property Limit Maximum Water Elevation [10]	Upstream Case Property Limit Maximum Water Elevation [16]		Downstream Case Property Limit Maximum Water Elevation [10]	Downstream Case Property Limit Maximum Water Elevation [16]	
	[inches]	[hours]	[feet msl]	[feet msl]	[feet msl]	[cfs]	[cfs]	[cfs]	[feet msl]	[feet msl]	[feet]	[feet msl]	[feet msl]	[feet]
March/April 1913 [1]	8.31	186	872.9 [10]	872.6 [16]	-0.3	325	2100	1775	854.6	861.4	6.8	854.5	860.1	5.6
January 1930	6.15	198	872.6 [15]	872.3 [16]	-0.3	265	1327	1062	854.0	859.6	5.6	853.9	859.1	5.2
April 1938 [2]	3.26	84	872.2 [9]	872.0 [15]	-0.2	177	663	486	852.9	857.0	4.1	852.9	857.0	4.1
May 1943	4.11	132	872.5 [9]	872.2 [16]	-0.3	229	1058	830	853.6	858.8	5.2	853.5	858.5	5.0
February 1950 [3]	3.37	108	872.2 [14]	872.1 [16]	-0.1	177	809	632	852.9	857.8	4.9	852.9	857.7	4.8
April/May 1972	5.72	276	872.5 [9]	872.1 [14]	-0.4	229	976	748	853.6	858.5	5.0	853.5	858.3	4.8
May 1981 [4]	4.99	156	872.3 [5]	872.2 [16]	-0.1	193	1044	852	853.1	858.8	5.6	853.1	858.5	5.4
July 1992	8.94	246	872.4 [9]	872.0 [16]	-0.4	210	1208	998	853.2	859.3	6.0	853.2	858.9	5.7
June/July 1993 [5]	5.83	204	872.7 [5]	872.4 [15]	-0.3	285	1448	1163	854.2	859.9	5.7	854.1	859.3	5.2
February/May 1997 [6]	2.59	108	872.2 [9]	872.0 [14]	-0.2	176	640	465	852.9	856.9	4.0	852.9	856.8	4.0
July/August 1998 [7]	3.60	180	872.5 [9]	872.1 [14]	-0.4	237	813	576	853.7	857.9	4.2	853.6	857.7	4.1
May 2002 [8]	2.93	300	872.6 [14]	872.0 [15]	-0.6	247	667	421	853.8	857.1	3.3	853.7	857.0	3.3
June/July 2003	10.67	138	873.7 [10]	872.6 [15]	-1.0	537	2185	1648	856.3	860.9	4.7	856.2	860.2	4.0
December 2005 [9]	3.42	324	873.3 [10]	872.5 [15]	-0.8	444	1744	1300	855.6	860.5	4.9	855.5	859.8	4.3
January 2005	7.43	106	873.5 [10]	872.6 [15]	-0.9	482	1961	1480	855.9	860.8	4.9	855.8	860.1	4.2
June 2006	N/A	N/A	873.0 [14]	872.4 [15]	-0.6	346	1535	1189	854.8	860.1	5.4	854.7	859.5	4.8
									Case Leasing and Rental, Inc. finished floor elevation = 858.74 [13]					

Notes: [1] Stage-lake elevation data was available at 1913, the cited event was modeled by HEC-1 using recorded rainfall data and an assumed starting lake elevation of 850.00 feet msl.
[2] The cited rainfall/runoff event was modeled in analysis of the CRA May 2006 Report.
[3] Data obtained from the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NCDC) for the following stations: Mercer, OH (331948), Angelica, OH (330280), Celina, OH (331809), Ada, OH (330076), Delphos, OH (332612), Shelby, OH (337613), and Defiance, OH (330375).
[4] Data obtained from the HEC-1 simulation output.
[5] Lake elevations cited are actual elevations as measured at GLSM.
[6] Lake elevations cited were calculated based upon the stage-storage relationship of the GLSM reservoir.
[7] The maximum lake elevation for the 500-foot spillway minus the maximum lake elevation for the 39.4-foot spillway.
[8] Discharges cited were calculated for the corresponding maximum lake elevation by use of the stage-discharge relationship of the curve-crest spillway.
[9] The maximum discharge for the 500-foot spillway minus the maximum discharge for the 39.4-foot spillway.
[10] Data obtained from HEC-2 simulation output.
[11] The maximum water elevation for the 500-foot spillway minus the maximum water elevation for the 39.4-foot spillway.
[12] The finished floor of Case Leasing and Rental, Inc. was surveyed by Concelogic-Rotary & Associates (CRA) on March 23-2006.
Highlighted values exceed the elevation of the Case Leasing and Rental, Inc. finished floor.
msl = mean sea level
cfs = cubic feet per second
N/A = Not obtained

TABLES

TABLE 2

SUMMARY OF LAKE SURFACE LEVEL MEASUREMENT DATA
GRAND LAKE ST. MARYS
MERCER AND AUGLAIZE COUNTIES, OHIO

	APRIL 1, 1927 THROUGH JUNE 1, 1997 [1]		*JUNE 1, 1997 THROUGH AUGUST 21, 2006* [2]		*Difference in Percentage*
	Number of Measurements	*Percentage of Total Measurements (percent)*	*Number of Measurements*	*Percentage of Total Measurements (percent)*	
Total	23,305	100	521	100	0
Above 870.6 (feet msl)	4,994	21.4	382	73.3	51.9
Between 870.6 and 870.99 (feet msl)	2,720	11.7	78	15.0	3.3
Between 871.0 and 871.49 (feet msl)	1,711	7.3	167	32.1	24.7
Between 871.5 and 871.99 (feet msl)	461	2.0	122	23.4	21.4
Above 871.8 (feet msl) [3]	227	1.0	52	10.0	9.0
Above 872.0 (feet msl)	102	0.4	15	2.9	2.4

Notes:

[1] Time period cited was prior to the construction of the 500-foot spillway.

[2] Time period cited is subsequent to the construction of the 500-foot spillway.

[3] The cited elevation is the approximate GLSM elevation at which the 500-foot spillway discharges a flow that will begin to overflow the Beaver Creek channel banks at the Case property.

msl = mean sea level

APPENDIX A

LAKE GAUGE SURVEY RESULTS

(Referenced in the text on page 3)

Lee Surveying and Mapping Co., Inc.

Land Surveys • Topography • Subdivisions • Construction Layout

117 N. Madriver Street
Bellefontaine OH 43311

Phone: (937) 593-7335
Fax: (937) 593-7444

1975 - 2005 - 30 YEARS OF EXCELLENCE

September 19, 2006

Schottenstein Zox & Dunn Co., LPA
P.O. Box 165020
Columbus OH 43216

ATTN.: Stephen Samuels

RE: Survey of Gauges and Spillway Notch on Grand Lake St. Marys, Ohio

Dear Mr. Samuels:

This project was personally surveyed by my associate, William K. Bruce, P.S., Ohio Registered Surveyor Number 7437. He completed the field portion of the survey yesterday afternoon and checked his final notes in the late afternoon. He ran the survey in approximate one mile loops a distance of twelve miles around the lake (24 survey miles) using a Zeiss Model DiNi Electronic Level (SN 207427). The pair of level rods are matching rods manufactured by Zeiss and Trimble (Model TD24). The level was checked for accuracy prior to proceeding with the survey. The survey proceeded at a fast pace in all types of weather including heavy rains on the first day of the survey. The final field work was completed at a speed of less than two hours per mile of survey by using extra personnel and two rods instead of the usual one.

Initially, Mr. Bruce had communication problems with the prior survey company regarding the location of the bench marks to use. The problem was unavoidable due to the absence of Mr. Charles Munce from his office for two days. Since it was imperative that the project be completed quickly, Mr. Bruce used an assumed elevation for his beginning point and completed the survey with that basis for elevations. Once, he obtained the bench mark locations required to match the prior surveys, he tied his survey to a point designated Bench Mark 2 in the Mercer County Engineer's Records.

Bench Mark 2 is a chiseled "O" cut in the southeast wing of the U.S. Route 127 bridge over Beaver Creek opposite center-line Station 7+50 per the 1977 highway plans. The published elevation for Bench Mark 2 is 860.72 feet.

The correction to his assumed elevations will require adding 17.003 feet to each of his field elevations. Mr. Bruce's unadjusted closure for the total twenty-four mile distance is 0.04 feet of error in the twelve miles. 0.04 feet is about 1/2 inch.

Your original scope for this project requested that we provide the following information:

1. The elevation of the 50-foot notch in the center of the spillway located on the western side of Grand Lake St. Marys. Note that Mr. Bruce simply called this the top of spillway in his notes.

2. The elevation of the gauge on the East Bank of Grand Lake St. Marys.

3. The elevation of the gauge on the Western Bank of Grand Lake St. Marys.

4. The elevation of the gauge on the boathouse located on the north side of Grand Lake St. Marys.

MEMBER: AMERICA CONGRESS ON SURVEYING & MAPPING (ACSM) • NATIONAL SOCIETY OF PROFESSIONAL SURVEYORS (NSPS)
PROFESSIONAL LAND SURVEYORS OF OHIO (PLSO) • SURVEYORS HISTORICAL SOCIETY

Lee Surveying and Mapping Co., Inc.

Land Surveys • Topography • Subdivisions • Construction Layout

117 N. Madriver Street
Bellefontaine OH 43311

Phone: (937) 593-7335
Fax: (937) 593-7444

1975 - 2005 - 30 YEARS OF EXCELLENCE

During a phone conversation with you, I was instructed to use the same mark on all of the gauges with a preference to use the 3 feet mark. Additionally, we were to, also, verify the elevations of each end of the dam and the top of the "V" slot in the dam.

The results of the survey after the addition of the 17.003 feet and necessary variations from the original scope are as follows. All elevations are in feet and thousands of a foot:

Top of the dam on the north side of the spillway	871.487'
Top of the spillway on the north side	870.646'
Top of the dam on the south side of the spillway	871.483'
Top of the spillway on the south side	870.620'

The gauge on the west bank does not exist anymore.

Mercer County Bench Mark 810 is the TBM for the west bank gauge if it is to be replaced. The location is defined on the attached county document at the end of this report The published elevation is 877.01 feet. The elevation from our field survey is 877.003'

The top of the 2 feet mark on the gauge at the O.D.N.R. maintenance area boat building. 872.764
There is no 3 feet mark on this gauge. This gauge could not be found at the beginning of the survey.

A "MAG" nail TBM was set in the west side of a light pole in the middle of the maintenance area parking lot. The top of the head of the MAG nail is 875.551

Top of the 3 feet mark on the water gauge at the east end of the lake 873.308

TBM at the water gauge area is a chiseled "+" on top of a bolt at the base of the hoist/crane. 878.612

I have attached a copy of Mr. Bruce's original field notes as well as a copy of the Mercer County Bench Mark notes as cited above. If you have need for any further information, please contact us.

Sincerely,

Jeffrey I. Lee
Ohio Professional Surveyor 6359

STATE OF OHIO
JEFFREY I. LEE
6359
REGISTERED PROFESSIONAL SURVEYOR

ORIGINAL STAMP IN GREEN

4314096.ltr.wps

FINAL ELEVATIONS

TOP/DAM (NORTH SIDE SPILLWAY)	871.487
T/SPILLWAY NORTH SIDE	870.646
T/DAM (SOUTH SIDE SPILLWAY)	871.483
T/SPILLWAY SOUTH SIDE	870.62
NO GAUGE @ WEST BANK SIDE	———
TOP/ 2' MARK ON WATER GAUGE @ O.D.N.R. MAINTENANCE AREA BOAT BUILDING	872.764
T.B.M. @ O.D.N.R. MAINTENANCE AREA IS A "MAG" NAIL SET IN THE WEST SIDE OF A LIGHT POLE IN THE MIDDLE OF MAINTENANCE AREA PARKING LOT	875.551
TOP/ 3' MARK ON WATER GAUGE @ EAST END OF LAKE	873.308
T.B.M @ WATER GAUGE AREA IS A CHISELED "+" ON TOP OF A BOLT @ BASE OF HOIST/CRANE	878.612

NOTE: ADD 17.003' TO ALL ELEVATIONS ON PAGES 2 through 19. (PAGE 20 TIES MAIN LOOPS TO MERCER CO. ENGINEERS B.M. #2)

STATE OF OHIO
IN
L
LAUGE
7207
PROFESSIONAL SURVEYOR

ORIGINAL STAMP IN GREEN

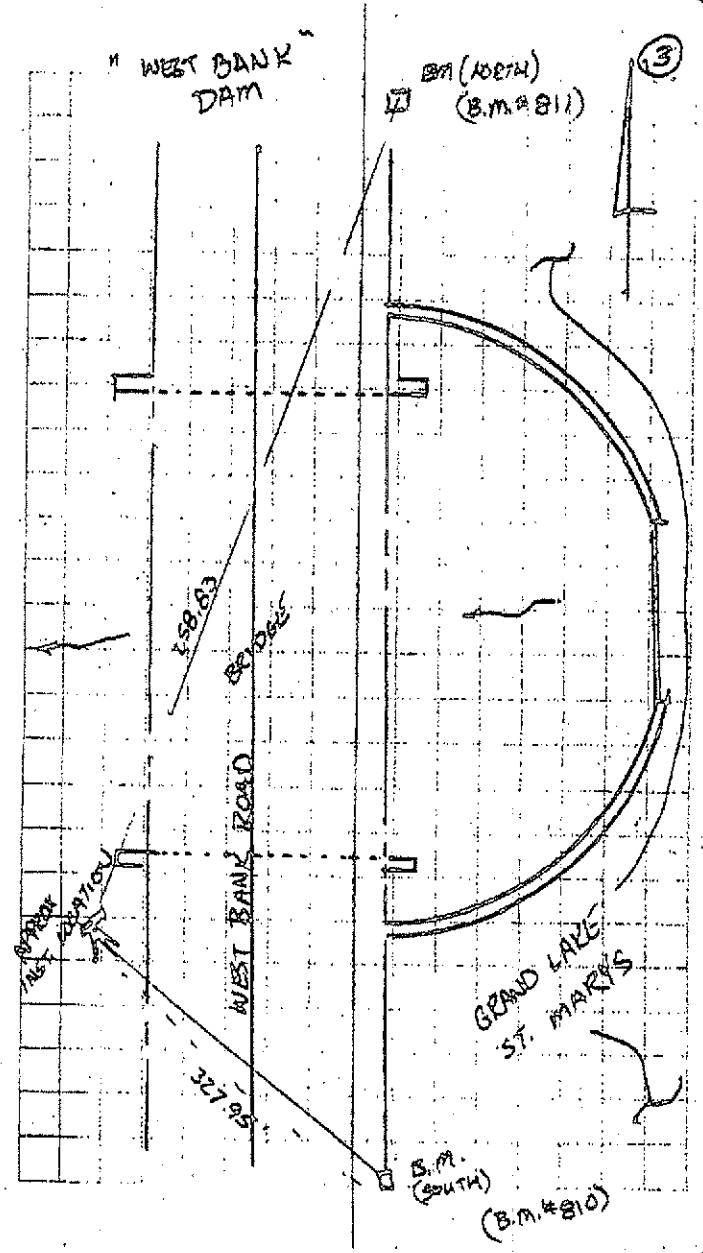
(2) 4314096
9/12/06 65°-OVERCAST, RAIN
KB-CW-DL

INSTRUMENT = ZIESS DINI 20

DESC	+	I	-	ELEV.	NOTE
B.M. CHISELED "□"	3.944	863.944		860.00	SOUTH
ASSUMED 860.00 (876.81) INFO OBTAINED 877.01 (4/15/06) #810					
B.M. CHISELED "□" (876.81) #811			4.164	859.78	NORTH
T/DAM @ SPILLWAY (NORTH)			9.460	854.484	
T/CONC. OF SPILLWAY (NORTH)			10.301	853.643	290.45'
T/DAM @ SPILLWAY (SOUTH)			9.464	854.48	
T/CONC. @ SPILLWAY (SOUTH)			10.327	853.617	273.56'
LINE IN @ SOUTH B.M.			3.942		

NOTE: BENCH LOOPS ARE BASED UPON ASSUMED ELEV.

(3)



(4)

4314096

KB-CW-DL 65°-OVERCAST/RAIN

9/12/06 LOWER LOOP #1

(BEGIN ON WEST BANK ROAD)

MEASURE NORTH

DESC	+	X	−	ELEV.	NOTE
B.M. CHISELED	0 ~~4.160~~ 4.610'	~~864.268~~ 864.39		859.78	NORTH
T.P. #1	4.728	864.348	4.770	859.62	
T.P. #2	5.049	864.824	4.573	859.775	
T.P. #3	4.973	865.227	~~4.569~~ 4.570	860.254	
T.P. #4	4.266	864.499	4.994	860.253	
T.P. #5	4.853	864.464	4.888	859.611	
T.P. #4	4.800	865.035	4.229	860.235	
T.P. #3	4.555	864.811	4.779	860.256	
T.P. #2	4.480	~~865.297~~ 864.257	5.034	859.777	
T.P. #1	5.373	864.996	4.634	859.623	
CHK. IN @ B.M.			5.213	859.783	

.003 HIGH

60°-OVERCAST KB-CW-DL

9/13/06 LOOP #2

(5)

DESC	+	X	−	ELEV.	NOTE
T.P. #5	3.577	863.188		859.611	
T.P. #6	5.508	861.325	7.371	855.817	
T.P. #7	5.499	861.713	5.111	856.214	
T.P. #8	6.186	863.415	4.484	857.229	
T.P. #9	5.169	861.424	7.100	856.315	
T.P. #10	7.355	864.537	4.242	857.182	
T.P. #11	7.005	864.414	7.125	857.409	
T.P. #12	1.702	864.237	1.879	862.535	
T.P. #11	8.199	865.606	6.630	857.407	
T.P. #10	4.420	861.604	8.422	857.184	
T.P. #9	7.888	864.204	5.288	856.316	
T.P. #8	~~4.660~~ 4.390	861.620	6.974	857.230	
T.P. #7	5.005	861.217	5.408	856.212	
T.P. #6	7.560	863.369	5.408	855.809	
T.P. #5			3.764	859.605	

(.004 LOW)

(6) 9/13/06 KB-CW-DW-RP

LOOP #3

DESC	+	π	−	ELEV.	NOTES
T.P.# 12	2.456	864.991		862.535	
TP# 13	5.804	864.398	6.397	859.594	
TP# 14	8.640	869.819	3.219	861.179	
T.P.# 15	4.970	872.269	2.520	867.299	
T.P.# 16	1.390	864.375	9.284	862.985	
T.P.# 17	6.604	~~863.948~~ 878.301	7.031	~~874.406~~	857.344
T.P.# 18	6.286	~~864.429~~ 880.428	3.806	~~874.807~~	866.142
T.P.# 19	2.543	~~864.321~~ 866.321	2.793	~~872.687~~	863.635
T.P.# 20	9.849	~~872.931~~ 876.845	3.096	~~877.144~~	863.082
T.P.# 21	4.472	~~871.618~~ 875.60	5.785	~~881.288~~	867.146
T.P.# 22	6.407	~~874.538~~ 875.60	6.487	~~879.193~~	865.131
T.P.# 21	5.551	~~874.592~~ 875.592	~~[illegible]~~	881.209	867.147
T.P.# 20	2.998	~~864.979~~ 866.979	4.391	~~872.443~~	868.081
T.P.# 19	2.530	~~864.166~~ 866.166	9.617	~~872.698~~	863.636
T.P.# 18	3.584	~~863.333~~ 866.333	2.443	~~874.884~~	860.142
T.P.# 17	7.419	~~864.429~~ 866.429	6.024	~~874.406~~	857.340
T.P.# 16	9.267	872.249	6.383	~~877.466~~	862.982
T.P.# 15	2.451	869.745	1.777	~~877.044~~	
T.P.# 14	3.100	864.275	4.955	867.294	
T.P.# 13	6.318	864.905	8.570	861.175	
T.P.# 12			5.688	858.587	
			2.376	868.529	

.006 CW

KB-CW-DW-RP (7)

9/13/06

LOOP #4

DESC	+	π	−	ELEV.	NOTES
T.P.# 22	4.339	869.468		865.131	
T.P.# 23	4.199	867.52	6.147	868.321	
T.P.# 24	9.867	873.454	3.983	863.587	
T.P.# 25	5.714	876.695	2.473	870.981	
TP# 26	5.259	875.766	6.188	870.507	
TP# 27	7.608	881.468	~~5.259~~ 7.906	873.860	
T.P.# 28	5.668	881.115	6.021	875.447	
T.P.# 29	5.883	881.923	5.075	876.040	
T.P.# 30	5.708	882.306	5.325	876.598	
TP# 31	3.921	881.002	5.225	877.081	
T.P.# 32	2.640	880.811	2.831	878.171	
T.P.# 31	5.072	882.154	3.729	877.082	
T.P.# 30	5.150	881.756	5.554	876.600	
T.P.# 29	4.943	880.986	5.707	876.043	
T.P.# 28	5.772	881.221	5.537	875.449	
TP# 27	1.647	875.511	7.357	873.864	
T.P.# 26	6.025	876.539	4.997	874.514	
T.P.# 25	2.425	873.410	5.554	870.985	
T.P.# 24	3.748	867.391	9.817	863.595	
T.P.# 23	5.867	869.199	4.009	863.332	
T.P.# 22			4.055	865.144	

.013 KGH

(8) 9/14/06 75° P. SUNNY
KB-GW-DL
LOOP #5

DESC	+	π	−	ELEV.	NOTES
T.P.#32	7.590	885.761		878.171	
T.P.# 33	4.548	883.392	6.917	878.844	
T.P.#34	7.745	886.909	4.228	879.164	
T.P.#35	3.990	883.281	7.618	879.291	
T.P.#36	4.715	880.663	7.333	875.948	
T.P.#37	5.719	879.989	6.393	874.270	
T.P.#38	6.229	880.870	5.348	874.641	
T.P.#39	8.421	885.764	4.027	876.843	
T.P.#40	2.792	881.458	6.598	878.666	
T.P.#41	0.700	870.153	12.005	869.453	
T.P.#42	4.237	864.892	9.498	860.655	
T.P.#43	9.601	869.304	5.189	859.703	
T.P.#44	0.445	869.429	0.320	868.984	
T.P.#43	5.171	864.880	9.720	859.709	
T.P.#42	9.386	870.047	4.219	860.661	
T.P.#41	12.004	881.464	0.587	869.460	
T.P.#40	6.571	885.245	2.790	878.674	
T.P.#39	4.048	880.900	8.393	876.852	
T.P.#38	5.430	880.081	6.249	874.651	
T.P.#37	6.482	880.765	5.798	874.283	
T.P.#36	7.298	883.258	4.805	875.960	
T.P.#35	3.771	882.076	3.953	879.305	
T.P.#34	4.328	883.506	7.898	879.178	

(9)

DESC	+	π	−	ELEV.	NOTES
T.P.#33	7.009	885.887	4.648	878.858	
T.P.#32			7.682	878.185	

0.014 HIGH

(10)

KB-CW-DL DUBREUIL 75°

9/14/06

LOOP #6

DESC.	+	π	−	ELEV.	NOTE
T.P.# 44	9.328	878.312		868.984	
T.P.# 45	7.429	882.023	3.718	874.594	
T.P.# 46	7.856	885.961	3.918	878.105	
T.P.# 47	2.971	884.371	4.561	881.400	THEN SHORT
T.P.# 48	0.518	875.520	9.369	875.002	THEN SHORT
T.P.# 49	6.427	866.593	9.354	866.166	SHORT
TP # 50	6.214	866.314	7.493	859.100	
T.P.# 51	~~7.698~~ 7.968	869.995	3.327	861.987	
T.P.# 52	9.695	876.775	2.875	867.080	
T.P.# 53	7.582	883.090	1.267	875.508	
T.P.# 54	1.217	878.888	5.419	877.671	
T.P.# 55	2.295	871.695	9.488	869.400	
T.P.# 56	4.806	868.650	7.851	863.844	
T.P.# 57	~~8.789~~ 8.908	872.246	5.312	863.338	
T.P.# 58	2.792	872.190	~~2.965~~ 2.848	869.398	
T.P.# 57	5.192	868.532	8.850	863.340	
T.P.# 56	7.585	871.427	4.690	863.842	
T.P.# 55	9.142	878.638	2.031	869.396	
T.P.# 54	5.284	882.950	0.972	877.666	
T.P.# 53	1.277	876.779	7.448	875.502	
T.P.# 52	2.712	869.791	9.700	867.079	
T.P.# 51	3.175	865.159	7.807	861.984	
T.P.# 50	7.387	866.488	6.058	859.101	

(11)

DESC	+	π	−	ELEV.	NOTES
T.P.# 49	9.226	875.396	0.318	866.170	
T.P.# 48	9.153	884.162	0.387	875.009	
T.P.# 47	4.514	885.922	2.754	881.408	
T.P.# 46	3.921	882.029	7.814	878.108	
T.P.# 45	3.954	878.555	7.430	874.599	
T.P.# 44			9.560	868.993	

0.009 HIGH

(12)

KB-MS-DL
9/16/06 70° - FOGGY
LOOP # 7

DESC	+	π	-	ELEV	NOTE
TP#58	5.553	874.951		869.398	
TP#59	5.403	874.421	5.933	869.018	
TP#60	5.971	876.997	3.395	871.026	
TP#61	4.459	872.194	9.262	867.735	
T.P.#62	8.830	877.521	3.503	868.691	
T.P.#63	9.458	885.797	1.182	876.339	
T.P.#64	5.095	887.298	3.594	882.203	
T.P.#65	2.707	882.708	7.297	880.001	AUGLAIZE MORROW CO LINE
T.P.#66	3.023	877.427	8.304	874.404	
T.P.#67	7.743	880.306	4.864	872.563	
T.P.#68	5.562	882.431	3.437	876.869	
T.P.#69	7.692	882.384	7.739	874.692	
T.P.#68	3.382	880.25	5.516	876.868	
T.P.#67	4.715	877.279	7.686	872.564	
T.P.#66	8.251	882.655	2.875	874.404	
T.P.#65	7.180	887.182	2.653	880.002	
T.P.#64	3.639	885.845	4.976	882.206	
T.P.#63	1.194	877.537	9.502	876.343	
T.P.#62	3.501	872.197	8.841	868.696	
T.P.#61	9.316	877.056	4.456	867.741	
T.P.#60	3.316	874.349	6.024	871.033	
T.P.#59	5.904	874.929	5.324	869.025	
T.P.#58			5.525	869.404	

(.006 HIGH)

9/16/06 75° OVERCAST
LOOP #8

(13)

DESC.	+	π	-	ELEV.	NOTES
T.P.#69	6.867	881.559		874.692	
T.P.#70	5.336	883.394	3.501	878.058	
T.P.#71	3.832 ~~3.382~~	884.125	3.101	880.293	
T.P.#72	4.037	878.504	9.658	874.467	
T.P.#73	1.337	873.174	6.667	871.837	ENTRANCE DRIVE TO STATE PARK
T.P.#74	4.826	868.283	9.717	863.457	
T.P.#75	9.565	872.978	4.870	863.413	
T.P.#76	5.233	875.296	2.915	870.063	
TP#77	7.348	879.314	3.330	871.966	
T.P.#78	6.846	878.055	8.105	871.209	
T.P.#79	1.443	878.004	1.494	876.561	
T.P.#78	8.115	879.326	6.793	871.211	
T.P.#77	3.250	875.221	7.355	871.971	
T.P.#76	2.732	872.804	5.149	870.072	
T.P.#75	4.797	868.214	9.387	863.417	
T.P.#74	9.686	873.146	4.754	863.46	
TP#73	6.745	875.583	1.308	871.838	
T.P.#72	9.594	884.061	4.116	874.467	
TP#71	3.071	883.361	3.771	880.290	
TP#70	3.580	881.633	5.308	878.053	
TP#69			6.949	874.684	

(.008 LOW)

(14)

9/16/06 75° SUNNY

KB-MS-DL

LOOP #9

DESC	+	π	−	ELEV	NOTES
T.P. 79	7.986	884.547		876.561	
T.P. 80	4.604	886.82	2.331	882.216	ON R.R.
T.P.# 81	4.024	884.21	6.634	880.186	
T.P.# 82	3.516	879.775	7.951	876.259	
T.P.# 83	3.568	875.45	7.893	871.882	
T.P.# 84	3.540	~~870.764~~	8.226	~~867.224~~	RR
T.P.# 85	5.458	~~864.118~~	7.104	~~863.408~~	
T.P.# 86	4.683	868.091	5.710	865.408	
T.P.# 87	4.781	866.554	6.318	861.773	
T.P.# 88	4.305	864.669	6.190	860.364	
T.P.# 89	5.207	864.609	5.267	859.402	
T.P.# 88	6.294	866.650	4.253	860.356	
T.P.# 87	6.062	867.831	4.881	861.769	
T.P.# 86	5.625	869.034	4.422	863.409	
T.P.# 85	7.007	870.670	5.371	863.663	
T.P.# 84	8.225	875.460	3.435	867.235	
T.P.# 83	7.821	879.717	3.564	871.896	
T.P.# 82	7.944	884.222	3.439	876.278	
T.P.# 81	6.539	~~884.797~~	4.014	~~880.783~~	
T.P.# 80	2.329	~~884.766~~	4.510	~~882.257~~	
T.P.# 79			7.988	~~876.500~~ 876.578	

0.017 HIGH

(15)

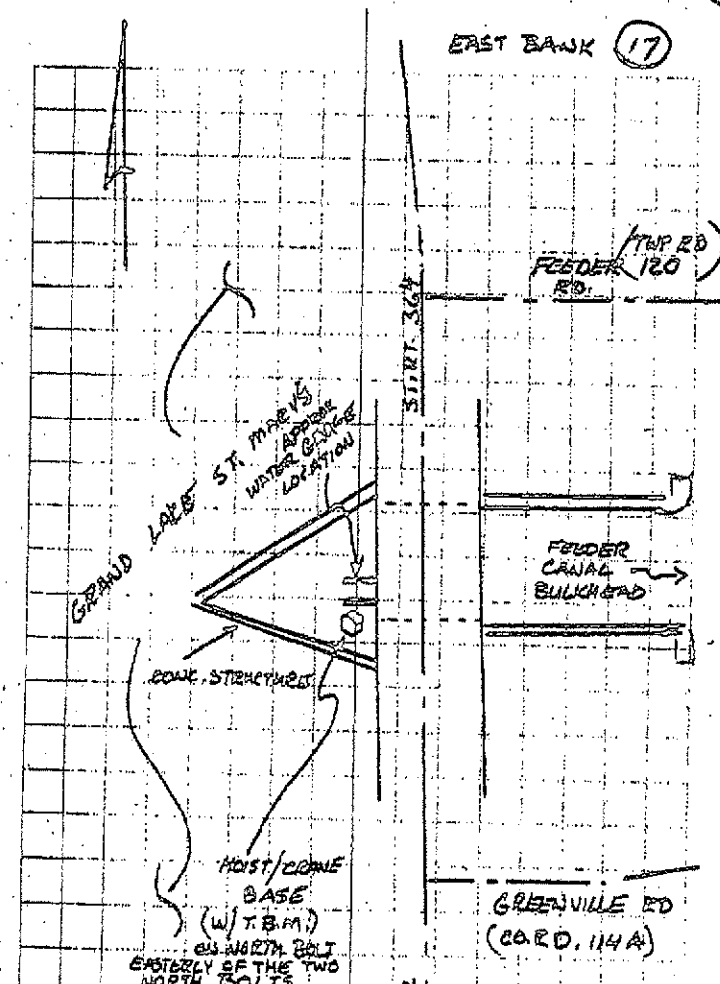
(16) 9-17-06 65% SHANT

KB-CW-DL

LOOP #10

DESC	+	x	−	ELEV	NOTES
T.P. #89	4.839	864.241		859.402	
T.P. #90	5.083	864.284	5.040	859.201	
T.P. #91	5.400	864.618	5.066	859.218	
T.P. #92	5.586	865.163	5.041	859.577	
T.P. #93	5.649	865.370	5.442	859.721	
T.P. #94	5.580	865.948	5.002	860.368	
T.P. #95	4.864	866.102	4.710	861.238	
T.P. #96	5.471	866.749	4.824	861.278	
T.P. #97	4.761	866.706	4.804	861.945	
T.B.M. #1	5.162	866.771	5.097	861.609	
BOLT ON CRANE HOIST @ GAGE #2 @ EAST BANK (CHISELED "X" ON BOLT)					
T.P. #97	4.827	866.77	4.828	861.943	
T.P. #96	5.108	866.383	5.495	861.279	
T.P. #95	4.789	866.023	5.149	861.234	
T.P. #94	4.874	865.237	5.660	860.363	
T.P. #93	5.429	865.147	5.519	859.718	
T.P. #92	5.074	864.647	5.574	859.573	
T.P. #91	4.944	864.156	5.435	859.212	
T.P. #90	4.837	864.032	4.961	859.195	
T.P. #89			4.635	859.397	

(0.005 LOW)



DESC	+	x	−	ELEV	NOTES
TBM #1	5.110	866.719		861.609	
TOP/3' WATER MARK	10.306	866.611	10.414	856.305	
T.B.M. #2			4.998	861.618	

(0.008 HIGH)

(18) KB-CW-DL 9/17/06 70° SUNNY

LOOP #11

FROM STATE PARK ENT. TO WATER GAUGE

DESC	+	π	−	ELEV.	NOTE
T.P.#73	4.093	875.93		871.837	
T.P.#98	0.302	~~875.507~~ 869.509		6.723	869.207
T.P.#99	3.193	866.314		6.387	863.122
T.P.#100	5.657	862.965		9.006	857.308
T.B.M.#2	4.395	863.138		4.222	858.743
MAG NAIL SET IN WEST SIDE OF LIGHT POLE IN CENTER OF STATE PARK MAINTENANCE FACILITY PARKING LOT (APPROX 1.0' ABOVE PAVEMENT ELEV.)					
T.P.#101	5.373	862.037		6.474	856.664
TOP/2' WATER* GAUGE	5.941	861.895		6.083	855.954
T.P.#101	6.26	862.925		5.231	856.664
T.P.#100	8.580	866.094		5.417	857.508
T.P.#99	7.340	870.152		2.772	863.322
T.P.#98	6.523	875.93		1.255	869.407
T.P.#73				3.897	872.033

* NOTE: 2' WATER GAUGE HANGS ON A CHAIN, INSIDE STATE PARK MAINT. FACILITY BOAT HOUSE

(19) LOOP #11-B 80° SUNNY

DESC	+	π	−	ELEV.	NOTE
T.P.#73	3.987	875.824		871.837	
T.P.#98	1.272	870.483	6.613	869.211	
T.P.#99	2.669	865.796	7.356	863.127	
T.P.#100	5.124	862.437	8.483	857.313	
T.P.#101	5.896	862.367	5.966	856.471 ←	
T.B.M.#2			3.819	858.548	
T.P.#100	8.545	865.86	5.052	857.315	
T.P.#99	7.411	870.54	2.731	863.129	
T.P.#98	6.432	875.647	1.325	869.215	
T.P.#73			3.803	871.844	
		(+.007)			
T.P.#100	5.373	861.844		856.471	
T/WATER GAUGE	5.941	861.702	6.083	855.761	
T.P.#101			5.231	856.471	

(20) KB-CW-DL 9-18-06

65° - OVERCAST/RAIN

LOOP #12

TIE-IN MAIN LOOP TO MERCER CO. ENGINEER'S B.M.#2 (DATED 7-17-03)

(B.M.#2 FROM BEAVER CREEK PLANS - 1977 - MERCER CO. ENG. OFFICE. "O" CUT IN S.E. WING OF US 127 BRIDGE STA 7450)

DESC.	+	π	−	ELEV.	NOTE
B.M.#2	5.510	866.23		860.72	
T.P.#102	11.409	874.728	2.911	863.319	
T.P.#103	7.575	881.76	0.543	874.185	
CHISELED "□" IN CURB ON WEST BANK RD IN T/CURB, 382'± SOUTH OF SOUTH END BRIDGE @ DAM					
	4.689	881.692	4.757	877.003	
T.P.#103	0.571	874.756	7.507	874.185	
T.P.#102	~~3.079~~ 3.081	866.400	11.437	863.319	
B.M.#2			5.676	860.724	

(.004 HIGH)

NOTE: MERCER CO. ENG OFFICE REF ELEV. = 877.81

PROJECT Determine Elevation of DATE 8-18-03
TASK 2 new bench marks as described based on
BM #2 from Beaver Creek plans - 1977

Desc./Loca.	BS	HI	FS	Elev.
BM #2 from Beaver Creek plans - 1977				
"O" cut in SE wing of US 127 bridge over Beaver Creek - Sta. 7+50	3.88	864.60		860.72
TP	6.72	864.65	6.67	857.93
TP	14.18	877.94	0.89	863.76
TP (Bolt)	3.49	881.00	0.43	877.51
BM # 810 - "□" Square chiseled in top of concrete seawall at catch basin located ±382' south of south end of West Bank Rd bridge over Beaver Creek at spillway			3.99	877.01
TP (Bolt)	5.24	882.75		877.51
BM # 811 - "□ Square saw cut in top of Concrete Seawall at catch basin located ±116' North of north end of West Bank Rd. bridge over Beaver Creek at spillway			5.94	876.81
BM # 810 - Elev. = 877.01				
BM # 811 - Elev. = 876.81				

NAD 29

APPENDIX B

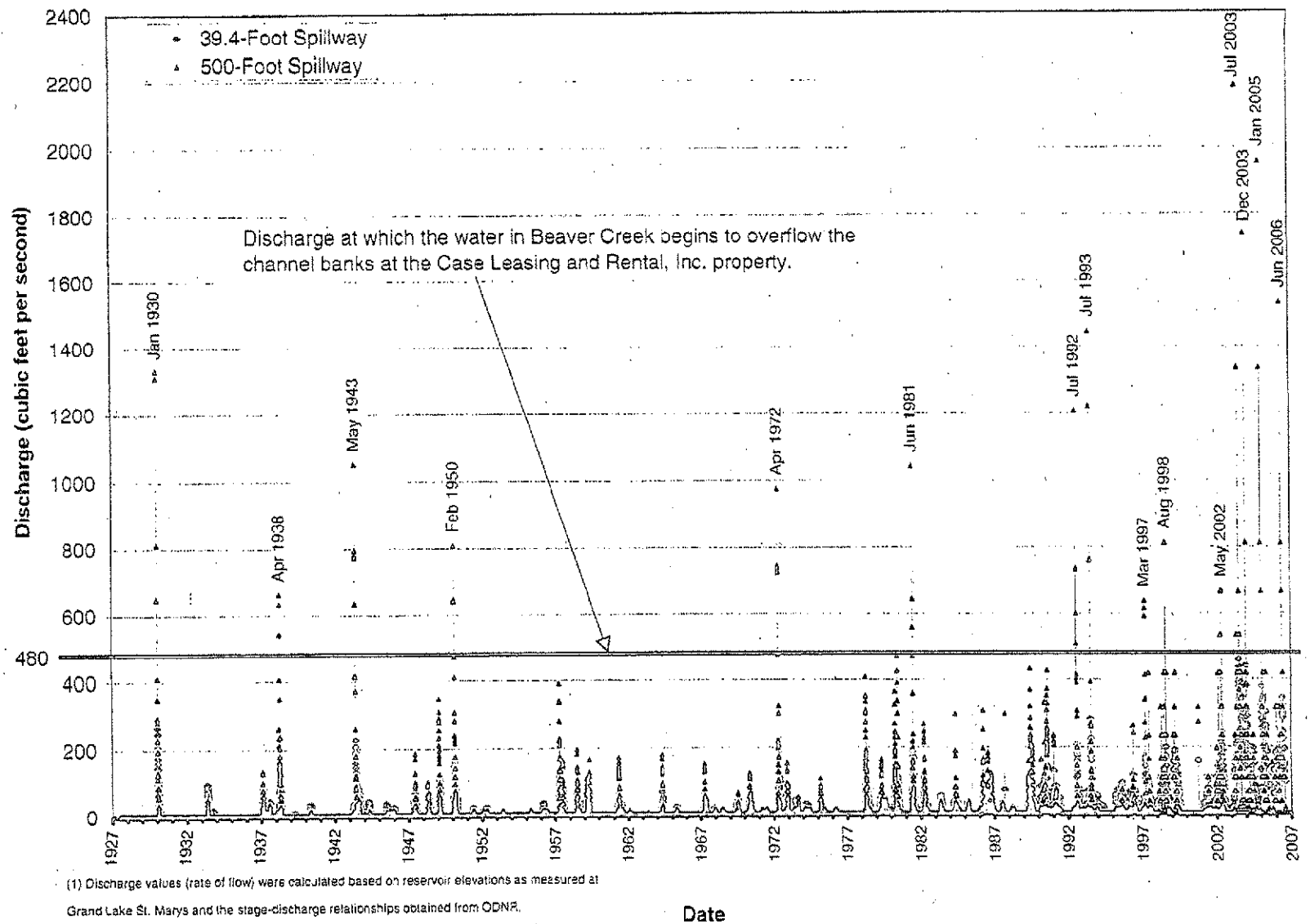
LAKE ELEVATION DATA
(Referenced in the text on page 3)

APPENDIX C

REVISED FIGURE 3 FROM THE CRA MAY 2006 REPORT

(Referenced in the text on page 3)

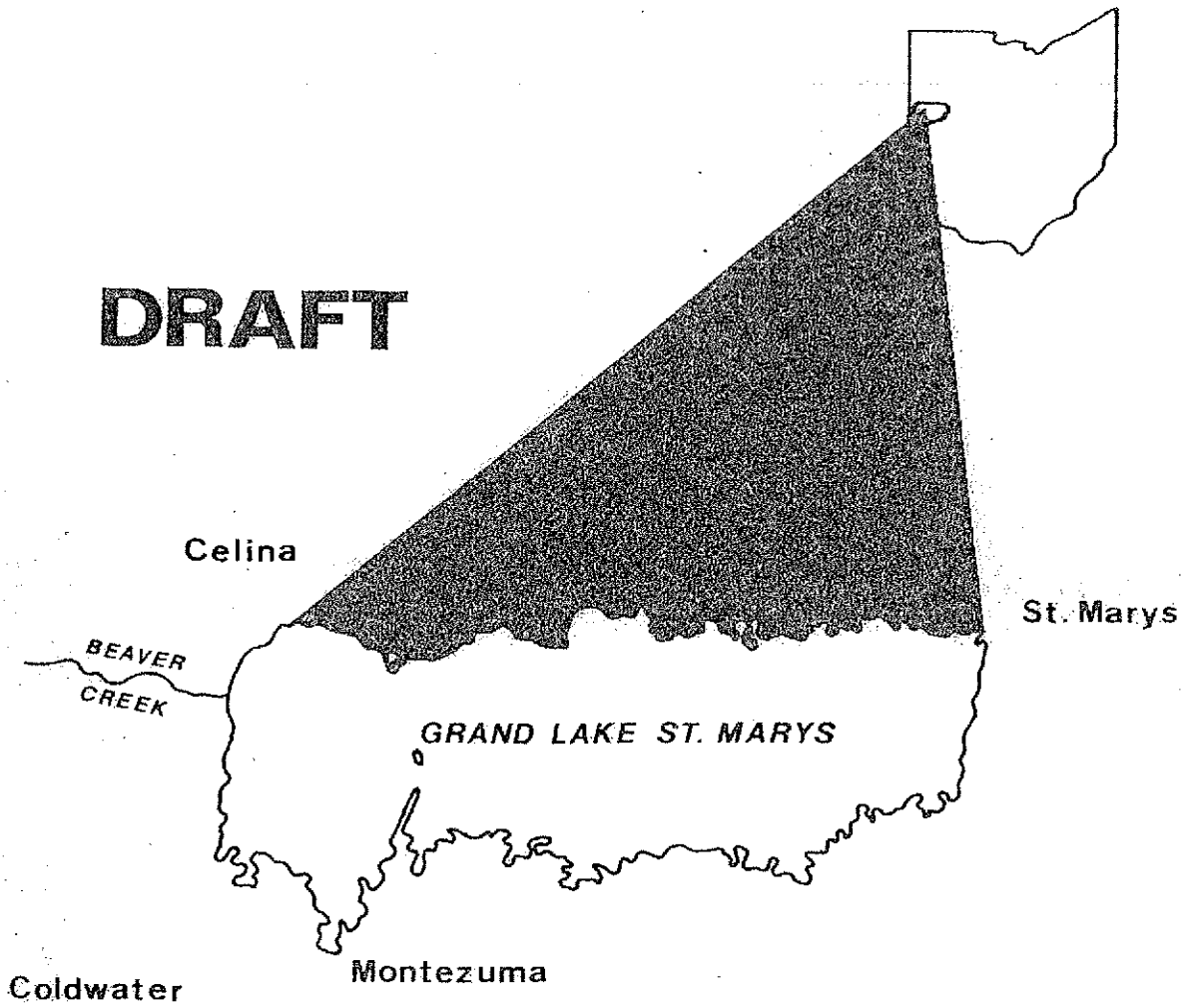
Revised Figure 3
Grand Lake St. Marys
Calculated Discharges into Beaver Creek[1]



(1) Discharge values (rate of flow) were calculated based on reservoir elevations as measured at Grand Lake St. Marys and the stage-discharge relationships obtained from ODNR.

GRAND LAKE ST. MARYS OHIO

DRAFT



Survey Report for Flood Control and Allied Purposes

Volume 1 of 2 Main Report

PENGAD-Bayonne, N. J.
Respondent
3

CORPS OF ENGINEERS
U.S. ARMY ENGINEER DISTRICT, LOUISVILLE, KY

MAY 198

Grand Lake St. Marys, Ohio

MAIN REPORT

Volume 1 of 2

Survey Report
for
Flood Control
and
Allied Purposes

Louisville District Corps of Engineers
Department of the Army

May 1981

SYLLABUS

The purpose of this study was to investigate flood and related water resource problems in the vicinity of Grand Lake St. Marys in Ohio to determine the need for and feasibility of improvements to solve these problems.

The principal areas of concern included flood damage, water quality, and recreation problems. Priority flood problem areas are on the south shore of Grand Lake St. Marys and along Beaver Creek, the western outlet channel of the lake. The Grand Lake St. Marys shore flood problem is caused by the inability of the 10.6-mile long westerly outlet channel to discharge sufficient flood flows to keep pace with inflow to the lake during peak periods plus the effect of wind setup and wave runup on low-lying developed areas when lake levels are high.

Beaver Creek flood problems are caused by a combination of a limited flood control capability of Grand Lake St. Marys, poor surface drainage, low stream gradient, constrictions to flow, and high stream stages for a long period of time which cause inadequate outlet conditions for numerous artificial agricultural drains.

Lake water quality has been declining in recent years. Four separate water quality problems have been identified as causing the deterioration. Bacterial contamination from human sources threatens body contact recreation, particularly in areas of greatest development. The rich nutrient content of the lake results in excessive algal growth which causes taste and odor problems. Water clarity is reduced by algae and suspended sediment, resulting in unattractive conditions for recreators. Accumulation of sediment, eroded from upland areas, and unprotected shoreline have reduced the lake depth.

A range of structural and nonstructural flood damage reduction measures were examined. Nonstructural measures investigated for Beaver Creek are not viable solutions because of the agricultural character of the flood plain. Structural measures considered for Beaver Creek including detention basins, diversion, clearing and cleaning, channel improvements, and agricultural levees were determined to be economically infeasible.

Nonstructural flood plain management measures generally will not improve the flood problems for existing structures on the south shore, but regulations adopted by local governments either voluntarily or as required by participation in the Flood Insurance program could be used to reduce damages to future development. Structural measures such as groins and shoreline levees (dikes) are not perceived to be economically feasible. Fixed breakwaters can be effective in reducing shoreline flooding and erosion, but economic benefits are derived primarily from the potential for increased visitation and not from flood damages reduced.

After having examined various alternatives for modifying the operation of Grand Lake St. Marys, it is concluded that the current operating procedures for lake regulation provide an appropriate balance in minimizing flood damage for Beaver Creek and lake shore and in maintaining a desirable recreation pool.

Lake water quality problems related to nutrient and algae control appear better resolved through reduction of nutrient loads to the lake and in particular control of agricultural and livestock waste sources rather than by in-lake treatment approaches.

Emphasis should be placed on the control of erosion and critical soil loss areas in the watershed and unprotected shoreline areas. An extensive lake-wide dredging program, besides being cost prohibitive, would result in no significant improvement in water quality or flood control storage. In-lake dredging of selected near-shore zones as is currently being performed should be continued for improving lake access and boater safety, public land development, and to keep pace with the current rate of sediment accumulation and redistribution.

No recommendations are made for Corps of Engineers construction projects nor is there a specific plan selection for short-term implementation by other agencies. It is recommended that the report be made available to Federal, State, and local government agencies and regional clearinghouses which have an interest in the control and development of water and related land resources in the area affected by the study.

GRAND LAKE ST. MARYS

SURVEY REPORT FOR FLOOD CONTROL AND ALLIED PURPOSES

AUGLAIZE AND MERCER COUNTIES, OHIO

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May 1981

GRAND LAKE ST. MARYS

SURVEY REPORT FOR FLOOD CONTROL AND ALLIED PURPOSES

AUGLAIZE AND MERCER COUNTIES, OHIO

THE STUDY AND REPORT

PURPOSE AND AUTHORITY

The purpose of this study was to investigate flood and related water resources problems and needs of the Grand Lake St. Marys area and describe the various alternatives considered to help solve the problems.

This report has been prepared in response to Section 217 of the Flood Control Act of 1970 (Title II, Public Law 91–611), dated 31 December 1970, concerning flood control and allied purposes, including channel and major drainage improvements, and floods aggravated by or due to wind or tidal effects.

The State of Ohio, Department of Administrative Services, Division of Public Works, studied possible diversion of greater flows through the eastern embankment outlet and canal system and also repair measures for the Grand Lake lock, St. Marys Feeder Canal, the Kopp Creek culvert, and the aqueduct over the St. Marys River. The project, as yet, has not been funded for construction.

The Ohio Water Development Authority had a report prepared in June 1977 entitled, "Grand Lake Regional Sewer System Facilities Plan," which was a planning study for the conveyance and treatment of sanitary wastes generated within the Grand Lake Regional Sewer System planning area.

The U. S. Environmental Protection Agency developed information on nutrient sources, concentrations and impact on the lake as part of a report entitled, "Report on Grand Lake St. Marys, National Eutrophication Survey."

RESOURCES AND ECONOMY OF THE STUDY AREA

ENVIRONMENTAL SETTING AND NATURAL RESOURCES

The Grand Lake St. Marys study area is situated in Mercer and Auglaize Counties in west-central Ohio on the low watershed divide between the Wabash and St. Marys Rivers (Maumee River Basin) as shown on the General Map, Plate 1.

Grand Lake is formed by a dam at its west end on Beaver Creek and a dam at its east end on Chickasaw Creek which drains to the St. Marys River via the St. Marys Feeder Canal. The impoundment covers the low watershed divide forming a lake with a surface area of some 21 square miles at approximately 870.5 mean sea level (msl). The lake is approximately eight miles in length east to west and averages over two miles in width north and south with a shore line of approximately 55 miles. Average depth of the lake is 6.8 feet. The total drainage area to the lake is some 112.1 square miles, of which over 18 percent is lake surface. Its principal tributaries are Coldwater, Upper Beaver, Prairie, Chickasaw, Little Chickasaw and Barnes Creeks, all entering from the south. The State of Ohio owns the lake, together with a few small parcels of lakefront property. Lake operation is by the Ohio Department of Natural Resources and the Ohio Department of Public Works.

The Ohio Division of Wildlife operates the St. Marys Fish Hatchery and the Mercer County Waterfowl Refuge at the lake. Several areas along the lake are operated as part of the Grand Lake St. Marys State Park. The lake is surrounded by a combination of agricultural, recreational, permanent and seasonal residential, and urban land uses. Beaver Creek, the western outlet channel, descends gradually through agricultural lands of Mercer County before merging with the Wabash River. Principal urban areas include Celina and St. Marys, with 1980 populations of 9,127 and 8,368, respectively. The study area is approximately 100 air miles due north of Cincinnati, Ohio, and 95 air miles northwest of Columbus, Ohio.

The project study area is in the Tills Plain Section. The topography is gently rolling with elevations ranging from highs of 910 feet NGVD to approximately 850. The terrain falls generally toward the lake which has a normal water surface elevation of 870.5 feet NGVD.

The agricultural land adjacent to Beaver Creek is predominantly Defiance–Wabasha silty clay loam which is a very poorly drained soil occupying low lying, level and depressional positions on flood plains. Drainage is difficult to establish due to a lack of suitable outlets on the nearly level topography. Soils in the lake watershed are dominantly in the Blount–Pewamo and Blount–Glynwood soil associations. These soils are nearly level to sloping, somewhat poorly to very poorly drained silty clay loam or clay loam glacial till which have poor bearing values, are subject to occasional flooding and are generally unsuitable for septic tank systems. Agricultural productivity is moderate to moderately high, and although naturally poorly drained, provide good farming when properly drained with tile.

The climate of the area is continental with warm summers and is characterized by abundant precipitation, fairly long growing seasons, and wide ranging annual and daily temperature. During January, the coldest month, the average daily temperature is 27° F., and in July, the warmest month, the average daily temperature is 73° F. Average annual precipitation is 37.5 inches, with rainfall distributed fairly evenly throughout the year. Showers and thunderstorms furnish much of the precipitation during the growing season. Heaviest rains occur in June. Frost-free days average 160 days. The normal rainfall is such that lake water level is relatively stable except during drought and heavy rainfall periods.

Grand Lake St. Marys is far from being a clear lake because of algal growth, turbidity and sediment entry. The proportion of pollutants in the lake has been aggravated by increased agricultural development and population growth. Despite the algal condition of the lake, it is a good warmwater fishery and is used exclusively for recreation and as a municipal/industrial water supply.

Much of the land in the Grand Lake St. Marys watershed is agricultural. Mercer and Auglaize Counties are among the most important agricultural counties in Ohio with cash grain farming dominated by corn and soybeans as the major farm enterprise.

Livestock operations (beef, dairy, swine and poultry) are also major farm enterprises. particularly in the lake watershed.

Less than 10 percent of the land in the Grand Lake St. Marys watershed area remains wooded. Forest areas are comprised of small, isolated woodlots surrounded by corn—soybean dominated farming. Travel corridors for wildlife are, to a large extent, limited to stream corridors. Some mammal species remain common, such as muskrat, raccoon, oppossum, fox and gray squirrel, cottontail rabbit and whitetail deer, although destruction of lakeshore wetlands, the removal of fencerows and large woodlots, and residential development has had adverse impacts upon a number of mammalian species. The area has been one of the best locations in Ohio for observing a diverse group of birds. Because of the lake's large surface area and the excellent wetland habitat surrounding the lake, it has become an important concentration area for waterfowl. The area lies within the Mississippi Flyway, a major north—south migratory route for many passerine species. As such, thousands of migratory ducks and geese use the lake as a resting area during spring and fall migrations.

Endangered or threatened species such as the Eskimo curlew, bald eagle, and the American peregrine falcon migrate through Ohio, but sitings in the area are very rare. The range of one endangered mammal, the Indiana bat, is known to include the study area.

There are no documented archeological sites, either prehistoric or historic, in the Grand Lake general study area and no surveys have been undertaken on lands included in the Grand Lake study area; however, undocumented reports have indicated possible sites in or near Celina and St. Marys. There is a high potential for the existence of undocumented prehistoric and historic archeologic sites, especially in the vicinity of the Beaver Creek—Wabash River confluence; lands on a ridge extending towards Erastus along Beaver Creek; lands adjacent to Montezuma Bay; and lands bordering Chickasaw Creek and other creeks tributary to the lake. A total of 248 historically or architecturally significant sites have been documented in the Grand Lake study area. Of these, three are listed in the National Register of Historic Places, one has been nominated to the National Register, and another is in the process of being nominated.

Grand Lake St. Marys came into being as a reservoir to supply water for the Miami–Erie Canal. Construction started in 1837 and was completed in 1845 at a cost of approximately $528,000 (Clark, 1960). The then 17,500-acre reservoir was for many years the largest man-made body of water in the world. With a current estimated surface area of 13,920 acres, it is the largest inland water body in the State of Ohio. The lake has a long and interesting history and played an important part in the development of the Northwest Territory. The St. Marys River served as a vital link between the Great Lakes and the Ohio River via the Miami–Erie Canal. The lake once supported a vast commercial fishery. The canal era, however, was short-lived as much of the business of transporting goods was taken over by the expanding railroads. The area experienced another boom in the late 1890's when oil was discovered and for a time the lake was dotted with oil derricks. Today a pile of rocks near the center of the lake marks the spot of the last producing well. The lake has gained growing popularity among recreationists and sportsmen since 1915 when the General Assembly of the State of Ohio passed an act through which this body of water and adjacent lands owned by the State were dedicated and set apart forever for the use of the public, as public parks or pleasure resorts.

Today the lake exists primarily for recreation purposes and is a favorite spot for thousands of vacationists from Ohio and neighboring states. It is also the principal water supply for Celina, Ohio, and St. Marys, Ohio, uses lake water for cooling purposes at their power plant. Primary recreational activities at the lake include boating, fishing, picnicking, swimming, winter sports, and camping. Several areas along the lake are operated as part of the Grand Lake St. Marys State Park. Grand Lake St. Marys Park is located along the northeast shore of the lake and provides recreational activities such as camping, fishing, hiking, picnicking, swimming, and boating. Approximately 500,000 persons visit the park annually. In addition, the Ohio Division of Wildlife operates the St. Marys Fish Hatchery located at the extreme eastern edge of the lake. The Division also operates the 1,400-acre Mercer County Waterfowl Refuge at the southwest section of the lake which provides a haven for migrating as well as nesting Canada geese. Thousands of birds stop at this refuge during spring and autumn migrations.

The lake is fairly heavily used, having at least six major marinas, one State campground, a 4–H camp, and two church camps. Fishermen abound during early spring. Hunters vie for licenses and blind privileges during early winter. There are three public beaches on the lake and hundreds of private beach areas.

HUMAN RESOURCES AND ECONOMIC DEVELOPMENT

Out of 88 counties, Mercer County ranks 56th and Auglaize 51st in Ohio county populations with 1980 populations of 38,242 and 42,461, respectively. While there are no large urban developments in Mercer and Auglaize Counties, those areas that are urbanized are located on or around the Grand Lake St. Marys rim, where most of the population lives. Celina, in Mercer County, and St. Marys, in Auglaize County, are the two most populated areas in the vicinity of Grand Lake St. Marys with 1980 census populations of 9,127 and 8,368, respectively. The Villages of Coldwater (population 4,000) and Montezuma (population 270) are also in the study area.

Between 1950 and 1960 the population of the lake area, including Celina and Franklin Township in Mercer County, and St. Marys and Jefferson Township in Auglaize County, increased by 24.4 percent. This compares to a national increase of 18 percent during the same period. However, from 1960 to 1970, the U. S. population increased by approximately 14.3 percent, while that of the lake area increased by only 8.1 percent. For the total period from 1950 to 1970, the U. S. population rose by 34.9 percent, while the lake area population grew by a comparable 34.5 percent.

From Memorial Day to Labor Day, the seasonal vacation population of Grand Lake St. Marys increases by approximately 20,000 persons, nearly matching the permanent population (23,500).

Most of Celina and St. Marys is residential, with the major portion of homes being single family. The land surrounding the lake is predominantly agricultural and open land except those areas immediately adjacent to the lake. A great portion of the lake's drainage area to the south is classified as prime farmland. The land immediately adjacent to the lake consists of many private and commercial settlements, used mostly for recreational purposes. Cottages, campgrounds, and trailer parks are found around the lake, with highest concentrations on the south side. Adjacent to the lake are several permanent, year-round residential subdivisions.

Land around the lake is presently unzoned, and current growth has been random, with no efforts made to control lot sizes or land use. Consequently, developed land abuts areas of undeveloped agricultural land. Because of its attractiveness for recreational use, the land immediately adjacent to Grand Lake St. Marys is anticipated to be used largely for residential and recreational purposes in the future.

In 1970, the labor force of the two-county study area was 29,068, or about 39 percent of the total population. Of this number, 2.6 percent was unemployed, considerably below unemployment levels statewide and nationally.

The major sectors of employment during 1970 were manufacturing (40 percent), service industries, including government and education (19.4 percent), wholesale and retail trade (19.2 percent), construction (5.3 percent), and agriculture, forestry and fisheries (8.1 percent). Mining activities accounted for less than 1 percent of the two-county workforce. Sizeable increases in the manufacturing, trade, and services sectors, with declining numbers in agricultural, forestry, and fishery occupations are typical of the state-wide employment trends in recent decades.

Agriculture and industry promote a successful economy in the study area. Mercer County is one of the leading agricultural producers in Ohio and ranks second only to Drake County in cash receipts. In 1970 the county contained about 2,000 farms, with acreage totalling over 289,000. Industrial development has also helped Mercer and Auglaize Counties to remain economically sound.

Per capita income in 1970 was $2,450 in Mercer County and $2,668 in Auglaize County. During the decade 1970 to 1980, per capita income was projected to rise to $3,580 in Mercer County and to $3,760 in Auglaize County, or 41 percent in both counties. From 1980 to 2000, per capita income levels are expected to show steady gains of some 74 percent in both Mercer and Auglaize Counties. By 2020, the expected per capita income for Mercer County is $10,116 and $10,626 for Auglaize County. These per capita income figures, unadjusted for inflation, indicate about a three-fold increase in levels between the present and the year 2020 in both counties.

The permanent population of the Grand Lake St. Marys study area and vicinity is projected to increase 34 percent from 21,700 in 1970 to 29,095 by 2000. This compares to a projected State-wide population increase of 24 percent during the same period. The population growth in the urbanized and urbanizing areas of both counties (Celina and St. Marys) are expected to be 14 percent lower (20 percent) than the overall population growth rate of the study area. Permanent population growth along the perimeter of the lake will be limited by space and basic service facilities, yet it is anticipated that the perimeter will support a great deal more than the present population. The summer seasonal resident population is projected to increase 54 percent from 17,600 in 1970 to 27,050 in 2000.

PROBLEMS AND NEEDS

The purpose of this section is to define and discuss the water and resource problems, needs and opportunities in the study area, including the status of existing plans of various Federal and non-Federal agencies and improvements desired by local interests. The study authority has indicated that the major water resource problem to be addressed is flood damages but as is true in most areas, there are general needs and desires for additional outdoor recreational opportunities and enhancement and preservation of the existing natural environment.

STATUS OF EXISTING PLANS AND IMPROVEMENTS

Beaver Creek

A Beaver Creek improvement project has been planned by Mercer County and the State of Ohio. The restoration program encompasses a 10.6-mile reach of Beaver Creek and includes clearing and cleaning the channel of flow restrictive debris and shoals together with reshaping the channel cross section and replacement of tile drain outlets. Beaver Creek was last restored in a similar improvement project in 1951 but was not followed by a regular maintenance program. The project cost estimate of approximately $500,000 was tentatively to be shared equally with $250,000 funding by the State of Ohio and matching funds by the Board of Mercer County Commissioners but the state share, to date, has not been funded.

Soil Conservation Service

The Soil Conservation Service (SCS) constructed three single purpose floodwater retarding structures to provide flood protection to 19.3 square miles of the 125-square-mile watershed of the Wabash River upstream of its junction with Beaver Creek. This PL–566 project named "Upper Wabash Watershed," included about 30 miles of major channel improvement on the Upper Wabash River main stem and tributaries upstream of the city of Fort Recovery. Flood plains not protected by this project include the Wabash River main stem downstream of Fort Recovery to the Ohio–Indiana state line and along the entire length of Beaver Creek below Grand Lake St. Marys and was the subject of additional SCS studies. The proposed structural measures include a multiple purpose flood prevention–water quality control structure, a multiple purpose flood prevention–recreation structure, two miles of multiple purpose flood prevention–drainage channel with six drainage pumps, and 13.4 miles of flood prevention channel improvements (Beaver Creek). Costs were estimated at $4,136,500 (1969 dollars) but the project has not been constructed because of lack of a local sponsor.

Grand Lake Regional Sewer System

This is a Public Law 92–500, Section 201 project for U.S. EPA construction grants to build a $14 million-plus, sewage collection and sewage treatment plant expansion and upgrading system for portions of Mercer and Auglaize Counties immediately adjacent to the lake. The original plan divided the lake area sewer system into two portions at the Mercer–Auglaize County line and conveys the Auglaize County flow to the existing St. Marys wastewater treatment facility and the Mercer County flow to the existing Celina wastewater treatment facility. The primary objective of this plan is the protection of Grand Lake St. Marys by elimination of human waste loads to the lake, especially the high coliform content.

The project has met with local opposition because of high costs. The Farmers Home Administration and U.S. EPA have tentatively withdrawn loan or construction grant approval pending additional studies and review for a modified lower-cost project or other alternative wastewater management plans.

Grand Lake/Miami and Erie Canal

The Ohio Department of Administrative Services, Division of Public Works, has had prepared a plan to provide greater flow capacity through the St. Marys feeder canal (the Grand Lake eastern outlet channel) together with significant repair of the eastern embankment lock structure, the Kopp Creek culvert, and the aqueduct over the St. Marys River. A major part of the plan calls for lowering the east spillway crest elevation to that of the west spillway crest elevation in order to "provide an east/west split of uncontrolled discharge capacity which is proportional to the drainage areas contributing runoff to the lake." To date the $951,500 improvement project has not been funded for construction.

FLOOD PROBLEMS

Flooding has been reported for years, not only around Grand Lake St. Marys, but also along Beaver Creek, the lake's natural outlet channel. Periodic flooding of primarily agricultural land along Beaver Creek is attributed to a combination of factors including a very limited flood control capability of Grand Lake St. Marys, poor surface drainage, low stream gradient (1.5 feet per mile), high stream stages which cause inadequate outlet conditions for numerous artificial agricultural drains, and constrictions to flow from vegetation on the banks, shoals, and debris throughout the entire 10.6-mile reach. Flooding problems along Beaver Creek are from both overbank inundation and subsurface saturation as a consequence of long periods of near bankful flow in the flat gradient channel. Peak discharges from the lake's western outlet are not great enough to cause instantaneous flooding, and are less than would be experienced without the lake. However, it often requires several weeks of steady outflow to pass flood runoff from the lake. This condition is sufficient to keep Beaver Creek near bankfull for long periods of time and is damaging to agricultural operations, particularly in the spring and early summer in the flood plain.

Periodic flooding occurs along the south shore of the lake where the topography and developments are generally at a low elevation. The flooding is attributed to many factors including poor natural drainage plus a high water table, and to a high lake level combined

with wind-induced wave action which causes water to runup on the shore with subsequent damage to residential buildings and contents. In most years, the lake level does not exceed one foot above west spillway crest (870.75 NGVD), but this rise is sufficient to cause flood damage on the south shore when the effects of wind setup, seiche effect and wave runup are considered. The recreation-oriented developments around the lake tend to make any lowering of the water surface undesirable.

Lake pool elevation 871.75 was identified as the water surface elevation, together with wind-induced wave action where lake shore flooding begins.

Limited data has restricted the analysis of historical flood events. However, the storms which occurred in March 1913, and were centered near Bellefontaine, Ohio, produced the flood of record for a majority of long–term gaging stations in both northeastern Indiana and southwestern Ohio. The 5–day rainfall total was 11.1 inches at Bellefontaine which is approximately 40 miles southeast of Grand Lake. Available water surface elevation records for the Grand Lake pool began in March 1927 and provide an indication of additional flood periods. The maximum pool level of recorded data occurred on 15 January 1930 at elevation 872.83. The Ohio Division of Parks and Recreation records also note an absence of gate operations during this high water period. This lack of outlet openings produced the maximum attainable pool structurally possible from available inflows. The peak lake inflow, during the period of recorded data, was estimated to be nearly 12,000 cfs. This event occurred on 18 May 1927 and was the result of a high intensity storm of short duration and low volume. This storm produced a peak pool elevation of 871.75 feet NGVD.

Table 1 presents 11 of the 12 observed annual events which exceeded elevation 871.75 for the period of record. Seven of the 12 events occurred during the recreation season.

Local residents and farmers along Beaver Creek were interviewed and reported significant flood events during January 1949, December 1957 through January 1958, March through April 1964, March 1965 and May 1972. Several lesser floods were reported during the June through November months when crop losses are greatest. No gaged data of historical floods are available for Beaver Creek.

TABLE 1

HISTORICAL LAKE POOL ELEVATIONS

Observed Data

Date	Peak Pool Elevation (feet)	Days Above Elev. 871.75	Peak Mean Daily Outflow (cfs)
Jan 1930	872.83	18	300
May 1943	872.67	24	330
Apr 1972	872.67	32	310
Apr 1938	872.42	19	550
Feb 1950	872.42	24	520
Apr 1978	872.17	37	380
Jan 1949	872.08	19	260
Apr 1957	872.08	23	550
Jun 1958	871.92	11	380
May 1933	871.92	5	490
Nov 1972	871.92	9	510

Flood Damages

The areas under consideration include Beaver Creek downstream from the lake and portions of the developed lake shore. The extent of flood damages has been identified by developing hydrologic and field data which considered such aspects as stream characteristics, lake releases, extent and character of the drainage basin and flood plain, projected future characteristics in the case of Beaver Creek and lake levels, wind and wave action and character of shoreland in the case of southshore flooding. These data were used in developing estimated present and future flood damages. Damages were developed for stream reaches and developed shoreland areas shown on Plate 2 in order to identify damage centers.

The Beaver Creek flood damage study extends from its confluence with the Wabash River upstream to the western outlet of Grand Lake St. Marys, a stream distance of about 10.6 miles. Table 2 shows the monetary damages that could be expected to result from the occurrence of three specific flood events (a flood that occurs on the average of once in 5 years, a flood that occurs on the average of once in 10 years, and a 100–year frequency flood). Table 3 provides the average annual equivalent damages that can be expected for each stream reach.

The southshore flood damage study area extends from west of Montezuma Bay (Zeb's Landing) eastward to Barnes Creek (Southmoor Shores) and includes most of the shoreland development in between. Flood damages for the lake shoreline area are attributed to a high lake level combined with wave action and wind setup.

Flood damage surveys were made for selected residences along the shoreline areas. Commercial establishments were not evaluated since most are located either at elevations out of reach of flooding or sufficiently distant from the shore, such that damages are virtually non-existent. The total value of all residences along the southshore is estimated to be $6,000,000. Present annual damages to residences in the form of structure and content damage are estimated to be $150,200 for approximately 142 private shoreline properties (Table 4).

TABLE 2

DAMAGE FOR OCCURRENCE OF SELECTED FLOOD HEIGHTS
BEAVER CREEK, MERCER COUNTY, OHIO
(1980 Conditions and Price Levels)

Reach	Upper Limit of Reach: Geographic	Upper Limit of Reach: Stream Mile	Item	Damage for Specific Flood Height ($1,000): 5-Year	10-Year	100-Year
BC–1	Gause Road Bridge	4.75	Acres	865	985	1,401
			Crop	12.7	14.4	18.3
			Noncrop	9.9	17.6	21.6
			Transportation Facilities	1.5	2.5	8.1
			Public Utilities	5.5	7.1	9.1
			Subtotal Damages	29.6	41.6	57.7
BC–2	Grand Lake Western Embankment	10.6	Acres	1,250	1,338	1,833
			Crop	18.3	18.9	21.6
			Noncrop	2.4	4.0	10.6
			Transportation Facilities	1.4	3.1	11.9
			Public Utilities	2.3	4.3	15.4
			Subtotal Damages	2.4	30.3	59.5
TOTAL ALL REACHES			Acres	2,115	2,323	3,234
			Crop	30.9	33.2	40.0
			Noncrop	12.3	21.6	32.2
			Transportation Facilities	2.9	5.6	20.0
			Public Utilities	7.8	11.4	25.1
			TOTAL	53.9	71.8	117.3

TABLE 3

AVERAGE ANNUAL DAMAGES
BEAVER CREEK
(Present 1979 Conditions)

Damage Category 2/	Reach 1/ BC–1	Reach 1/ BC–2	Damage Totals
Crop	$30,850	$32,350	$63,200
Non-Crop	9,700	3,200	12,900
Transportation Facilities	1,400	1,310	2,710
Public Utilities	3,950	2,240	6,190
Totals	$45,900	$39,100	$85,000

1/ See Plate 2.
2/ Crop – for major crops produced; corn, soybeans and hay
Noncrop – agricultural properties such as siltation of tiles, debris removal, land erosion and repair, surface ditch maintenance, farm roads and levees.
Transportation facilities – roads, fills, bridges, culverts
Public utilities – after flood maintenance of telephone, gas and electric, and other public utility services.

TABLE 4

AVERAGE ANNUAL DAMAGES
SOUTH SHORE OF
GRAND LAKE ST. MARYS

Location 1/	Estimated Number of Properties Subject to Damages	Estimated Annual Damages 2/
1	10	$ 10,680
2	31	32,500
3	39	42,610
4	14	14,940
5	6	6,900
6	18	15,750
7	12	15,000
8	7	7,480
9	5	5,340
Totals	142	$150,200

1/ See Plate 2
2/ Structure and contents damage

WATER QUALITY PROBLEMS

Based on local observations and on actual data collected on Grand Lake St. Marys, lake water quality has been declining in recent years. This can be seen through increased siltation and algae blooms. Previous studies have shown that the primary contributors to the decline in lake water quality are from phosphorus and sediment. As the water quality declines, the quality of the recreational experience the lake will support will also decline.

The Grand Lake St. Marys area has been the object of several water quality related studies in the past few years. The lake is used primarily as a recreational facility and is administered by the Ohio Department of Natural Resources. Its recreational uses include boating, fishing, and body contact water activities such as skiing and swimming. Another important use is as a water supply source for the City of Celina.

The lake is classified as an exceptional warm water habitat, a public water supply, and as bathing waters. Its tributaries are classified as warm water habitats.

Because the lake has three designated uses, no one set of State water quality criteria is exclusively applicable to it. In the case where several sets of criteria exist for the same body of water, the most stringent criteria apply.

The water quality of Grand Lake St. Marys has been examined in connection with its eutrophication problems. The lake experiences massive algal blooms several times each year, and taste, odor, and fish-tainting problems with the water have been reported frequently. In a survey conducted by the U.S. Environmental Protection Agency on Grand Lake St. Marys, algal productivity was found to be phosphorus-limited during the spring and summer and nitrogen-limited in the fall. The estimated phosphorus loading of the lake (0.49 $g/m^2/yr$) was 1.8 times greater than the commonly accepted eutrophic loading limit of 0.28 $g/m^2/yr$.

In addition to the U.S. EPA study, the Mercer–Auglaize Environmental Research Association monitored water quality in the Grand Lake St. Marys area from 1973 to 1975 at ten locations. In general, the data support the high nutrient loadings found during the U.S. EPA study, but it also indicated significant bacterial pollution of the lake. The average fecal coliform concentrations from 1972 to 1975 exceeded the state water quality criteria for bathing waters (200 coliform/100 ml) at all ten sites sampled. A Master's thesis by James P. Loughran (1973) entitled, "The Analysis of Tributary Outfalls as Possible Sources of Micro–biological Contamination of Grand Lake-St. Marys," concluded that the bacterial pollution of the lake was severe enough to warrant action discouraging its use for primary body contact recreation. Data presented in this thesis indicated that bacterial contamination of the lake was from both human and animal sources, although the relative magnitude of each of these sources was not identified.

The bacterial contamination of the lake has been attributed to the Mercer Wildlife Refuge on Montezuma Bay; however, considering the large number of persons that visit the lake annually and the extensive use of septic tanks in many unsuitable areas along the south shore, it is probable that a large part of the lake's microbiological contamination is due to human waste.

Severe taste and odor problems have been reported with the water of Grand Lake St. Marys. People living around the lake frequently complain of a musty odor in the air and the City of Celina experiences taste and odor problems with both the raw water it withdraws from the lake and with finished water distributed to its customers. Odorous compounds of biological origin known to taint water supplies were reported by A. A. Rosen, et. al in 1970 as being found in Grand Lake St. Marys. These compounds include geosmin and 2–methylisoborneol, which are produced by certain strains of actinomycetes. Although geosmin is characteristically associated with the musty odor of heavy algae blooms in reservoirs, data indicated that 2–methylisoborneol constituted 68 percent of the odor from Grand Lake. In a 1964 taste and odor study of Celina's water supply (Grand Lake) conducted by Finkbeiner, Pettis & Strout, Ltd. algae, either directly or indirectly, were identified as responsible for the majority of the taste and odor problems.

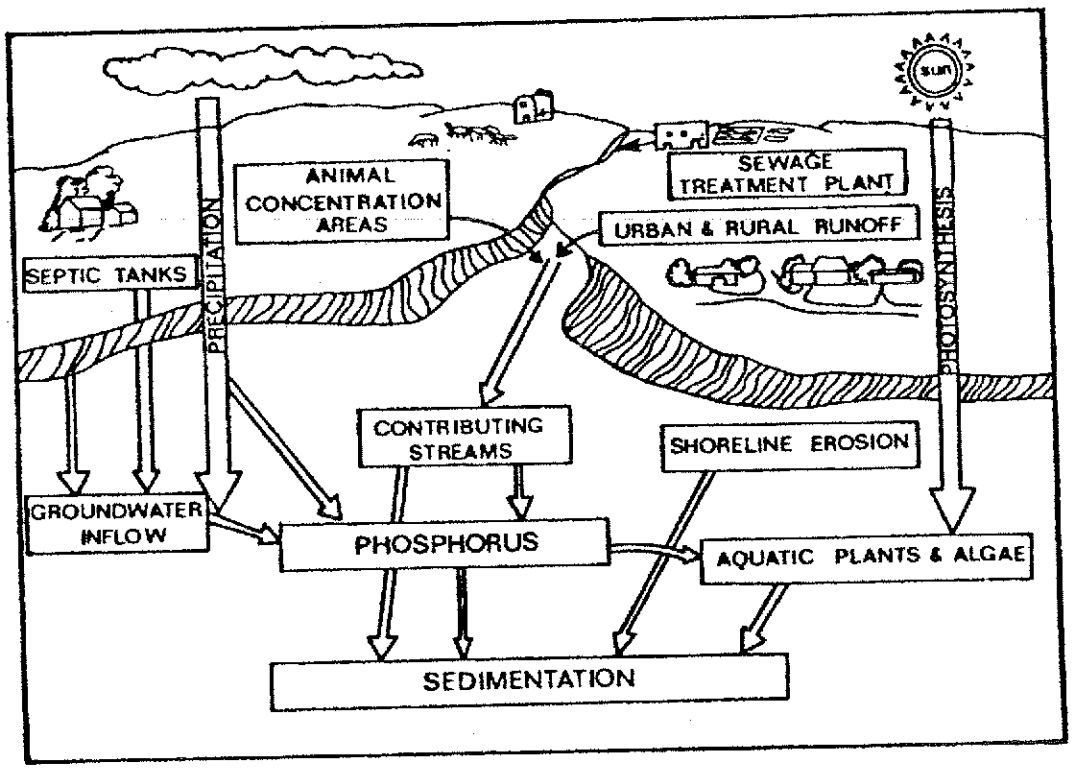
More recent studies undertaken by Finkbeiner, Pettis & Strout, Ltd. in August 1980 on Grand Lake St. Marys centered on water quality adjacent to greatest development and on parameters indicative of human wastes. The investigation confirmed previous studies of lake pollutant loadings and showed that human wasteload originating from lake shore development continues to degrade lake water quality. Bacterial counts confirmed the presence of sewage, creating a problem which at peak use periods affects the entire lake.

In summary, the primary water pollution problems in Grand Lake St. Marys is the eutrophication of the lake as described above. The main water quality problems are associated with nuisance algae blooms and inadequate sewage treatment. Taste and odor problems in the lake have been linked to the algae blooms, which also interfere with recreation and water supply uses. Other information indicates significant bacterial pollution of the lake.

Other than in Grand Lake St. Marys, water pollution problems are associated with Beaver Creek. During dry periods, the flows in the upper reaches of Beaver Creek essentially cease and the only flow in Beaver Creek is the effluent from the Celina wastewater treatment plant. This has resulted in serious water quality problems in the creek, including high levels of suspended solids and nutrient concentrations and low dissolved oxygen. Facilities plans are presently being prepared for improvements to the Celina wastewater treatment plant that will alleviate this problem.

Sources

The drawing below shows a conceptualization of phosphorus and sediment pollution sources which contribute to lake water quality problems.



Phosphorus input sources have been categorized as either "point" or "non-point" sources for purposes of estimating total annual phosphorus loadings to the lake.

Point sources are those which discharge effluent at known locations and include one municipal sewage treatment plant (St. Henry) and 17 small premanufactured (package) treatment plants surrounding the lake, each of which discharge effluent with varying degrees of treatment directly or indirectly to the lake.

Non-point sources include phosphorus from such diverse sources as precipitation, agricultural and livestock areas, waterfowl, septic tank-soil absorption systems, and direct urban and suburban runoff. Phosphorus contained in rainwater falling directly on the lake surface is generally uncontrollable and the ability of algae to utilize the phosphorus is still in

question with researchers. Cropland and animal concentration areas (feedlots) both contribute nutrients and sediments through runoff and erosion. The high concentration and number of waterfowl at Grand Lake has been suspected of contributing phosphorus and bacterial contamination of the lake. Although the concentration of septic tank-soil absorption systems around the lake is generally known, they are considered non-point sources because pollution from them seeps into the lake over a dispersed area. Urban and suburban runoff contributes pollutants after rainfall events from residential areas and streets.

Finally, erosion of watershed lands, streambanks and shoreline contribute sediments which cause turbidity and phosphorus-bound particulate matter which causes the proliferation of odor and taste-producing algae throughout the lake.

Annual Phosphorus Loads

It is estimated that approximately 33,000 kilograms of total phosphorus are currently contributed to Grand Lake on an annual basis. The estimated phosphorus loading rate of 0.49 gram per meter square per year to the lake is nearly 1.8 times greater than the commonly accepted loading limit. This means that Grand Lake St. Marys can be considered eutrophic. The excess nutrient concentration results in increased biological activity and culminates in nuisance algal growths, reduced oxygen content, and noxious tastes and odors. With these conditions the lake may become unacceptable as a source of water supply and recreation.

Of the total phosphorus loading, it is estimated that, on the average, approximately 15,000 kilograms are removed from the lake annually via Beaver Creek and the St. Marys Feeder Canal. At the current estimated rates of phosphorus input and output, approximately 18,000 kilograms of the total phosphorus accumulates annually in the lake.

Several sources of phosphorus which were thought to be significant, specifically septic tank systems and waterfowl, are contributing only small quantities of phosphorus to the lake.

The estimated percentage contributed by each source is identified in Table 5. The most significant contribution of phosphorus to Grand Lake St. Marys and to the rapid rate of eutrophication of the lake appears to be from non-point sources or rural, primarily agricultural land and livestock concentration areas.

TABLE 5

ESTIMATED ANNUAL
TOTAL PHOSPHORUS LOADINGS FROM SPECIFIC SOURCES
GRAND LAKE ST. MARYS, OHIO

Source	Kilograms	Percentage of Total
Precipitation	780	2.3
Waterfowl (Geese)	216	.6
Animal Concentration Areas (Feedlots)	7,500	22.6
Agricultural/Rural Land	21,000	62.9
Municipal Point Source (St. Henrys)	1,449	4.3
Domestic Point Sources	746	2.2
Septic Tank-Soil Absorption Systems	610	1.8
Direct Urban and Suburban Runoff	1,088	3.3
Totals	33,389	100.0

EROSION AND SEDIMENT PROBLEMS

Soil erosion and sedimentation pose major problems to lakes and streams. In bulk, sediment is the greatest single water pollutant nationwide and is no exception at Grand Lake St. Marys. The introduction of sediment to the lake occurs as part of natural watershed processes. However, man's activities which have dictated the land use and manipulated the vegetative cover have greatly accelerated this process over a long period of time by removing protective vegetation from the watershed. The effect of erosion-induced sediment accumulation in the lake is realized in many ways. Physically, turbidity caused by suspended and resuspended sediments decreases light penetration and thereby affects photosynthesis which in turn may reduce oxygen production. Sediment accumulation is suspected of destroying fish spawning areas; curtailing recreational activities, especially boating; reducing aesthetic values; and creating shallower areas which cause an increase in biological activity. Besides the physical effects of sedimentation, fine-grained suspended solids composed predominantly of clays have a high absorption capacity. Sediments may bind or immobilize pollutants and remove them from the water. On the other hand, if the sediments are overloaded with pollutants, they may be released to the water column. In the Grand Lake St. Marys watershed, most soils being of the silty clay loam type would absorb pollutants, particularly phosphorus carried to the lake. The release of these nutrients can also be increased when bottom sediments are stirred up by power boats, carp and other bottom scavengers. Evidence exists which supports the occurrence of these changes at the lake.

Erosion has been identified in six categories of concern to lake users: farm drainage erosion, streambank erosion, lake shoreline erosion, channel erosion, island erosion and dredge spoil erosion.

Farm Drainage Erosion

Erosion of the soils in the lake's watershed consists of moderate sheet erosion. Nearly all waters observed entering the lake have considerable amounts of suspended silt. Watershed erosion from primarily agricultural lands, includes washoff of soils and farm chemicals

dissolved in the runoff. Soil erosion creates economic problems because fertile soil and components are depleted from the surface. Soil erosion creates environmental problems because suspended and dissolved solids affect water quality, sedimentation and shallowing of the lake, and bottom dwelling organisms. Significant improvements in lake water quality are tied to reducing suspended sediment loading from the lake's agricultural drainage basin.

Streambank Erosion

Streambank erosion occurs in the study area although this type of erosion is considered moderate. Soils notable for erosion problems – Blount and Glynwood – occur throughout the lake watershed. The most notable streams having erosion problems include Coldwater, Burntwood, and Chickasaw Creeks. Coldwater Creek banks have developed serious erosion problems due to runoff scour which increases sediment load delivered to the lake.

Lake Shoreline Erosion

Lake shoreline erosion is caused by a number of factors including wind-driven waves, boat wake attack, high water, and winter ice. In general, the north, east and west shores of the lake have adequate bank protection through use of seawalls and riprap. Although a few exceptions are noted along inlet channels and embayments, shoreline erosion problems are limited to the southshore. It is reasonable to state that developed shoreline is protected and undeveloped shoreline is not. Bank erosion along the undeveloped southshore areas is the most dramatic in the study area, with approximately 5-foot vertical drops and uprooted trees observed nearly throughout. Some riprapping of these mostly State–owned areas has been undertaken, but the success of any such program is limited by access problems and funding. The rate of shoreline erosion has not been quantified because of a lack of long-term survey data; however, the amount of unprotected shoreline is estimated at 60,000 linear feet, or 11.3 miles. This represents some 23 percent of the total lake shoreline.

Channel Erosion

This erosion problem results from a combination of factors and affects boat channels, boat basins, and natural inlets in the lake. The shallow depth makes the channel banks susceptible to wave scour. Rapid surface runoff erodes soils and results in silt deposition in natural inlets. Prop wash and boat wakes, together with a general lack of coarse gravels and rock or bottom vegetation contribute to the erodibility of channels and other bottom features.

Island Erosion

Existing islands in the lake are especially susceptible to ice and wave-induced erosion because of their small size and exposure from any side. Except for Safety Island, most all island formations are generally unprotected from these effects. The contribution of sediment to the lake is considered minor compared to other erosion sources, but they are the most susceptible to erosion and should be preserved for their intended long-term use as waterfowl areas.

Dredge Spoil

Dredged spoil material placed in unprotected rows and left unprotected erodes quickly back into channels and into other parts of the lake. Unprotected dredge rows are suspected of contributing sediment back into the lake and channels where turbidity is increased for long periods of time. Contained spoil areas for dredge materials are warranted in a large water body such as Grand Lake St. Marys which is subject to high wind and wave activity.

Summary

Erosion of the unprotected shoreline, streambanks, and upland areas in the watershed contributes to the rate of sediment accumulation in the lake. The estimated annual loading of sediment to Grand Lake St. Marys from tributary streams and upland areas is approximately 26,000 tons. No estimate was made as to the amount of eroded shoreline island or dredge spoil material which accumulates in the lake annually.

Although sedimentation does not appear to be seriously depleting the lake storage, the material accumulates in places where it is especially noticeable and troublesome. Sediment accumulations are most prevalent around the perimeter of the lake where water velocity is low. The combination of shallow water and wind-induced wave action creates circulation patterns capable of eroding and transporting sediments in the lake.

The general problem categories of flooding, lake water quality, and erosion/sedimentation impact on several other water-related problems that exist at the lake. These include: shallowness, siltation, taste and odor, and wind and wave problems, all of which impact on the quality of the recreational experience, water supply, and fish and wildlife resources.

FISH AND WILDLIFE NEEDS

According to the U. S. Fish and Wildlife Service the natural productivity of desirable fish and wildlife resources has declined at Grand Lake St. Marys over the last 75 years. During the early years up to 1900 the lake was used as a very successful commercial fishery with dominant fish being black bass, sunfish, perch and catfish. Between 1890 and 1900, several droughts lowered the lake level considerably causing heavy fish kills, stump and snag removal, and the disappearance of aquatic vegetation. When the lake refilled after the drought, wave action and turbidity increased and the lake changed from a relatively clear, cool body of water to a turbid, warmwater area with increased wave action. The fish population changed to less desirable species (carp, white crappie, bullhead and channel catfish). Since the time the lake was turned over for recreational purposes, in the 1930's, many attempts were made to improve fish habitat, and in recent years fishing has improved greatly. Several decades of intensive efforts were made to replicate earlier conditions which contributed to the lake's excellent fishery resources. This included regulation of angling during spawning seasons, rough fish removal, stocking of fish, and habitat improvement. Despite these efforts, returning the fishery population to its former condition has not been accomplished.

Since the formation of Grand Lake St. Marys, the changes of the fishery population has been as drastic as the changes which occurred to its aquatic environment. With a more degraded condition of water quality and diminished fishery habitat, populations of more desirable sport fish have decreased. Nevertheless, a good warmwater fishery is maintained which provides fishing enjoyment for many thousands of sport fishermen.

Current wildlife habitat populations in the Grand Lake St. Marys area are very much dependent on cover and nesting habitat. Intensive farming in the watershed has resulted in the destruction of necessary habitat to maintain a high density of upland wildlife. The area still provides adequate wetland habitat to make it important for waterfowl population, but this condition must be maintained or enhanced.

With continued development around the lake, the quality and quantity of the existing resource base is expected to erode. The problem is complex; however, degraded water quality and degraded fish and wildlife habitat are two key factors which account for the resource losses. The U. S. Fish and Wildlife Service further concludes that associated wetlands are vital segments in Grand Lake's resource production and perpetuation and will be further jeopardized if reduced or committed to non-resource use.

GENERAL RECREATION NEEDS

The State of Ohio Comprehensive Outdoor Recreation Plan indicates significant deficiencies in realizing the recreational potential for boating, camping, sailing, swimming, and picnicking in the Mercer and Auglaize County area. The Plan, for example, states that the study area "has not developed its full potential because of lake siltation and pollution problems, lack of adequate lands to balance water area and unconsolidated land ownership surrounding the lake." Although a large portion of the lake's 50-mile shoreline has been developed for water–associated recreation, including lakeside residences, public and private beaches and docks, and public park areas, a comparison of visitor numbers at other lake facilities in a 60-mile radius region generally indicates that Grand Lake St. Marys is underutilized. A smaller than usual amount of boating occurs for such a volume of water

as this. The reasons are many and varied, but water-related problems including shallowness, siltation, pollution, submerged objects, odors and wind and wave problems create difficulties with the existing and potential recreational use. Lowering of the lake level, for any reason, is considered a detriment by recreation interests. As discussed in "Water Quality Problems" another detriment to recreation is the periodic growth of blue-green algae in Grand Lake St. Marys.

Review of other study area problems and needs indicated that there was a need to include opportunities for improvement, restoration, or enhancement of overall water quality of the lake as a planning objective as well as erosion control and sedimentation control. All of these objectives are oriented toward enhancing and increasing the potential of water-oriented outdoor recreation opportunities.

IMPROVEMENTS DESIRED

State and local officials and organizations have from time to time since 1970 expressed, through meetings, correspondence, and minor reporting efforts, their desires for improvements to problems in the areas of flood control, drainage, water quality, erosion and water-related recreation. Local interests cite lake water quality problems including adverse odor and taste caused by frequent widespread blue-algae blooms, severe wave action, shallow lake water depths, and erosion as problem areas of primary concern. The State of Ohio, Department of Natural Resources, has indicated that erosion control, pool level control, and nutrient-algae control are the State's primary concerns as related to the lake's primary purpose which is water-related recreation. Local concerns would like to have the water quality improved and the lake level stabilized to enhance recreation potential and control flooding of portions of the lake perimeter. Downstream farmers along the lake's western outlet channel, Beaver Creek, seek relief from periodic field flooding caused by restrictive channel conditions, low stream gradient, inadequate tile outlets and releases from the lake.

Planning Objectives

The primary objectives of this survey investigation were to report to Congress an inventory of the publicly identified water and related resources problems and needs in the study area and to investigate a range of feasible alternatives for resolving water-related problems that may be implemented individually or collectively by local, state, and Federal agencies. The general overall objective is to determine what, if any, feasible, economic measures could be undertaken to restore and enhance Grand Lake St. Marys and its environs as a viable water resource.

For the Beaver Creek and lake shore area, specifically, planning objectives were established to provide for problems and needs which were identified. The authorization for this investigation made particular reference to the flood problems at Grand Lake St. Marys. Therefore, flood control for the south side of the lake and for Beaver Creek was established as a primary planning objective.

FORMULATION OF ALTERNATIVES

The following section is intended to identify and discuss the range of alternatives considered for the three general problem categories of flooding, lake water quality and erosion/sedimentation and the two main problem areas: Beaver Creek and Grand Lake St. Marys. Each alternative discussion contains information where applicable on: description, impacts and effects, costs, economic data and comments on economic, technical, and institutional feasibility. Table 6 is the list of possible measures initially developed. The first subsection, Initial Screening, offers comments on those alternatives which have not been given detailed consideration. The second subsection offers a summary of alternatives worthy of more detailed consideration.

INITIAL SCREENING

Beaver Creek Flooding

Natural Impoundments (Alternative IA.3).

Few natural impoundments exist, either naturally or as might be modified, outside of Grand Lake St. Marys itself, to retard peak flows entering from the uncontrolled drainage area of Beaver Creek. Therefore, this alternative was given no further consideration.

TABLE 6

ALTERNATIVES CONSIDERED

I. DOWNSTREAM FLOODING (BEAVER CREEK)

A. Measures to Modify Flooding Prior to Reaching Critical Damage Areas

1. Detention Basins in Lake Watershed
2. Diversion to St. Marys River via Fourmile Creek
3. Natural Impoundments (NS)
4. Weather Modifications (NS)
5. Lake Regulation

B. Measures to Modify Flooding at Critical Damage Areas

1. Channel Modification
   a. Clearing, Cleaning and Snagging
   b. Channel Enlargement
2. Agricultural Levees
3. Pre-Flood Emergency Action (Flood Fighting) (NS)

C. Measures to Modify Actual Damages (Prevention)

1. Flood Proofing (NS)
2. Permanent Evacuation (NS)

D. Measures to Modify Individual Economic Losses while Permitting Major Damages

1. Flood Forecasting and Temporary Evacuation (NS)
2. Flood Insurance (NS)

II. LAKESHORE FLOODING

A. Measures to Modify Flooding Prior to Reaching Critical Damage Areas

1. Detention Basins in Lake Watershed
2. Diversion to St. Marys River via Fourmile Creek
3. Spillway/Outlet Modification
4. Natural Impoundments (NS)
5. Lake Regulation (NS)

B. Measures to Modify Flooding at Critical Damage Areas

1. Reduce Wind Set-up (Breakwaters, Groins)
2. Protect Low-Lying Areas (Shoreline Levees)

C. Measures to Prevent Actual Damages

1. Flood Proofing (NS)
2. Permanent Evacuation (NS)
3. Structure Relocation (NS)
4. Flood Proofing Future Structures (NS)
5. Flood Plain Management-Future Development

D. Measures to Modify Individual Economic Losses while Permitting Damages

1. Temporary Evacuation (NS)
2. Flood Insurance (NS)

III. LAKE WATER QUALITY IMPROVEMENT

A. Measures to Reduce Nutrient Inflow (External Source Controls)

1. Treatment of Wastewater Inflows (Point Source Controls)
2. Control of Non-Point Sources
   a. Agricultural Land Management
   b. Livestock Waste Management
   c. Runoff Treatment
   d. Other Non-Point Source Controls

B. Measures to Disrupt Internal Nutrient Cycles (In-Lake Controls)

1. Dredging
2. Destratification/Aeration
3. Nutrient Inactivation/Precipitation
4. Dilution/Flushing
5. Drawdown
6. Lake Bottom Sealing

C. Measures to Accelerate Nutrient Outflow

1. Biotic Harvesting of Algae, Aquatic Plants, Rough Fish

D. Measures to Control Erosion and Sedimentation

1. Shoreline, Streambank and Watershed Erosion Control Measures
2. Sedimentation Ponds

NS – refers to nonstructural protection measures.

Weather Modifications (Alternative IA.4).

The effectiveness of identifying and then modifying potential storm centers is not sufficiently accurate at this time to warrant further consideration.

Pre-flood Emergency Action (Alternative IB.3)

There are no established physical emergency actions that can be effectively employed by landowners because potential flooding problems are not localized, but extend throughout the Beaver Creek reach.

Flood Proofing and Permanent Evacuation (Alternative IC.3,-.4).

Since few structures are located along the Beaver Creek reach and none are affected, this alternative is not an alternative to the primarily agriculturally-related flood problems.

Floodplain Zoning, Land Use Regulation (Alternative IC.3).

These alternatives offer little opportunity by themselves along Beaver Creek since major damages occur to cropland and no change or variance in this existing land use is expected in the future.

Flood Forecasting and Temporary Flood Evacuation (Alternative ID.1).

Flood forecasting information is and will continue to be used in the Beaver Creek reach, but the predictive capability of the method in a drainage/lake system such as exists at Grand Lake St. Marys makes this an ineffective solution in reducing flood damages. Temporary evacuation is not a realistic solution to rural, agricultural flood damage problems.

Flood Insurance (Alternative ID.2).

Insurance does not prevent flood damage or future losses, but indemnifies a policy holder for financial losses suffered during a flood. Insurance available through the National

Flood Insurance Program does not cover growing crops, or livestock, and therefore is not available for agricultural crop damages. The Federal Crop Insurance Act of 1980 (FCIA), however, offers farmers new alternatives for reducing crop production risks from natural disasters such as flooding. For the 1981 crop year farmers may elect Agricultural Stabilization and Conservation Service (ASCS) disaster payments, Federal Crop Insurance Corporation (FCIC) payments, or both, depending upon whether their FCIC premiums are subsidized. Beginning in 1982 the ASCS disaster payment program will be discontinued. Disaster payments will be replaced by a crop insurance program which permits farmers to select the level of protection desired and pay a corresponding premium. Mercer and Auglaize Counties will offer the new crop insurance program in 1981 and 1982. Since this Federal program is available to affected farmers, no further evaluation is necessary in this study.

Lake Shore Flooding

Natural Impoundments (Alternative IIA.4).

Few natural impoundments exist either naturally or as might be modified to retard peak flows entering from the lake's watershed. Those that do exist have insufficient capacity to result in flood damage reduction to lake shore property.

Floodproofing Existing Dwellings (Alternative IIC.1).

This involves the modification of dwellings by waterproofing or raising them to prevent floodwater intrusion. Waterproofing measures such as closures and wall structures placed in contact with affected frame-type dwellings are not considered practical or effective protection from the hydrostatic and uplift pressures exerted by waves nor would they provide a secure watertight seal for the crawl space and dwelling at and above the first floor elevation. It has been determined that due to the expense and scope of the requirements inherent in waterproofing, it is also not cost effective as a primary solution.

Permanent Evacuation (Alternative IIC.2).

This alternative involves the purchase of all properties affected, which at the flood damage level, involves some 131 to 142 properties. The alternative was found to be undesirable and economically infeasible. It would require abandonment of desirable shoreline property. The economic analysis showed unfavorable benefit-to-cost ratios of 0.48 and 0.45 with and without conversion of vacated lands to recreation, respectively, making the alternative economically impractical.

Structure Relocation (Alternate IIC.3).

This alternative was eliminated from further consideration since, even though most dwellings are relocatable, most effected structures are not primary dwellings, the desirable recreation objective would be lost and unfavorable benefit-to-cost ratios of 0.77 and 0.76 resulted with and without conversion to recreation, respectively.

Floodproofing Future Facilities (Alternative IIC.4).

As will be discussed below, Mercer County, as a participant in the National Flood Insurance Program, will be required eventually to adopt ordinances or other controls to regulate land use and construction within the 100-year flood plain (land area inundated once per hundred years, on the average). With this alternative, future development would additionally be required to be floodproofed to the level of the standard project flood, which is a flood representing the critical flood runoff volume and peak discharge that may be expected from the most severe combination of meteorologic and hydrologic conditions that are considered reasonably characteristic of the hydrologic region involved. Floodproofing would consist of elevating future buildings on pads or piles, constructing dikes, providing watertight closures and anchorage systems, waterproofing, or using any such method designed to resist inundation. Because expenses would be borne by individual property owners, the increased costs of floodproofing may tend to discourage development in the flood plain. This plan, however, would not protect existing development, and the economic and individual costs of floodproofing new and replacement structures may prove to be excessive.

Temporary Evacuation (Alternate IID.1).

This alternative, while questionable in regard to levels of damages prevented or reduced, does offer a principal means of protecting the personal safety and personal property aspects of risks associated with the type flooding at Grand Lake St. Marys. To be effective, a flood warning system, which gages the critical parameters of lake levels, wind velocity and wind direction, would need to be utilized to signal the threat of flooding. The effectiveness of an evacuation plan and response of the community to it cannot be accurately predetermined and consequently neither can potential flood damage reduction.

Flood Insurance (Alternative IID.2).

Flood insurance does little or nothing to prevent or reduce damages from flooding, but rather indemnifies the insured property owner against economic loss. Participation in the National Flood Insurance Program is a local option in which Mercer County is enrolled in the first or "emergency" phase and limited Federally subsidized coverage is available to all property owners. A Flood Insurance Study (F.I.S.) to convert from the emergency to the "regular" phase has not been scheduled for Mercer County as of February 1981. Auglaize County was identified by the Federal Emergency Management Agency as having flood-prone areas but to date the county has chosen not to participate in the program. Since this Federal program is available to the local governments, no further evaluation in this study is deemed necessary.

Flood Plain Management, Future Development

Zoning, subdivision regulations, and building codes for the lake shore flood plain could be accomplished on the basis of the flooded area. Ordinances could be developed that would allow only certain types of development in different flood zones. Developments such as parks, etc., which will not impede flow or be easily damaged may be permitted. Residential and commercial development could be permitted in areas subject to flooding, but not required for flowage provided that improvements were constructed or flood proofed to provide protection to the levels of protection specified by the public agencies involved. Although this approach will not improve the flood problem for existing construction,

it will help to eliminate or greatly reduce the damages that would have otherwise occurred for future construction. This is particularly important in the study area in light of the potential for increased future development from implementation of centralized waste-water management alternatives. Regulations adopted by local governments either voluntarily or as required by participation in the Flood Insurance Program are considered to be one of the more practical non-structural measures that could be used to reduce future damages.

Lake Water Quality Improvement Alternatives

Lake water quality restoration measures considered but deemed inappropriate for various reasons are described as follows:

Destratification/Aeration (Alternative IIIB.2).

This is a restorative technique applicable to lakes in which the hypolimnion, (the bottom third layer in a stratified lake) is essentially devoid of oxygen. The objective is to artificially increase oxygen levels by mechanical means, thereby promoting the oxidation of organic substances and enhancing biotic distribution. The method is not a viable alternative for Grand Lake St. Marys since (1) oxygen levels in the lake are generally high from top to bottom, (2) the lake does not stratify because of its shallow depth, and (3) the technique would not restore the lake since it treats the symptoms rather than the source.

Nutrient Inactivation/Precipitation (Alternative III 3B.3).

This restorative technique is the physical addition to the lake of some type of chemical or inert material which absorbs or chemically bonds with soluble phosphorus and removes it from the water column. Chemicals such as aluminum sulfate are used to control nuisance algae and plant growth by settling nutrients to the bottom and making them unavailable to plants. Although relatively new as a lake restoration technique, it is essentially an extension of existing wastewater and water supply treatment technologies. The effectiveness of this in-lake treatment process is doubtful at Grand Lake St. Marys for several reasons: (1) the lake is well mixed throughout its depth and the chemical flocs formed would probably not

settle to the bottom as would be required, but would remain in suspension and be shifted to lake shore areas; (2) addition of chemicals such as aluminum sulfate (alum) to lake water would impact adversely on existing water treatment; (3) tremendous amounts of materials would be required (1,500 tons every three years) at a cost of $232,000 per year, and (4) long-term impacts on fish and wildlife are unpredictable.

Dilution/Flushing (Alternative IIIB.4).

Another lake water quality improvement alternative investigated involves replacing the nutrient-rich lake water with nutrient-poor (higher quality) water from another source. The technique is used to prevent algae and plant growth by releasing excess nutrients from the lake. Several factors make this method impracticable for use at Grand Lake St. Marys. First, there is no adequate, dependable supply of dilution water in the region that can replace the lake contents. Second, groundwater is high in minerals, and would not be suitable unless treated prior to introduction to the lake. Thirdly, a low-nutrient water source is not available in proximity to the lake. Surface water supplies such as the St. Marys River and nearby Lake Loramie are undependable, expensive sources.

Drawdown (Alternative IIIB.5).

Drawdown is a technique used for water quality improvement in which the lake level is drawn down to expose and consolidate bottom sediments. It accomplishes several objectives including controlling rooted aquatic vegetation and stabilizing bottom sediments to prevent nutrient release from them. It also results in deepening the lake and increasing lake volume through sediment consolidation and/or removal after the drawdown. The method, however, has several drawbacks which make it unsuitable at Grand Lake St. Marys. It would be difficult to release water from the lake at a greater rate than inflow without causing some flooding downstream in Beaver Creek. There are inadequate outlet facilities to accomplish the drawdown over a short period of time. There would be a loss of recreation, and fish and wildlife resources. More importantly, there would be a significant reduction in now dependable water supply for Celina, severe aesthetic loss, and potentially offensive odors for an extended period of time.

Lake Bottom Sealing (Alternative IIIB.6).

It may be more feasible to prevent nutrient release from sediments by covering the sediments rather than by dredging or drawdown. Sealing, using such methods as covering sediments with polyethylene sheets, sand, clay or flyash, was examined but eliminated from further consideration since cost and material availability would prohibit its use on a lake of this size. In addition, not enough is known as to the permanance and stability of the treatment and the effects these sealants have on bottom living organisms and fish spawning areas.

Biotic Harvesting (Alternative IIIC.1).

Algae harvesting by mechanical means has been considered as an alternative for improving water quality, but is impractical at Grand Lake St. Marys because of the large lake surface area and widespread dispersal of algae blooms. Aquatic plant harvesting has also been discarded because of a lack of concentration of growth at the lake. The few aquatic plant areas that do exist should be preserved as habitat for bottom organisms, young-of-the-year fish, and wildlife. Harvesting of rough fish such as carp, which release nutrients by disturbing bottom sediment, has not been sufficiently studied to evaluate its impact on water quality and expected nutrient reductions.

ALTERNATIVES CONSIDERED IN DETAIL

This subsection discusses alternatives given active and more detailed consideration either because they have been suggested by local, regional and state interests, or because they would appear to have technical merit.

Flood Control

Structural plans considered for Beaver Creek and lake shore together, included detention basins, diversion and spillway/outlet modifications. In addition, non-structural reservoir regulation alternatives were examined. Structural plans considered for Beaver Creek

alone included channel improvement alternatives (cleaning, clearing and snagging; and channel enlargement), and agricultural levees. Structural plans considered for lake shore alone included breakwaters, groins and shoreline levees.

Detention Basins on Tributaries (Alternative IA.1).

Detention basins refer to structures in which runoff from the lake's watershed would be stored in the basin during peak flood flows and released downstream to the lake as soon as conditions permit. The purpose is to reduce flood damage on the lake rim and store runoff that would otherwise be released through the lake to Beaver Creek. The ultimate objective is to prevent the lake level from rising more than one foot above west spillway crest. This elevation, 871.75, is the start of lake shore flood damage. With this plan, detention reservoirs would be constructed on four tributary streams, namely Coldwater, upper Beaver, Chickasaw, and Little Chickasaw Creeks, as shown on Plate 3, controlling areas of 9.3, 18.9, 15.3, and 6.6 square miles, respectively, for a total of 50.1 square miles or 45 percent of the total lake drainage area. Studies determined that those sites were not economically feasible to adequately reduce Beaver Creek and lake shore flooding and the costs of such a system would greatly exceed benefits. Total cost for constructing the four reservoirs was estimated at $14,800,000; average annual costs would total about $1,400,000. Considering that average annual equivalent damages are $235,000 for Beaver Creek and lake shore, this alternative would not be economically feasible. Adding recreation and sediment control benefits to the plan would still not result in a favorable project.

Diversion to Fourmile Creek (Alternative IA.2).

A plan consisting of diverting excess flow from the lake to another basin was also considered. The primary objectives were to reduce flood damages along Beaver Creek by allowing outflows from the lake in proportion to the historic drainage areas of the lake (59 percent Wabash River Basin, 41 percent St. Marys River Basin) and also prevent the lake level from rising more than one foot above the existing west spillway crest elevation which is the start of lake shore flood damages (elevation 871.75). This plan consisted of diverting lake overflows to the St. Marys River via Fourmile Creek as shown on Plate 4. The plan requires a new outlet structure and approximately 2 miles of deep-cut channel connecting the lake pool, through a portion of the State Park west of Villa Nova, to Fourmile Creek near U.S. Route 33. Total first cost of this plan is estimated at $3,500,000 and

average annual costs total $299,000. Since total annual costs exceed potential annual flood damage reduction benefits for both Beaver Creek and lake shore ($235,000) the diversion plan was eliminated from further consideration.

Spillway/Outlet Modification (Alternative IIA.3).

This subject has been addressed in a report prepared in August 1979 for the Ohio Department of Public Works as previously discussed under "Status of Existing Plans and Improvements." The plan as proposed includes replacement of the existing east bank bulkhead with a new concrete ogee spillway having the same crest elevation as the present west spillway (870.75) and channel improvements providing greater flow capacity through the St. Marys Feeder Canal. According to the report the proposed modification provides for a west/east split of lake outflow equivalent to 59/41 percent which is the percentage of Grand Lake St. Marys drainage area tributary to the Wabash and St. Marys River Basins. The modification, according to the report, results in: (1) decreases in the outflows to Beaver Creek, (2) approximately the same maximum lake elevation, and (3) greater increases in east outflow to the St. Marys Feeder Canal.

The modification is expected to decrease outflows to Beaver Creek but of such low magnitude (on the order of 5 cfs and 15 cfs for 25-year, and 100 recurrences, respectively) as to result in negligible flood control impacts on Beaver Creek. In addition, because the expansive lake surface is capable of storing large volumes of inflow, the modified east spillway, though giving a large increase of east outflow, creates only a slight decrease in lake levels (on the order of 0.1 inch) thereby providing no measurable flood control impacts on the south shore.

Lake Regulation (Alternative IA.5).

Several plans for modifying the operation of Grand Lake St. Marys for flood control were investigated. The objective of this alternative is to reduce flood damages along the lake shore and Beaver Creek, as well as providing greater flexibility and dependability in obtaining and maintaining a stable seasonal recreational pool level.

A regulation schedule or plan of operation was apparently non-existent during the early years. However, after examining a 51-year record of pool elevations, it has been

noted that there has been increasing emphasis on lake regulation during the last 15 to 20 years, with a corresponding emphasis for recreation and agricultural considerations. The existing "rule curve" includes a one-foot drawdown from recreation pool elevation 870.75 beginning the first of November. However, after the one-foot of flood storage is attained, minimal effort is exercised to maintain elevation 869.75 through the winter months. A practice of impounding some excess runoff early in the calendar year, to aid in attaining recreation pool by late March or early April, appears to prevail.

Alternatives considered in this study have included variations in (1) winter pool drawdown which would provide additional flood control storage, (2) initiation of pool filling to attain recreational pool requirements, and (3) controlled releases from the west spillway outlet to reduce flood damages along Beaver Creek and also south shore. Development, analysis and evaluation of hydrologic and hydraulic relationships of observed conditions for the period of record, existing operation schedule, and the variations of drawdown, filling, and releases revealed that the current operating procedures for lake regulation as followed by the State of Ohio provide an appropriate balance in minimizing flood damages for Beaver Creek and lake shore and maintaining a desirable recreation pool.

Clearing, Cleaning and Snagging (Alternative 1B.1.a.).

This channel improvement alternative consists of removal of flow-obstructing objects such as debris, logjams, shoals and bank vegetation for the purpose of restoring the channel to provide better hydraulic characteristics for Beaver Creek. Some excavation and reshaping would be required in addition to extensive replacement of tile outlets. Stump removal would not be included in order to preserve streambank stability and fish and wildlife habitat to the extent possible. This alternative, while being the least costly of channel improvements, was found to be the least effective in reducing flood flow heights and provides only short-term solutions since new growth and obstructions require that the operation be repeated at some later time. Total first cost of this alternative for 9.6 miles of channel improvement is $1,000,000. Average annual costs would total $97,000. Annual flood damage reduction benefits from the alternative would amount to $38,000. Since annual costs exceed annual benefits, this alternative is economically infeasible.

Channel Enlargement (Alternative IB.1.b).

This alternative was investigated for the purpose of increasing the Beaver Creek carrying capacity while lowering creek stages for better tile outlet discharge. The plan seeks to reduce agricultural flood damages. Two channel sizes were investigated.. The smaller channel would have a bottom width of 40 feet at the upstream limit and 65 feet at the downstream limit. Total capital costs would be $1,610,000 and average annual costs would be $228,000. Annual flood damage reductions would be $70,800 making the alternative economically infeasible. The larger channel would have a bottom width of 60 feet at the upstream limit and 70 feet at the downstream limit. Total first cost is $5,342,000 and average annual costs would be $523,000. Average annual benefits of $77,100 are considerably lower than average annual costs making this alternative economically infeasible.

Agricultural Levees (Alternative IB.2)

Agricultural levees provide a possible means of reducing agricultural flood damages related to overbank flows. The plan examined consisted of 12.5 miles of levee, as shown on Plate 5, affording a 10-year level of protection for 1,148 acres along Beaver Creek. Total first costs are estimated at $4,000,000 with average annual costs of $308,000. Annual benefits attributed to the plan in the form of damages prevented amount to $60,700. Since average annual costs exceed average annual benefits, this alternative is economically infeasible.

Breakwaters (Alternative IIB.1).

The use of breakwaters at Grand Lake St. Marys was considered primarily as a measure to reduce shoreline flooding caused by wind set-up. Flooding of the shoreline due to wind set-up has been shown to be possible, particularly if the lake level is high. Breakwaters also have potential to reduce shore erosion by dampening wave impact forces and they can also improve water quality by reducing lake turbidity. For recreation, breakwaters could create stillwater areas for boating, thereby increasing boater safety, and providing access to deeper water for fishermen. Breakwaters also provide an obstruction to ice movement.

Of the many types of fixed and floating breakwater concepts available, two types in each category were selected as being applicable to the Grand Lake St. Marys wave situation. Fixed breakwaters examined include diked dredge islands, suitably contained, and rubblemound breakwaters since both represent the least expensive of fixed breakwaters, materials are available locally, and the shallow lake depth and wave situation are conducive to their use. Floating breakwaters examined include rigid floating concrete and flexible floating tire breakwaters, since the former has had application in similar wave environments and the latter has received considerable attention as an inexpensive alternative for reducing wave action in inland lakes.

It was found that to be effective for flood reduction, an extensive, complex and costly breakwater system would be required to realize significant reductions in wave action over the entire lake. Segmented, longitudinal fixed breakwaters (Plate 6, Figure 6A) oriented parallel to and close to shore have a greater potential for alleviating or reducing south shore flooding and erosion problems. Floating breakwaters would have little value for reduction of wind set-up at the shore but would assist in reducing wave-induced shoreline erosion.

Costs of breakwaters depend on several factors including location, orientation, and spacing in the lake. Order of magnitude costs have been developed based on a configuration which parallels the shore. It is estimated that costs to parallel the south shore with breakwaters would be $8,000,000 for dredge islands, $18,000,000 for rubblemound breakwaters, $12,000,000 for floating concrete breakwaters, and $2,000,000 for a floating tire system.

Based on the cost analysis conducted in this study, a single breakwater is not expected to produce enough of an effect on wave heights, shore erosion, or water quality to result in measurable direct or indirect monetary benefits. An extensive series of breakwaters would be required before benefits based solely on improvements to these problems could be realized. The most significant benefits to be realized would be for recreation with respect to boating and fishing in the form of income potential due to increased or restored lake visitation.

Groins

Groins are structures similar to rubblemound breakwaters, but connected to and somewhat perpendicular to land (Plate 6, Figure 6B). It was determined that because of the northerly exposure of the southshore, groins, connected to and in a northeasterly orientation to the southshore, may not be effective in alleviating the worst problem conditions resulting from wave action. They are not expected to achieve the desired impact of shoreline protection and from a benefit standpoint are not perceived to be economically feasible.

Shoreline Levees (Alternative IIB.2).

The concept of constructing shoreline levees for the purpose of protecting against flooding from high water levels, wind set-up and waves was also considered (Plate 6, Figure 6C). Two levee heights, 2 feet and 5 feet, were selected to provide protection from storms producing high water levels and winds up to 50 mph.

Two levee layouts were examined. The first retains total channel access by construction of the levee to follow the existing shoreline. The second minimizes levee length by cutting across boat access channels. Plate 7 shows a typical system conceptualized for the developed area west of Moorman Road.

There are many problems with this approach, the most notable of which are: aggravated upland drainage and ponding problems, disruption of privately owned waterfront property, reduction in access to open water and to boat docks, obstruction to lake view, and considerable rights-of-way across private property are necessary. Costs would be extremely high to protect all affected developed areas and are not cost effective for the expected level of reduced damages. Benefit to cost ratios for either of the approaches are less than 1.0 indicating that shoreline levees are infeasible.

Lake Water Quality Improvement Alternatives

Treatment of Wastewater Inflows (Alternative IIIA.1).

The deterioration of lake water quality is attributed, in part, to contamination by domestic wastewaters. A great portion of homes, resorts, and other public and private facilities surrounding the lake are not currently connected to public facilities and, therefore, use individual on-site systems (septic tanks) or small package treatment plants. Both methods have severe shortcomings when located near an impoundment because of improperly treated sewage seeping or discharging into the lake. Two disposal approaches were examined in dealing with wastewater inflows. The first involves elimination of all septic tank and package plants surrounding the lake and providing for collection, treatment and disposal of effluent directly to the lake. The method would require very high levels of treatment, at great expense, to remove excess nutrients prior to discharge to the lake. The second approach is to collect, divert, and treat domestic wastewater away from the perimeter of the lake such that no effluent would be allowed to discharge to the lake.

A regional sewage facilities plan for the developed immediate areas surrounding the lake has been prepared by Finkbeiner, Pettis & Stroud, Ltd. Wastewater would be collected and treated at plants in Celina at St. Marys with effluent discharged other than directly to the lake. Elimination of septic tank systems and numerous point source discharges through local management solutions utilizing the conventional collection and treatment alternative was seen as a positive step toward reducing pollutants to the lake and in particular bacteriological pollution emanating from human sources.

The contribution of nutrients from 20 domestic wastewater treatment plants that currently discharge directly or indirectly to the lake is minor, being approximately 2 percent of the total load entering the lake on an annual basis. This nutrient discharge will have a negligible impact on the long-range overall water quality of the lake with respect to phosphorus load and concentration. Likewise, phosphorus input to the lake from faulty septic tank-soil absorption systems close to the lake are contributing only small quantities of phosphorus to the lake (less than 2 percent). The implementation of a regional sewage system that encompasses the south shore is expected to reduce the existing phosphorus loading to Grand Lake by less than 10 percent and little improvement in the

phosphorus concentration or trophic state of Grand Lake St. Marys would be anticipated as a result. (This may not be the critical concern, however, since the primary water quality improvement associated with the proposed sewage system is the reduction of bacterial pollution to the lake.)

Although the planned $14,000,000 regional sewerage project is seen to be a positive step toward reducing pollutants to the lake and in particular bacteriological pollution emanating from human sources and would effect a lifting on the currently imposed construction ban, a major unresolved question is whether centralized collection and treatment of wastewater, as planned, is justified because of the financial burden it places on its residents due to the high costs of collecting wastewater from each dwelling, especially along the south shore where houses are scattered.

Studies to re-evaluate regional sewerage needs to include modifying the scope of the existing plan; alternative and innovative on-lot systems, either on an individual household or group of households basis; and upgrading or converting existing treatment plants to include tertiary treatment and chlorination, are necessary but beyond the scope of this study. Federal funding is available to local governments through the Public Law 92–500, Section 201 Construction Grants Program to facilitate such studies.

Agricultural Source Controls (Alternative IIIA.2a)

Soil erosion, migration of phosphorus and other nutrients from cropland, barnyard runoff, and the application of manure on frozen ground are all problems in the Grand Lake watershed affecting water quality. To a large extent, the problems of eutrophication in the lake are the result of intensive agricultural land use within its watershed. Estimates are that 26,000 tons of sediment and 23 tons of total phosphorus reach the lake annually from agricultural areas. This phosphorus loading represents approximately 60 percent of the total annual load reaching the lake from all sources. From the standpoint of types of crops being grown, surface susceptibility to erosion is high, with 60 to 70 percent of the cropland area being planted in low density row crops, mainly corn and soybeans. In addition, farmers have been applying increasing amounts of phosphate fertilizer throughout northern Ohio. In Mercer and Auglaize Counties, there has been an approximate doubling of available phosphorus values for field crops between 1961 and

1976: from 30 pounds per acre to 51 pounds per acre in Mercer County and from 21 pounds per acre to 44 pounds per acre in Auglaize County. Reduction in phosphate yields to streams in the Grand Lake St. Marys watershed will, therefore, require controlling not only the loss of sediment from cultivated lands, but also the rate of fertilizer applications.

The use of agricultural land management has as its primary objective the abatement of soil and nutrient loss. From the standpoint of Grand Lake and its identified problems, the consequential benefits that can potentially be realized are (1) a reduction in sediment load, (2) a reduction in nutrient input, and (3) improved water quality. No significant adverse environmental impacts on the lake should occur as a result of improved agricultural practices.

A number of agricultural conservation practices are available for promoting and enhancing long-term productivity of the soil. Although few of these practices were originally developed to improve water quality, these practices are now recognized as being beneficial to water quality and soil protection as reflected in new cost-sharing programs. Conservation practices available through cost-sharing programs include: conservation tillage; establishing hay or rotation pasture; improving permanent hay or grass stands; stripcropping, terraces; diversions; winter crop cover; shaping and seeding critical soil loss areas; sediment retention, erosion or water control structures; stream protection and soil waterways. In general, the following cultivation techniques appear most suitable for the Grand Lake St. Marys watershed: delayed plowing and residue management, cover or green manure crops, minimum tillage, and no-till planting.

The purpose of the cost-sharing programs is to encourage landowners to install conservation practices to protect and preserve the land for future use. The proper use of the practices and costs involved are dependent upon detailed conservation planning for individual farm units, taking into account the needs and objectives of the individual landowner, and are beyond the scope of this study. Likewise, total benefits and costs to be realized in the Grand Lake St. Marys watershed by the implementation of various agricultural waste management and conservation techniques cannot be specified. However, both Mercer and Auglaize Counties rank high as preferred areas for agricultural management practices.

Potential benefits to individual landowners include increased crop yields, long-term reduction in topsoil and nutrient losses, decreased fertilizer requirements, and potential reductions in labor if fewer operations are involved.

In general, costs to individual landowners would exceed these benefits, but Federal and/or State cost-sharing could shift the balance to favor implementation and reduce the economic burden. Indirect monetary benefits to "downstream" users would be difficult to ascertain, but would include increased lake usage due to water quality improvements.

If all cropland in the watershed could be managed to satisfy Soil Conservation Service-designated maximum allowable erosion rates (T—factors), the following estimates of improvement could be realized:

- Gross erosion could be reduced from the current 4.28 tons per acre per year to 2.05 tons per acre per year, a 52 percent reduction

- The annual sediment load to Grand Lake could be reduced from 0.428 tons per acre to 0.205 tons per acre, a 52 percent reduction

- The annual phosphorus load to Grand Lake could be reduced by 9.6 tons, or 40 percent of the estimated total phosphorus load to the lake.

- Long-term water quality improvement.

- Increase in productivity and crop yield for some agricultural land management alternatives.

Livestock Waste Management (Alternative IIIA.2b)

Potential pollution of water courses as a result of livestock operations is particularly critical in the Grand Lake St. Marys watershed due to the widespread presence of animal feedlots. Animal concentration areas are a problem when rainfall runoff carries manure with high concentrations of suspended solids, nutrients, bacteria, and oxygen-demanding materials into surface water.

There are approximately 12,000 animal units producing 236 tons of total phosphorus per year in the lake's watershed. A conservative estimate is that 5 percent of produced phosphorus will be exported to a watercourse if livestock operations are located within 3,000 feet of a receiving stream. Approximately seventy (70) percent of the livestock are so located. Therefore, the annual phosphorus load to Grand Lake as a result of livestock operations is estimated to be 8.3 tons. If discharges from livestock operations can be completely eliminated, a 35 percent reduction in the annual nutrient input to the lake can be realized and result in reduced phosphorus concentrations in the lake.

Proposed State of Ohio Regulations call for zero pollutant discharge from some pollutant sources and minimizing pollution potential for all "concentrated animal feeding operations." Most of the livestock operations in the Grand Lake St. Marys watershed will be subject to the regulations.

The State of Ohio has developed a Livestock Waste Management Guide which helps the livestock operator to make decisions in choosing and operating a livestock waste handling system which controls pollution. In addition, primary benefits to the livestock operator are increased value of manure for crop production, an increase in feed efficiency, and potentially reduced labor requirements. Typical capital investment costs for dairy cows, beef cattle, and swine (the predominant watershed livestock types) are $200 per head, $100 per head, and $20 per head, respectively. Typical annual operating costs per head are: dairy cows, $50; beef cattle, $25; and swine, $5.00. In general, costs to the individual owner/operator exceed benefits. Cost sharing could shift the balance and encourage implementation. Indirect benefits would be to downstream water users, including increased lake usage due to improvement in lake water quality.

Treatment of Tributary Inflows (Alternative IIIA.2c)

This is a method of treating tributary flow with chemical flocculents with the objective to remove phosphorus and suspended sediment by settling them out prior to inflow to the lake. Facilities would be required on each of the five major tributaries to the lake. Several problems exist with this approach, however. Chemical treatment is limited by the extreme fluctuations in flow rate and the need to vary the chemical rate. While actual chemical

addition has a relatively low cost due to low phosphorus concentrations, the process produces sludge that would cause environmental and water quality concerns and facilities for its removal would be cost prohibitive. Treatment facilities would be required capable of treating 43 million gallons per day which is, by comparison, twelve times the design flow rate for the Celina Sewage Treatment Plant, and is therefore physically and economically infeasible by a wide margin.

Other Non-Point Source Controls

Precipitation Phosphorus Control

Precipitation contributes an estimated 780 kilograms of phosphorus or 2.3 percent of the annual total to Grand Lake St. Marys. This phosphorus originates principally outside the lake basin from such sources as wind-induced soil erosion, industrial ash, smoke, certain mining activities, and the addition of organic phosphates to gasoline. It takes the form of particulate phosphorus carried by wind and other input processes which is later removed by rainfall and other precipitation. In general, it can be said that the phosphorus content of direct precipitation on the lake surface, besides being small as compared to other sources, is not manageable or controllable by man. In addition, the availability of phosphorus in rainfall to algae is still in question with researchers.

Goose Population Control

Less than one percent of the total annual phosphorus load to the lake is attributed to waterfowl (primarily geese), but the amount available to the lake system is considered insignificant. Therefore, any program recommending a reduction in waterfowl population on Grand Lake by hazing or hunting is expected to have little impact on lake water quality.

Urban and Suburban Runoff Control

Direct urban and suburban runoff in areas directly adjacent to the lake contributes approximately 3 percent of the total phosphorus load to the lake. In addition, fertilizers, pesticides, detergents, oil, grease, salts, domestic animal wastes, and street litter are carried through ditches directly to the lake. Property owners can have a positive effect on water

quality by reducing the amount of pollutants in stormwater runoff to the lake. This can be accomplished by minimizing fertilizer and pesticide applications, composting yard debris, frequent street cleaning, and using low phosphate detergents.

Dredging (Alternative IIIB.1).

A widespread dredging of Grand Lake St. Marys has been considered since in-lake dredging addresses more planning objectives than any other alternative. In addition to deepening the lake for the benefit of recreation uses, dredging is a potential lake restoration technique for improving water quality by removing the accumulated products of degradation (phosphorus-enriched sediment) from the lake system. It has been determined that Grand Lake St. Marys contains high concentrations of sediment-bound phosphorus. In shallow lakes such as Grand Lake St. Marys, nutrient release from the sediments by wind-generated mixing, boat motors, and bottom scavengers can be a major source of excessive nutrients. Thus, dredging to expose a nutrient-poor layer can, in theory, result in nutrient concentration reductions in the water column. Potential secondary considerations from dredging include decreasing wind-generated wave action and lake shore erosion, improving lake level fluctuations, and improving water-related recreation.

With regard to water quality, the results of modeling the lake system under various scenarios and conditions of external load reductions, sediment mixing (with and without), spoil disposal (in-lake and out-of-lake), and dredging (no dredging, 3 feet of dredging), have indicated that no significant improvements in the phosphorus concentration and related biologically-oriented nuisance condition (proliferation of algae) can be expected from the dredging of bottom sediments at Grand Lake St. Marys. In fact, some degradation of water quality could result if the dredged spoil material is contained within the lake. In-lake disposal appears to be the only practical method since the flat topography and lack of suitable sites inhibit disposal on the watershed. The primary reason for a negative impact on water quality is that any projected wide-scale dredging operation would either remove an insignificant depth of sediment over the entire lake, thereby exposing more of the same phosphorus-laden sediment, or as removing all the accumulated sediment from an inconsequential portion of the lake as is now being done. The analysis of the movement of sediment in the lake due to wind and resultant bottom transport have shown that no significant reduction of suspended sediments can be expected, even for the extreme

case of 3 feet of sediment removal, and, therefore, no noticeable improvement in water quality can be expected as a result of the alleviation of wind-mixing effects by dredging.

With regard to physical improvements due to dredging, flooding of downwind shorelines due to long period set-up of the water surface could be reduced by a wide-scale dredging program, but in conflict with this, results indicate that the existing severe wave action is expected to be aggravated further by extensive dredging of the lake bottom. A similar conclusion is reached regarding erosion of the lake shoreline. Even though wind set-up impacts on the erosive process, a greater concern is intense wave action and the overtopping of erosion control structures. Lake bottom dredging intensifies short-period waves and would be detrimental to shoreline erosion.

Long-term fluctuation in lake levels will not be significantly influenced by dredging. If anything, the situation would be aggravated if dredge spoil is contained within the lake because as the surface area is reduced, the change in water level resulting from a unit increase or decrease in water volume is greater.

The major benefits of a wide-scale dredging program at the lake are associated with water-based recreation. These would include increased boater access to extended portions of the lake, improved boater safety by elimination of shallow (and stumped) areas, enhancement of fish habitat and related recreational fishing in the long-term. Additionally, dredging has the potential for extending wildlife areas by the creation of dredge islands or other new landforms from dredge spoil materials.

The two major constraints to dredging are (1) proper containment and disposal of huge volumes of dredged materials and (2) economic feasibility.

As mentioned earlier, in-lake disposal appears to be the only practical method since the flat topography and lack of suitable sites inhibit disposal on the watershed. A large-scale, lake-wide dredging program, however, may be cost prohibitive. Costs and volumes for comparison are given as follows:

Average Lake Depth, Feet	Cost to Achieve Average Lake Depth	Dredged Material Volume Million Cubic Yards
4	$13,200,000	6.6
6	37,200,000	18.6
8	88,600,000	44.3

An estimated $135,000,000 would be required to remove an average of 3 feet of sediment throughout the lake to achieve an 11-foot average lake depth.

Dredging would have negligible direct monetary impact on nuisance south shore flooding, erosion, and wave attenuation; however, improvements in water-based recreation as a result of a wide-scale dredging program would provide indirect monetary benefits from increased lake usage. A direct benefit of a dredging program would be increased revenue generated from the sale of dredge islands, peninsulas, or other newly created land forms to offset the cost of dredging.

Erosion and Sedimentation Control Alternatives

Erosion control alternatives were investigated for unprotected shoreline, streambanks, and upland areas of the lake watershed.

Shoreline Erosion Protection

In addition to breakwaters previously discussed, other alternatives to eliminate or reduce shoreland erosion are the traditional uses of riprap, gabions, bulkheads (Plate 8, Figures 8A, 8B, 8C) or concrete fabriform mats. Each of these structural measures has the beneficial effect of reducing erosion, protecting against loss of shoreland, and reduction in sediment load to the lake. Of these methods, bulkheads and concrete mats would impair drainage behind them. All methods would contribute somewhat to reductions in access to open water and boat docks, require land to establish desired slope at the shore and cause localized disruption during construction.

In general, shoreline erosion problems are limited to the southshore where bank erosion occurs along the undeveloped shore reaches. Some attempt has been made to riprap these publicly-owned areas, but the success of any program is limited by access problems.

Complete protection of 60,000 feet of currently unprotected, irregular southshore areas would cost $1.62 million for riprap, $2.5 million for gabions, $3.6 million for bulkheads, and $3.74 million for concrete mats. Use of these measures, however, are more cost effective than near shore breakwaters. Treatment of privately-owned shoreline is the responsibility of the owner. Unprotected public shoreline is the responsibility of the State of Ohio.

Streambanks

Tributary streambanks have the lowest protected length among the four categories (streambank, channels, lake shore, and islands) at Grand Lake and therefore, appear the most susceptible to the disposal of erodible material to the lake. Retardation of streambank erosion would be beneficial in stabilizing land bordering the tributary and reducing sediment load to the lake. While the dominant sediment load is watershed soil loss, streambank erosion could increase in the future with progressive development and urbanization of the watershed. This is of particular concern on Coldwater Creek due to the high current and projected rates of development around the municipality of Coldwater. The range of typical costs to completely protect accessible portions of seven tributaries are estimated as follows:

	Feet	(Least Cost) Riprap	(Greatest Cost) Concrete Mats
Coldwater Creek	18,000	$486,000	$1,120,000
Chickasaw Creek	15,000	405,000	936,000
Little Chickasaw Creek	6,000	162,000	374,000
Prairie Creek	9,000	243,000	936,000
Barnes Creek	6,000	162,000	374,000
Monroe Creek	4,000	108,000	250,000

Coldwater Creek should be given priority streambank protection due to high potential for upstream development which will increase peak flow rates and promote erosion of banks.

Watershed Soil Erosion

Conservation practices available through government cost sharing programs include among others: establishing hay or rotation pasture, improving permanent hay or grass stands; strip cropping; terraces; minimum or no tillage practices; winter crop cover; sediment retention structures; erosion control structures; stream protection; sod waterways; grass buffer strips between crops and waterways. The purpose of these conservation measures is to protect and preserve the land for future use and would be effective in controlling sediment and nutrients from entering the streams which drain to the lake. The proper use of the practices and costs involved are dependent upon detailed conservation planning for individual farm units, taking into account the needs and objectives of the individual land owner. Locations where priorities should be given to specific agricultural practices are the Coldwater Creek, Beaver Creek, and Chickasaw Creek watersheds.

Sedimentation Ponds

These physical structures have been considered to reduce the amount of sediment and nutrients entering the lake. The purpose of the ponds is to provide a containment area in which flowing water is slowed long enough to settle large amounts of suspended and settleable particulate matter during runoff events thereby reducing the sediment load to downstream water bodies and providing for easier removal of the collected matter. In addition, sediment ponds would remove nutrients attached to the captured sediments. The long-term effect of these ponds is improvement of the lake's water quality. Adverse impacts of sedimentation ponds are the creation of localized nuisance conditions (weeds), threat of possible washout, need for currently productive land, long-term commitment to operation and maintenance for periodic cleanout and disposal of sediment.

Depending on the design retention time required, estimated total cost of seven sedimentation basins (one each of the major tributaries to the lake) is on the order of $1,280,000 for 4-hour retention and $6,220,000 for 20-hour retention.

DISCUSSION

The purpose of this section is to discuss the more pertinent findings in the related problem categories examined in the Grand Lake St. Marys survey investigation.

FLOODING, BEAVER CREEK

1. Periodic flooding of agricultural land along Beaver Creek is attributed, in part, to a limited flood control capability of Grand Lake St. Marys, poor surface drainage, low stream gradient, inadequate outlet for numerous artificial agricultural drains, and constrictions to flow from vegetation on the banks, shoals, and debris throughout 9.6 miles of the 10.6-mile reach.

2. Flooding problems along Beaver Creek are due to both overbank inundation and subsurface saturation as a consequence of long periods of near bankfull flow in the flat gradient channel.

3. Peak discharges from the Grand Lake St. Marys western outlet are not great enough to cause instantaneous flooding, and are less than would be experienced without the lake. The lake does provide some limited flood control, but extends the period of bankfull flow in Beaver Creek. Current regulation practices for the Grand Lake St. Marys western outlet will reduce natural peak discharges from excessive runoff to a modified condition. Lake outflows are maintained, when structurally possible, to reduce natural Beaver Creek flows to a maximum bankfull flow. Lake storage capacity is estimated to be 1-3/4 inches of runoff (based on total contributing drainage area including the lake) from elevation 869.92 to elevation 870.75 (west spillway crest). Additionally, from elevation 870.75 to one foot above west spillway crest an estimated 2-1/4 inches of runoff storage is available. To deplete stored waters at a net outflow rate of 150 cfs will require approximately 35 days

and 46 days for the 1-3/4 inches and 2-1/4 inches of runoff, respectively. Therefore, the flood control capability of Grand Lake is considered limited.

4. Flood damages to crop, non-crop, transportation facilities, and public utilities in the Beaver Creek reach from its confluence with the Wabash River upstream to the western outlet of Grand Lake St. Marys is estimated at $85,000 annually. Of this total, approximately 74 percent is damage to major crops produced -- corn, soybeans, and hay.

5. Non-structural flood protection measures considered that would modify damage susceptibility, such as weather modification, pre-flood emergency action, flood proofing, evacuation, flood plain zoning, land use regulation, flood forecasting and flood insurance, are not viable solutions because of the agricultural character of the Beaver Creek flood plain.

6. Structural plans considered for Beaver Creek, including detention basins, diversion to another basin, clearing and cleaning, channel improvement and agricultural levees, were all found not to be cost effective means for reducing flood damages along Beaver Creek. This finding is based on Federal cost analysis procedures which tend to reflect higher costs than would locally sponsored projects.

7. The Ohio Public Works proposal to release a greater proportion of lake peak inflows to the St. Marys River Basin through modification of the eastern embankment outlet works and channel is expected to decrease outflows to Beaver Creek, but of such low magnitude as to result in negligible flood control impacts on Beaver Creek.

FLOODING, SOUTH SHORE

1. Periodic flooding occurs along the south shore of Grand Lake St. Marys where the topography and developments are generally at a low elevation. The flooding is attributed to many factors including poor natural drainage plus a high water table, and to a high lake level combined with wind-induced wave action which causes water to run up on the shore with subsequent damage to residential buildings and contents. In most years, the

lake level does not exceed one foot above west spillway crest, but this rise is sufficient to cause flood damages on the south shore.

2. Present annual damages to residences in the form of structure and contents damage are estimated to be $150,000 for approximately 142 private shoreline properties.

3. Non-structural measures such as permanent or temporary evacuation, relocation, flood plain zoning, subdivision regulation, and building codes were considered alternatives to existing impacted properties, but were eliminated from further consideration because these flood plain measures have negligible effects on reducing flood damages to structures currently in the flood plain.

4. Flood proofing, involving waterproofing or raising structures to prevent flood water intrusion, is inhibited by the predominance of single-family frame structures on individual lots and is not cost effective as a primary solution to reducing or eliminating south shore flood damages.

5. The considered structural alternatives such as detention basins, diversion, and shoreline levees are not cost effective methods of preventing or alleviating south shore flood damages.

6. Several plans were examined for modifying the operation of Grand Lake St. Marys in order to reduce flood damages along the lake's south shore and Beaver Creek, as well as for providing greater dependability in obtaining and maintaining the seasonal recreational pool level. It was found that the current operating procedures for lake regulation, consisting of maintaining a lake level about 10 inches below the west spillway crest during the winter months and closing the gates on 15 March for refilling provide an appropriate balance in minimizing flood damages and maintaining a desirable recreation pool.

7. Periodic flooding of the shoreline due to wind setup has been shown to be possible, particularly if the lake water level in Grand Lake is high. Therefore, relief, under these conditions, could be provided by strategic placement of fixed breakwaters such as dredge islands or rubblemound breakwaters. Floating breakwaters would have no effect on wind setup.

8. A fixed breakwater system that spans the length of the south shore is perceived to be an appropriate technical solution for alleviating both south shore erosion and flooding problems due to wave action, but an extensive series of breakwaters about 40,000 feet long and close to shore would be required before benefits based solely on improvements to these two problems could be realized.

9. Fixed breakwaters are not perceived to be economically feasible solely from a flood damage reduction benefit standpoint, but from a recreational usage, water quality and physical improvement standpoint, an expenditure for construction of a properly designed breakwater system would be preferred to the dredging that could be done for the same amount.

10. A fixed breakwater system parallel to the south shore could prove more beneficial for shoreline erosion and flooding problems due to wave action than a groin system placed somewhat perpendicular and connected to the south shore.

11. The Ohio Public Works proposal to release a greater proportion of lake peak inflows to the St. Marys River Basin through modification of the eastern embankment outlet works and channel is expected to create only a slight decrease in lake levels (on the order of 0.1 inch), thereby providing no measurable flood control impacts on the lake south shore.

LAKE WATER QUALITY

1. Lake water quality has been declining in recent years. Four separate water quality problems have been identified as causing the deterioration. Bacterial contamination from human sources threatens body contact recreation, particularly in areas of greatest development. High nutrient concentrations result in severe blooms of algae which cause taste and odor problems. Water clarity is reduced by algae and suspended sediment, resulting in unattractive conditions for recreators. Accumulation of sediment, eroded from upland areas, and unprotected shoreline has reduced the lake depth.

2. The lake's ambient total phosphorus concentration of 178 micrograms per liter (ug/l) remains well above 15 ug/l, the generally accepted threshold level for algal blooms in northern lakes. Continuing nuisance growth of algae in the lake indicates that the problem of cultural eutrophication needs to be resolved.

3. The present phosphorus loading rate of 0.49 gram per square meter of lake surface per year is nearly 1.8 times the rate commonly considered as a dangerous eutrophic rate indicating that phosphorus inputs should be reduced or minimized to slow the cultural aging of the lake.

4. Approximately 33,000 kilograms of total phosphorus are currently contributed to the lake on an annual basis from all sources. Of this total approximately 45 percent is removed from the lake annually via Beaver Creek, the St. Marys feeder canal, direct fish harvest, and absorption into lake sediments. At current estimated rates of phosphorus input and output, approximately 18,000 kilograms of total phosphorus accumulate annually in the lake.

5. Total annual phosphorus loadings to Grand Lake St. Marys from specific sources are estimated as follows:

	Total Phosphorus		Percent
	Pounds	Kilograms	of Total
Precipitation	1,720	780	2.3
Waterfowl (geese)	475	216	.6
Animal Concentration Areas (feedlots)	16,540	7,500	22.6
Agricultural Runoff	46,305	21,000	62.9
Municipal Point Source (St. Henry)	3,195	1,449	4.3
Domestic Point Sources	1,646	746	2.2
Septic Tanks	1,345	610	1.8
Direct Urban and Suburban Runoff	2,394	1,088	3.3
Total	73,620	33,389	100.0

6. Several sources of phosphorus input which were previously thought to be significant, specifically septic tank systems and waterfowl, are contributing only small quantities of phosphorus to the lake.

7. The most significant contribution of phosphorus to the lake appears to be from non-point sources or rural, primarily agricultural land and livestock concentration areas. These areas contribute an estimated 86 percent of the total annual phosphorus load to the lake.

EROSION AND SEDIMENTATION

1. The shoreline in several areas around the lake, particularly State-owned lands along the south shore, is undergoing moderate erosion and needs stabilization. Until lake banks are stabilized and lake fluctuations are controlled, turbidity levels in the lake, due in part to shoreline erosion, will continue to remain high.

2. Erosion of unprotected shoreline areas contributes to the turbidity level of the lake but only when heavy wave action is present. At these times turbidity levels are raised considerably in the immediate area of the erosion, but it is doubtful that the complete stabilization of the lake's shoreline would reduce the turbidity and sedimentation of the lake by any appreciable degree. The major cause of turbidity and sedimentation at Grand Lake is the introduction and subsequent resuspension of sediment from thousands of acres of eroding farm land located in the drainage basin above the lake.

3. The rate of streambank erosion is currently not excessive even though the streambanks of the tributaries to Grand Lake have the lowest percentage of protected length among the four categories of streambank, shoreline, island, and dredge spoil. However, streambank protection can become important in the future and streambank erosion rates could be significantly increased as progressive development and urbanization cause increases in peak discharge rates in the tributaries.

4. Streambank erosion is of particular concern in Coldwater Creek (due to the high current and projected rates of development around the municipality of Coldwater) where noticeable widening of downstream reaches has already occurred.

5. To a large extent, the problems of sedimentation and water quality problems (eutrophication) in the lake are the result of intensive agricultural land use within its watershed. It is estimated that 26,000 tons of sediment and 23 tons of total phosphorus reach the lake annually from agricultural areas. From the standpoint of types of crops being grown, surface susceptibility to erosion is high, with 60 to 70 percent of the cropland area being planted in low density row crops, mainly corn and soybeans.

6. Erosion and sediment loads from boat access channels around Grand Lake St. Marys are not a severe problem since these channels are not subjected to the erosive forces of streamflow and waves, and a large percentage of boat channel lengths has already been protected from boat wake attack. The potential effects of channel erosion are better handled by individual property owners using protection measures similar to streambank protection.

7. Existing islands, although especially susceptible to ice and wind-induced wave erosion because of their small size and exposure from any side, contribute minimally to both the annual sediment load to the lake and the overall recreational usage of the lake. What is in question, however, is the preservation of these islands for their intended long-term use as waterfowl areas.

8. In the case of existing islands, alternatives for preventing continued erosion include retrofitting shore protection measures, allowing the natural loss of the islands to proceed, or developing a large scale plan related to creation of large dredged material containment areas that could include the existing islands within protected dikes.

9. Grand Lake St. Marys is currently a eutrophic water body and can be expected to remain as such until an approximate 60 percent reduction in the annual phosphorus load is realized. This percent reduction is quoted with reservation since the high degree of wind-induced resuspension of nutrient-rich bottom sediments limits the use of generally accepted trophic state criteria.

10. Lake water quality will not be improved by dredging of bottom sediments. In fact, some degradation of water quality could result if the spoil material is contained within the lake. Water quality problems and physical problems would not be significantly impacted by an extensive lake-wide dredging program. The extent of dredging required for large-scale recreation improvement is cost prohibitive.

11. Reducing the nutrient load to the lake is the most effective measure for improving lake water quality. Because of a lack of permanent phosphorus loss to the sediments, and because phosphorus does not appear to be readily available for release into the lake due to the aerobic nature of the lake water, the reduction in the steady-state concentration of total phosphorus in the lake water is proportional to the reduction in the loading rate.

12. Within three years of a reduction in nutrient loads, the total phosphorus concentration in Grand Lake is expected to reach approximately 90 percent of its new steady-state value.

13. The contribution of nutrients from 20 package domestic wastewater treatment plants that discharge directly or indirectly to the lake is minor, being less than 2.5 percent of the total load. The discharge of the treated sewage from these plants will have a negligible impact on the long-range overall water quality of the lake as far as phosphorus load and concentration is concerned. The major concern with these point discharges, according to recent studies (August 1980 by Finkbeiner, Pettis and Strout, Ltd.) is related to high bacteriological concentration which at peak week-end periods of use affect the entire lake. Likewise, potential phosphorus migration from 500 permanent and 169 seasonal septic tank-soil absorption systems is estimated at less than 2 percent of the total phosphorus loading to the lake and is, therefore, considered to be a minor contribution.

14. The implementation of a regional sewage system along the south shore is expected to reduce the existing phosphorus loading to Grand Lake from septic tank systems and domestic point sources by less than 10 percent. Little improvement in the phosphorus concentration or trophic state of Grand Lake would be anticipated as a result of elimination of this source alone. This is not the critical concern, however, since the primary water quality improvement associated with the sewage system is the public health-related reduction in bacterial pollution to the lake.

15. A major unresolved question is whether collection and centralized treatment of wastewater generated along the lake shore, as has been proposed by ongoing Section 201 planning, is feasible because of the financial burden it places on its residents due to the high cost of collecting wastewater from each dwelling, especially where houses are scattered.

16. If all cropland in the watershed could be managed to satisfy Soil Conservation Service designated maximum allowable erosion rates (T–factors), the following estimates of improvements could be realized:

- Gross erosion rates could be reduced from the current 4.28 tons per year to 2.05 tons per acre per year, a 52 percent reduction.

- The annual phosphorus load to Grand Lake could be reduced by 9.6 tons, or 40 percent of the estimated total phosphorus load to the lake.

- Long-term water quality improvement.

- An increase in productivity and crop yield for some agricultural land management alternatives.

17. Agricultural management practices are technically feasible, but results would vary with the practice and individual sites to be treated.

18. Both Mercer and Auglaize Counties rank high as preferred areas for agricultural management practices.

19. The annual phosphorus load to Grand Lake as the result of livestock operations is estimated to be 7,500 kilograms.

20. If discharge from livestock operations can be completely eliminated, a nearly 25 percent reduction in the total annual nutrient input to the lake can be realized and result in reduced phosphorus concentrations in the lake.

21. A mechanism exists, through State of Ohio Regulations, for zero pollutant discharge from some pollutant sources and minimizing pollution potential for all "concentrated animal feeding operations;" however, in general, costs to the individual owner/operator exceed benefits. Public cost sharing is available to assist in offsetting costs because some benefits are to the general public.

22. Treating tributary inflows, directly, with the objective to remove phosphorus and suspended sediment is cost prohibitive.

23. According to estimates in this investigation, less than one percent of the total phosphorus load is attributed to migrating and nesting geese and the amount available to the biological system is judged to be insignificant. Any program recommending a reduction in goose population on Grand Lake St. Marys would have little impact on water quality.

24. Urban and suburban runoff in the Grand Lake St. Marys watershed originates from the Village of Coldwater, portions of Celina adjacent to the lake, and developed direct drainage areas surrounding the lake. The phosphorus loading from these areas makes up an estimated three percent of the total phosphorus loading to the lake.

CONCLUSIONS

The following conclusions have been reached as a result of the Corps of Engineers investigation at Grand Lake St. Marys. The conclusions and subsequent recommendations reflect Corps of Engineers judgments regarding desirable future actions and priorities, not necessarily limited by existing feasibility or authorizations.

BEAVER CREEK FLOODING

Channel clearing and cleaning is the most cost effective measure for reduction of flood damages along Beaver Creek.

LAKE SHORE FLOODING

Nonstructural measures such as raising structures in—place and temporary evacuation in combination with a flood warning system may best reduce structural flooding problems as exist along the south shore.

Shoreline erosion and property damage can effectively be reduced by measures such as rubblemound breakwaters. Consideration should be given to a demonstration project utilizing a partial fixed breakwater system or islands along an affected south shore area.

PHOSPHORUS REDUCTION

Continued efforts should be directed toward phosphorus reduction from sewage wastes. This can be accomplished by regional collection, treatment and disposal outside the lake watershed or by improved on—lot and "package" plant alternatives or a combination of solutions. Because of the relatively high cost of installation of a centralized sewerage

system, the Ohio Water Development has received a grant from the U. S. Environmental Protection Agency to perform additional facility planning and consider alternatives to the proposed centralized system. From the point of view of best lake water quality management, discharge of all sewage effluent to some point outside the lake watershed would be the preferred alternative.

SEDIMENT REDUCTION

Shoreline protection utilizing a combination of protective measures (riprap placed over a thickness of filter material) and no action (allowing the shore to assume a natural angle of repose) offers the best opportunities with priority areas as follows:

1. Portions of Montezuma Bay
2. North exposure reaches of the Mercer County Waterfowl Refuge shore
3. West of Prairie Creek
4. West of Moorman Road
5. West of Behm Road (Duckfoot's Landing)
6. East and west of mouth of Chickasaw Creek
7. Area between South Shore Acres and Channel Isle
8. West of Barnes Creek
9. East embankment recreation area.

Streambank protection should be utilized where erosion is occurring through such measures as streambank fencing, grading and seeding of banks, or rearranging pasture and cropland with priorities in Coldwater Creek and Chickasaw Creek.

Erosion and sediment control practices, in accord with Soil Conservation Service and Ohio Department of Natural Resources standards and specifications, should be utilized at all construction sites.

In-Lake disposal of dredged material appears to be the most practical method of disposal. Riprap should be placed along shoreline facing the lake with additional consideration

given to one or two large islands constructed to serve as breakwaters and then several small islands constructed behind them (riprap shoreline of large islands only).

SEDIMENT CONTROL AND PHOSPHORUS REDUCTION

Management methods for runoff control should be employed in the following areas:

1. Efficient fertilizer and pesticide application – lakeshore residents; areas adjacent to the lake including cropland areas.

2. Composting yard debris – lakeshore residents; areas adjacent to drainageways to the lake.

3. Frequent street sweeping – developed areas adjacent to the lake (Celina, Montezuma, north and south shore); Coldwater.

4. Use of low phosphate detergents – north shore from Harbor Point to Lakeland Beach, Northwood and Sandy Beach; southshore from Village of Montezuma to Southmoor Shores.

5. Reduce sediment and phosphorus loads from agricultural areas by "best management practices" implemented under traditional soil conservation programs.

6. Bring all agricultural land under Soil Conservation Service criteria for allowable soil loss.

7. Investigate measures to increase funding levels of current conservation programs.

8. Consider legislation at the State level to enforce standards to reduce soil loss.

9. Conservation practices should be promoted in the lake watershed through State and Agricultural Stabilization and Conservation Service cost-sharing programs.

10. A detailed inventory of the potential sediment, phosphorus, and animal waste pollution problem areas should be conducted in the lake watershed to more accurately determine the extent of the problem.

11. The practice of conservation tillage and ultimately no–tillage should be encouraged in the lake watershed on properly drained soils.

12. Animals should be housed on or above an impervious base. In no case should runoff from livestock areas be allowed to discharge directly to waterways of the watershed. Methods such as frequent waste removal and storage, direct application to land, manure storage facilities, interceptor trenches, holding ponds and fenced waterways should be encouraged.

13. Priority areas for livestock waste management practices are those within 3,000 feet of waterways where an estimated 70 percent of animal concentration areas are located.

14. Grass buffer strips between row crops and waterways should be encouraged in areas adjacent to Prairie, Coldwater, Chickasaw, Barnes and upper Beaver Creeks.

15. Existing wetlands should be preserved to aid in filtering out nutrients and sediments; priority areas are Chickasaw, Prairie and Barnes Creeks, and small wetlands adjacent to animal concentration areas or critical soil/nutrient areas.

16. Close cooperation is considered necessary between the U.S. Fish and Wildlife Service, the Ohio Department of Natural Resources, and the Corps of Engineers in determining and evaluating suitable dredge spoil sites and project design.

17. The Dredging Operations Technical Support (DOTS) team, an activity of the Environmental Laboratory of the Waterways Experiment Station, U.S. Army Corps of Engineers, Vicksburg, Mississippi, should be consulted as a possible means of assisting the State in preparing a long–range dredging plan for the lake.

18. In-lake dredging should be limited to selective dredging of nearshore zones for lake access, boater safety improvements, and public lands development.

19. The conclusions reached with regard to sediment control and phosphorus reduction provide the basis for consideration of a Section 314 Clean Lakes project.

TENTATIVE RECOMMENDATIONS

Based on the conclusions contained in this report and following coordination with pertinent Federal, State and local interests, whose comments and responses generally concur in the study conclusions, it is recommended that the Corps of Engineers give no further consideration, at this time, to providing improvements in the interest of flooding, water quality, and other water and related resources at Grand Lake St. Marys, Ohio.

EXHIBITS

EXHIBIT NO. 1 Aerial view Grand Lake St. Marys

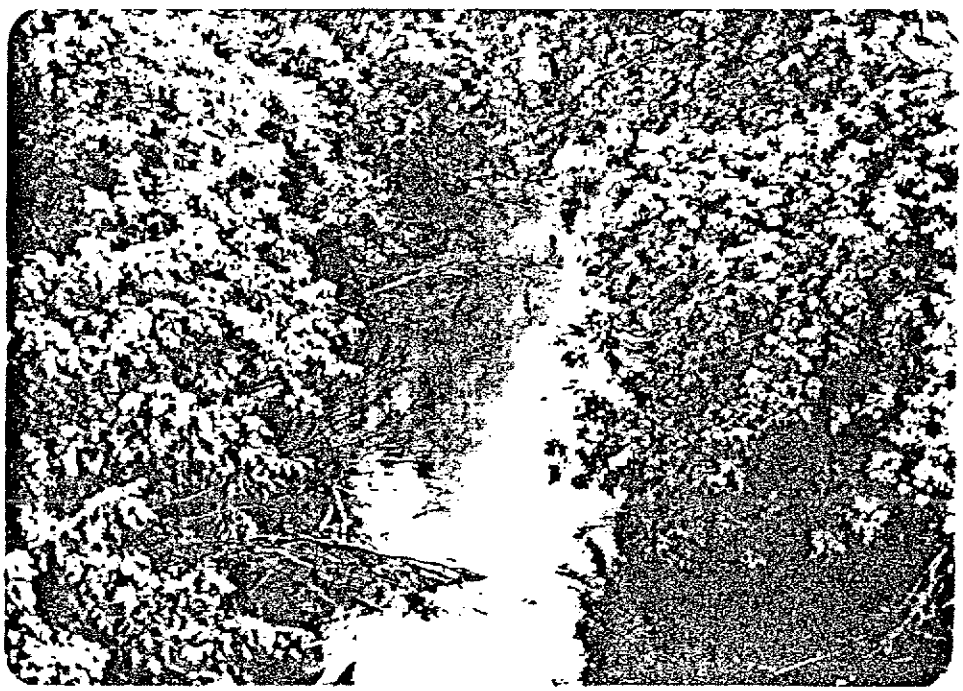


EXHIBIT NO. 2 View of Beaver Creek west from Meyers Road Bridge (April 1979)

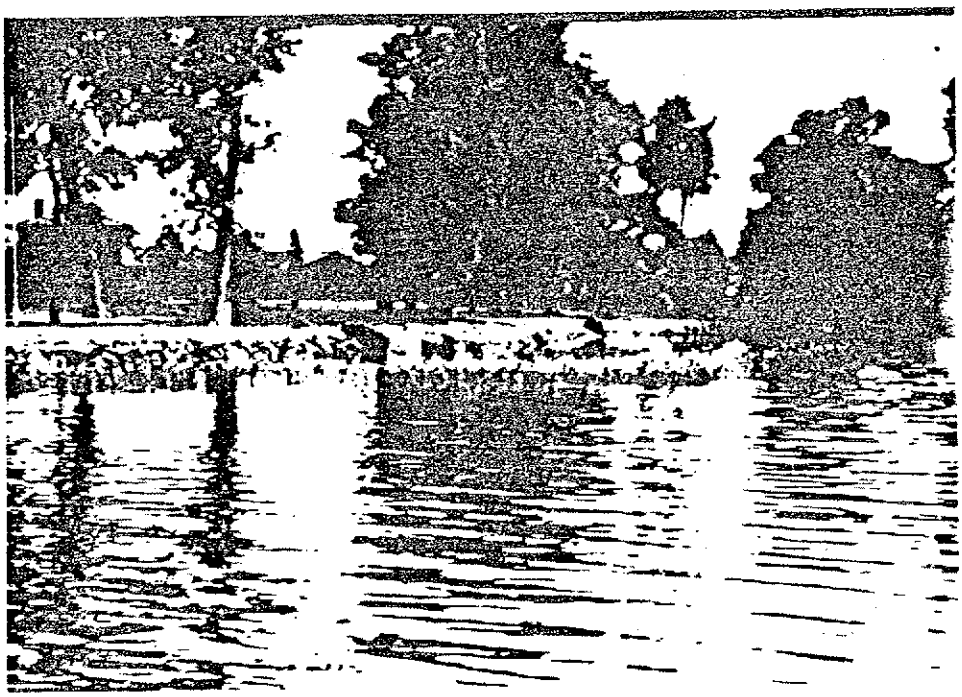


EXHIBIT NO. 3 Low-lying developed area on south shore. Some riprap bank protection. (1979)

EXHIBIT NO. 4 East embankment recreation area showing sloughing banks, the result of waves over-topping riprap. (1979)

EXHIBIT NO. 5 View looking north along east embankment recreation area showing riprap and sloughing banks. (1979)

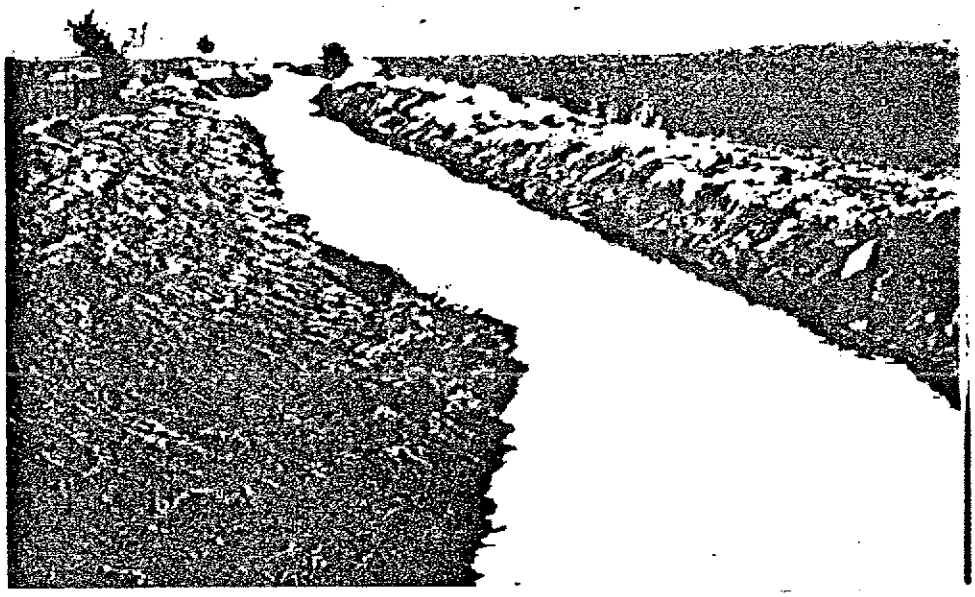


EXHIBIT NO. 6 Little Chickasaw Creek at S.R. 219 showing eroding banks 3,000 feet from lake. (1979)

EXHIBIT NO. 7 Eroding dredge spoil site, south shore. (1978)

EXHIBIT NO. 8 Severe bank erosion on State-owned south shore lands.

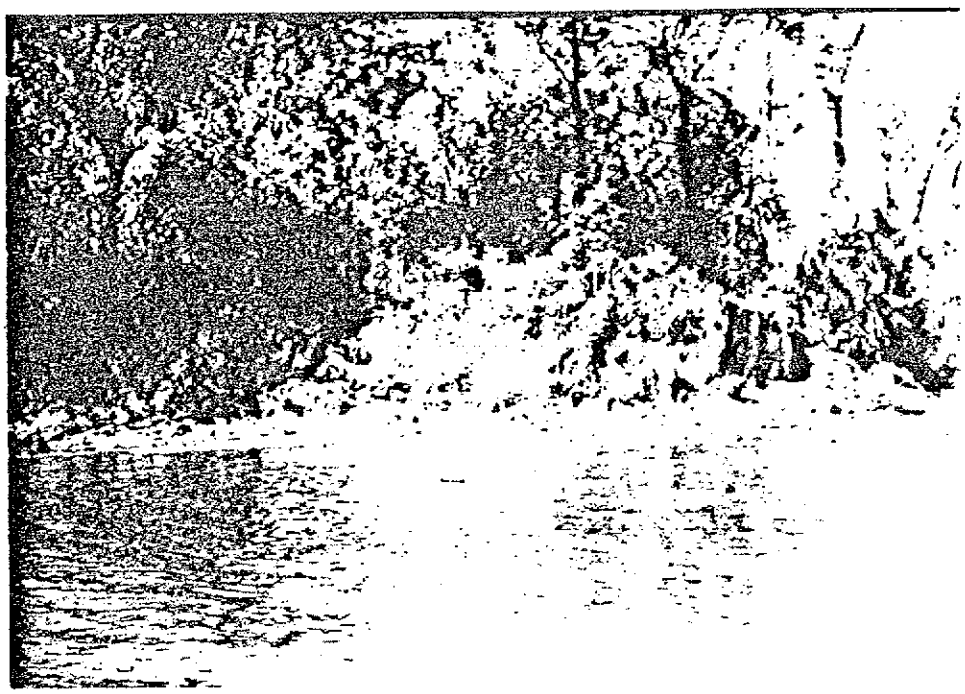


EXHIBIT NO. 9 Severe bank erosion on lake south shore channel inlet. (1979)

EXHIBIT NO. 10 Boat access channels requiring frequent maintenance dredging. (Dec. 1978)

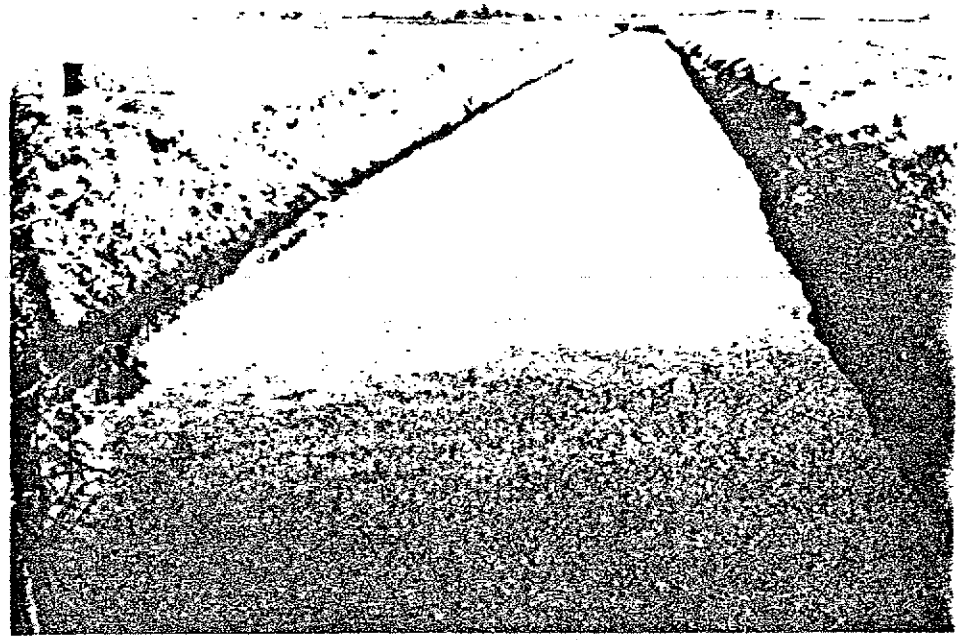


EXHIBIT NO. 11 View of cleared portion of Beaver Creek approximately one mile from lake outlet. (1979)

EXHIBIT NO. 12 Grand Lake State Park on north side near Villa Nova. (1979)

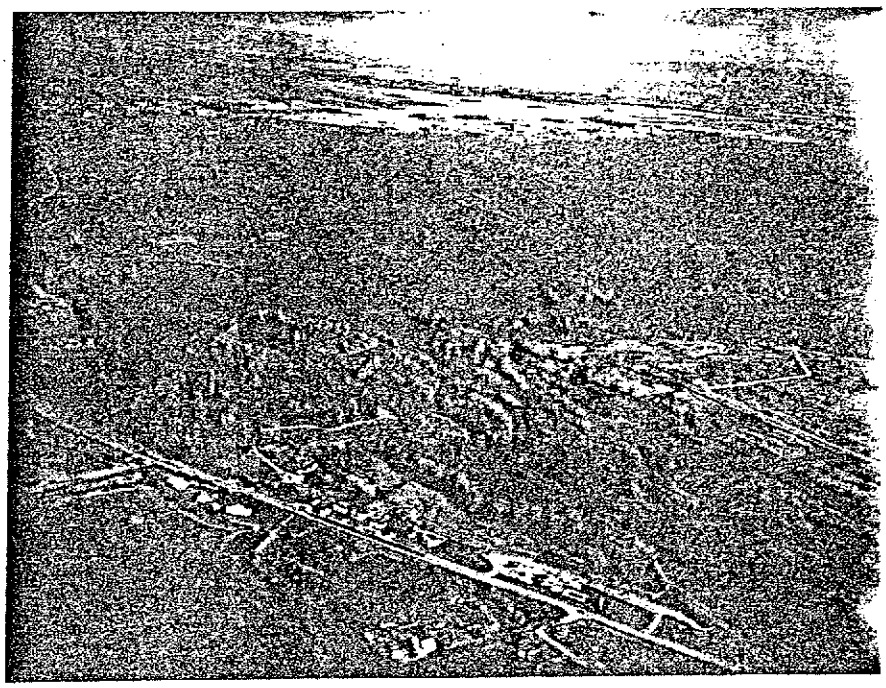


EXHIBIT NO. 13 Mercer County Waterfowl Refuge in Lower Southwest Corner of Grand Lake St. Marys. (Dec. 1979)

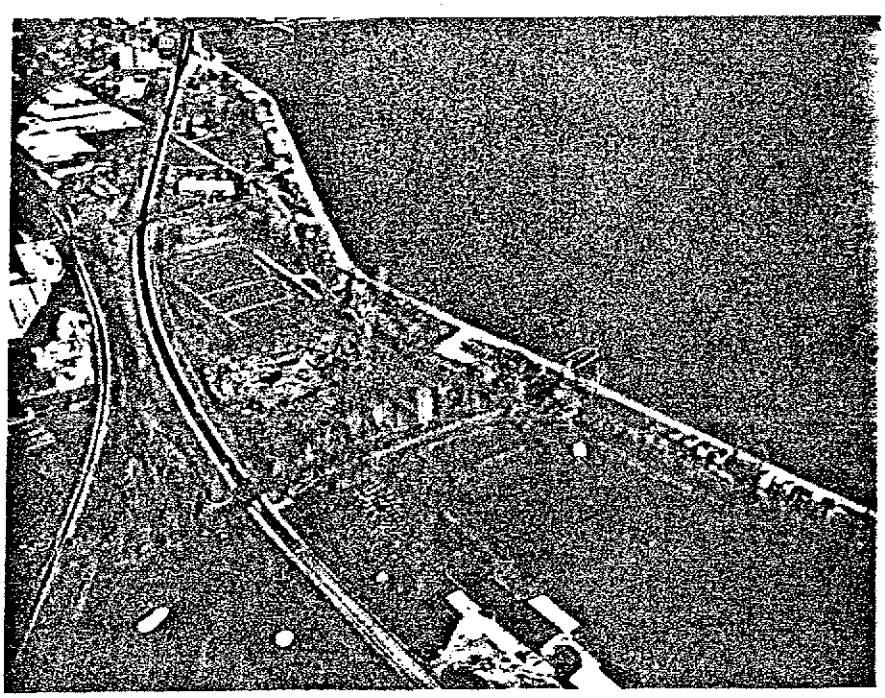


EXHIBIT NO. 14 Western Embankment and Beaver Creek Outlet Channel, City of Celina to the north. (Dec. 1979)

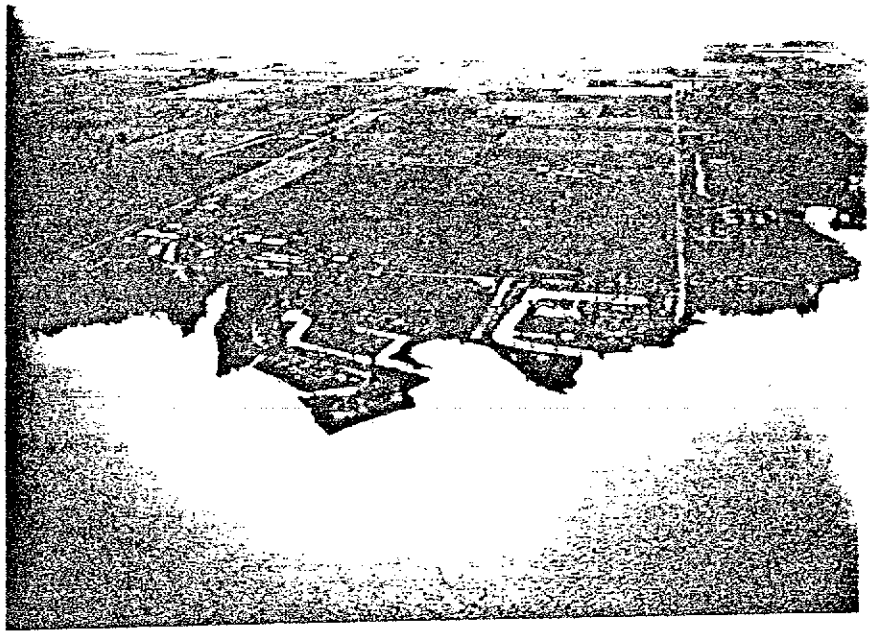


EXHIBIT NO. 15 Development and agricultural lands to the south, east of Windy Point Pier. (Dec. 1979)

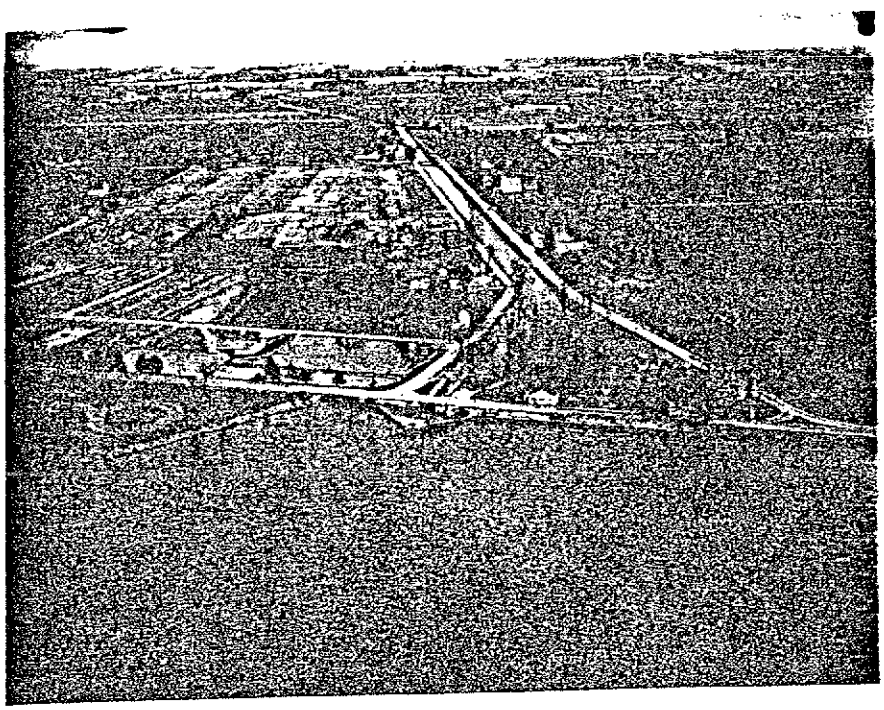


EXHIBIT NO. 16 East Embankment Outlet, St. Marys Feeder Canal and Fish Hatchery. (Dec. 1979)

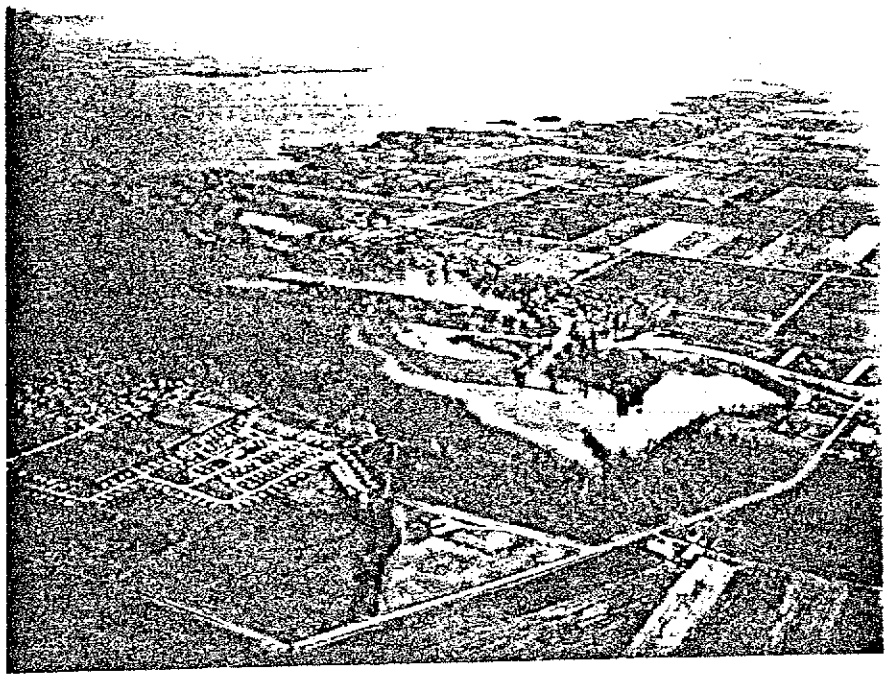


EXHIBIT NO. 17 Grand Lake St. Marys looking to northeast, Montezuma Bay in foreground. (Dec. 1979)

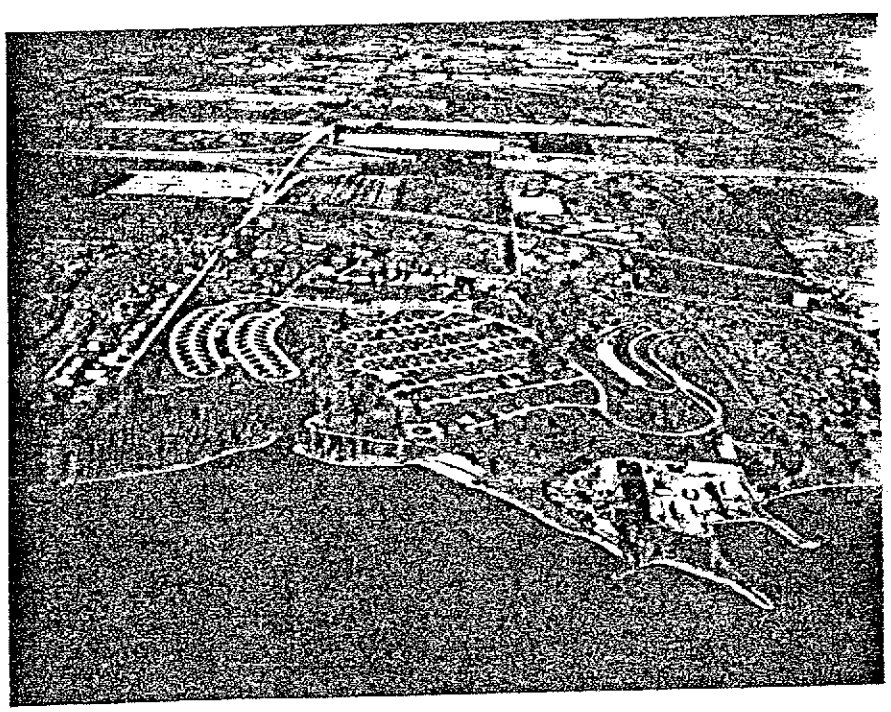


EXHIBIT NO. 18 State Campgrounds and Beach on north shore. (Dec. 1979)

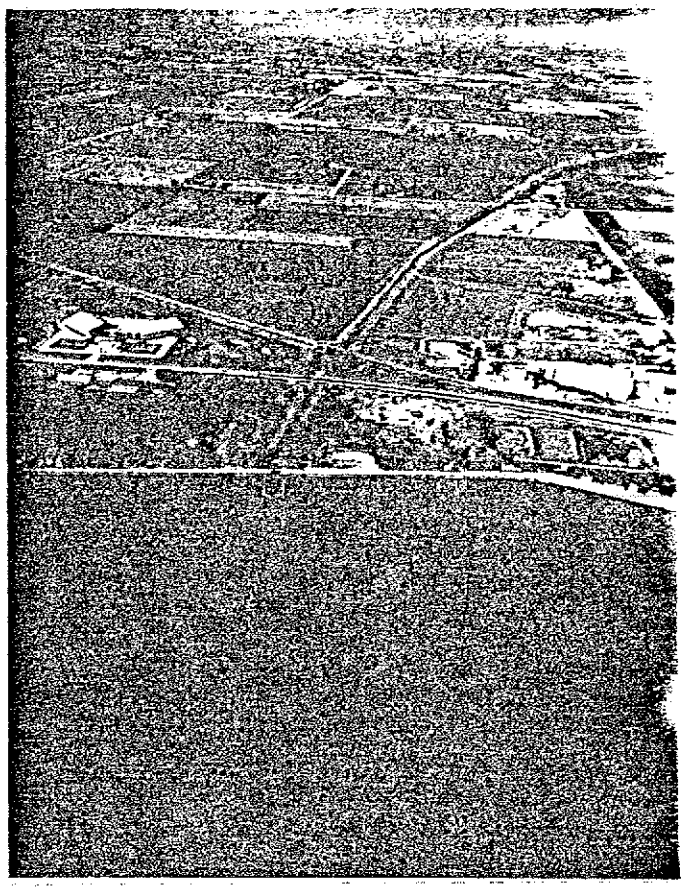


EXHIBIT NO. 19 Western Embankment and Beaver Creek Outlet Channel. (Dec 1979)

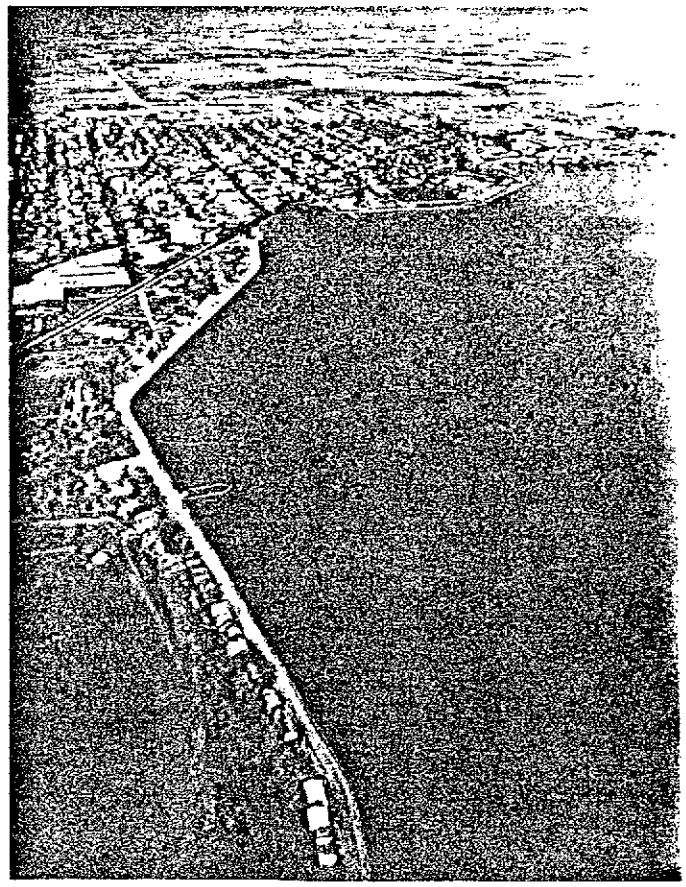


EXHIBIT NO. 20 Western end of Grand Lake and City of Celina (Dec. 1979)

EXHIBIT NO. 21 Wave action and shallow lake areas on north shore, Vicinity of Holiday Park. (Dec. 1979)

EXHIBIT NO. 22 Chickasaw Creek winding through farmland. Lake is on the horizon. (Dec. 1979)

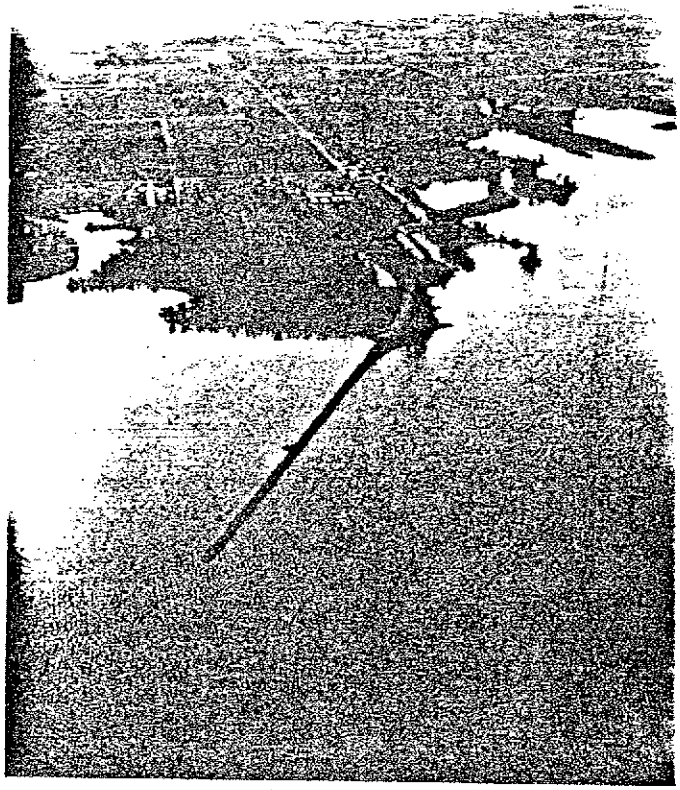


EXHIBIT NO. 23 Windy Point Pier and Recreation Area (Dec. 1979)

EXHIBIT NO. 24 Southwest corner of lake at mouth of Coldwater Creek. (Dec. 1979)

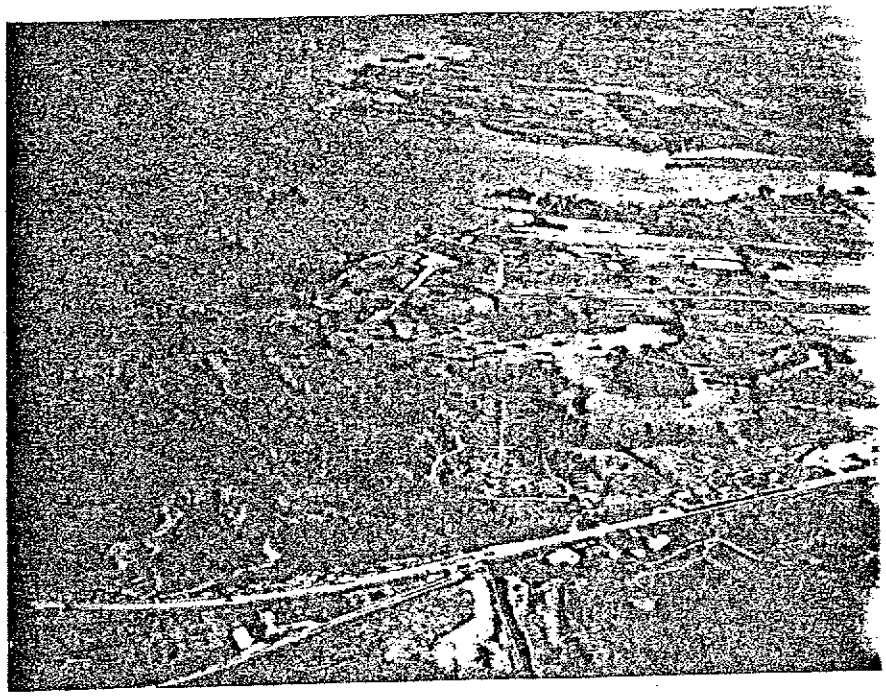


EXHIBIT NO. 25 View of Mercer County Waterfowl Refuge, Route 703 in foreground, Montezuma Bay in background. (Dec. 1978)

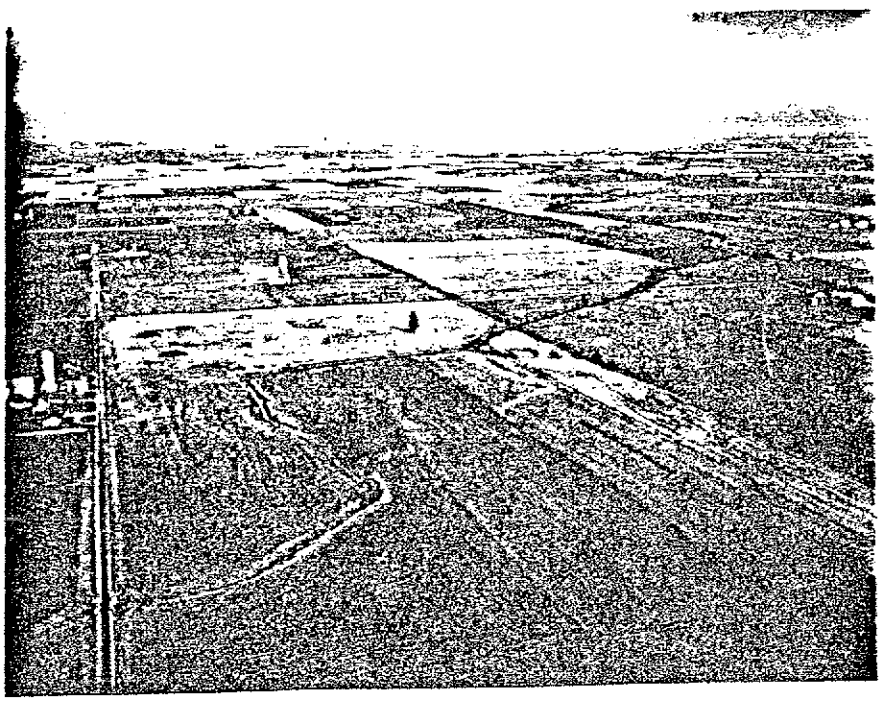


EXHIBIT NO. 26 Chickasaw Creek winding through prime agricultural land south of the lake. Lake on the horizon. (Dec. 1978)

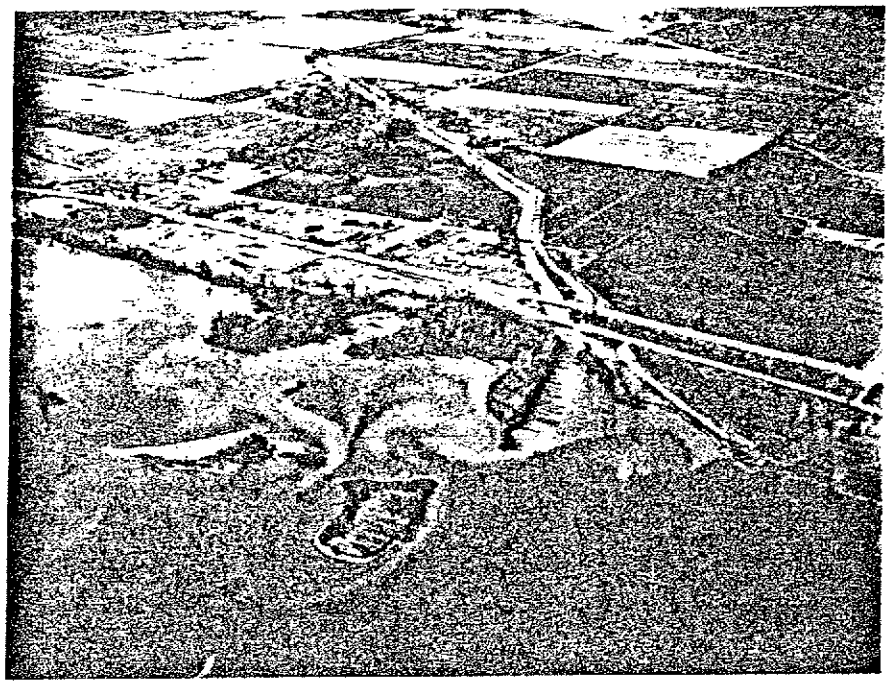


EXHIBIT NO. 27 Mouth of Coldwater Creek at southwest corner of lake. Sediment input to the lake. (Dec. 1978)

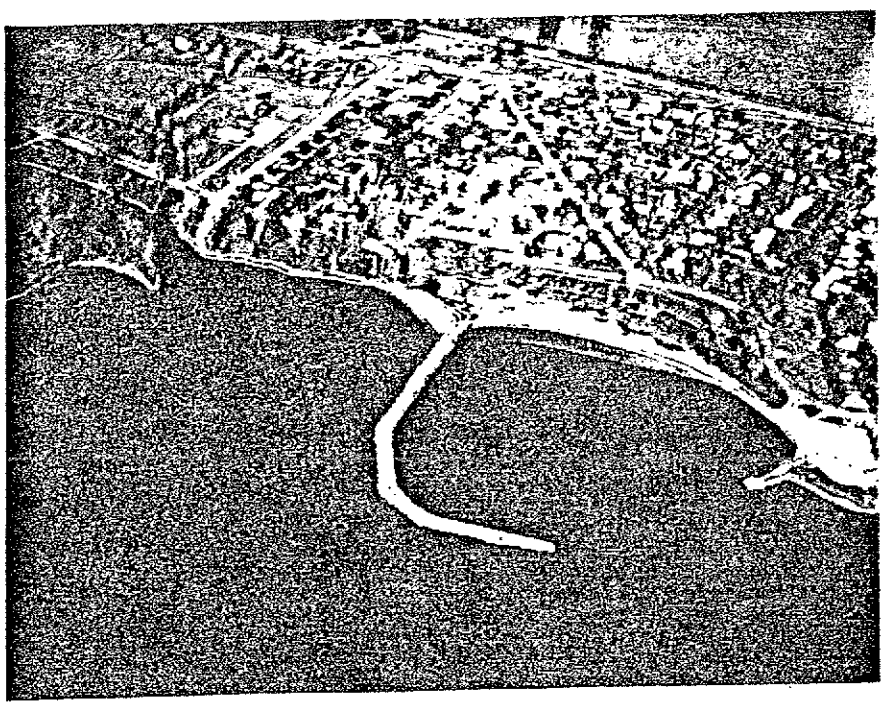


EXHIBIT NO. 28 Beach at State Park on north shore showing good example of protection from wave action. (Dec. 1978)

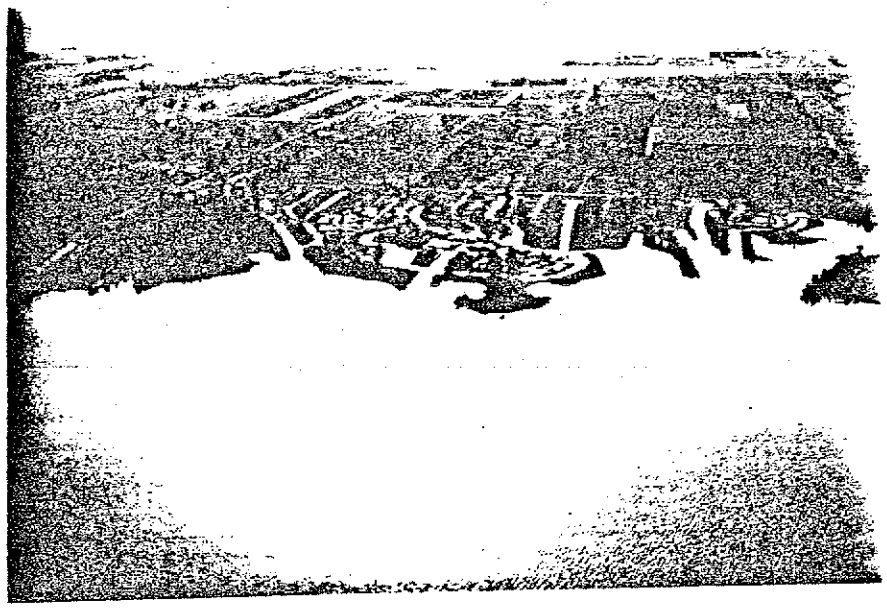


EXHIBIT NO. 29 South shore developments (Moorman Road, Bayview) and adjacent agricultural lands. (Dec. 1978)

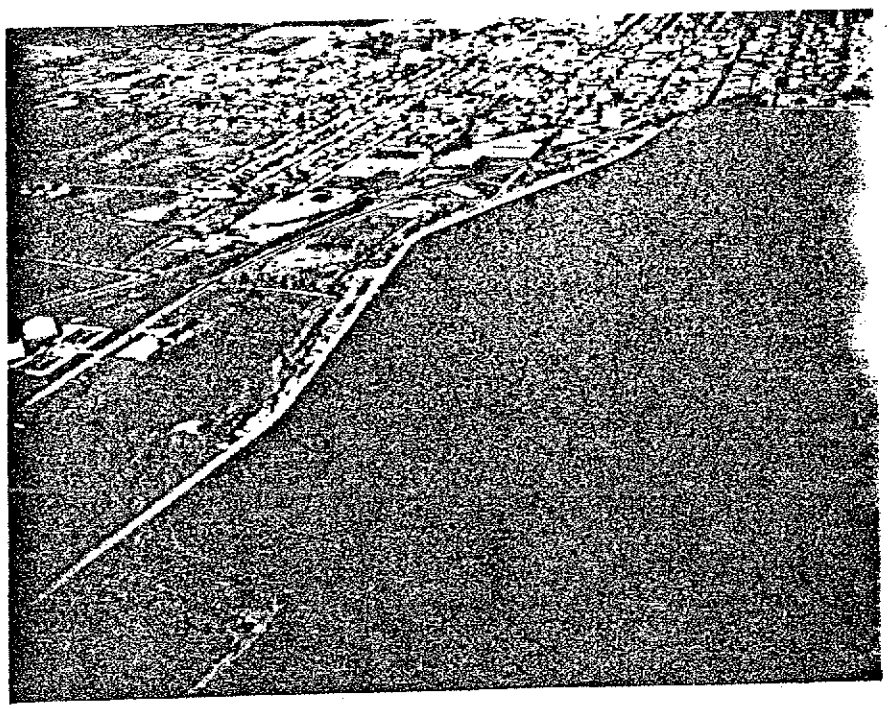
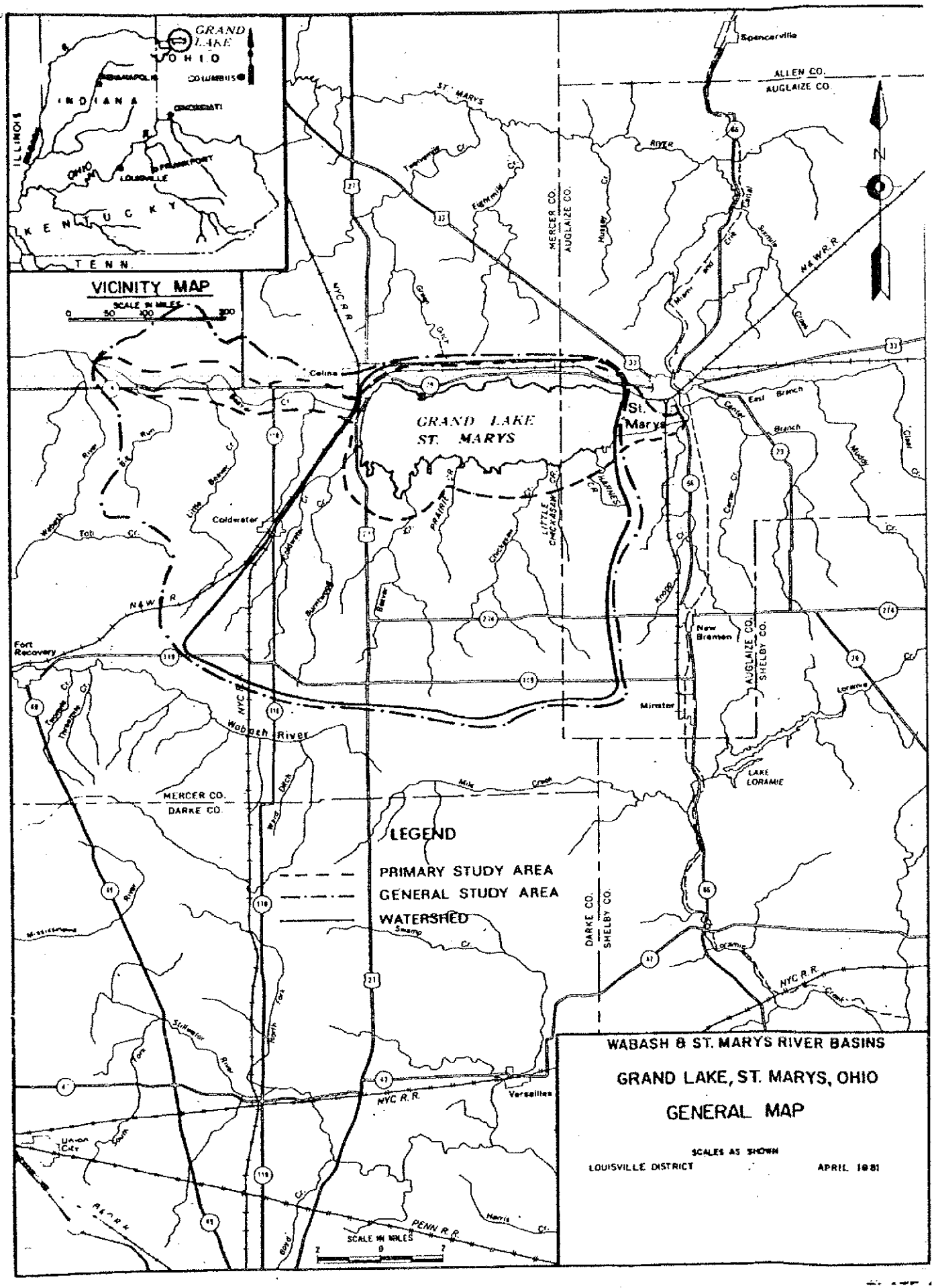


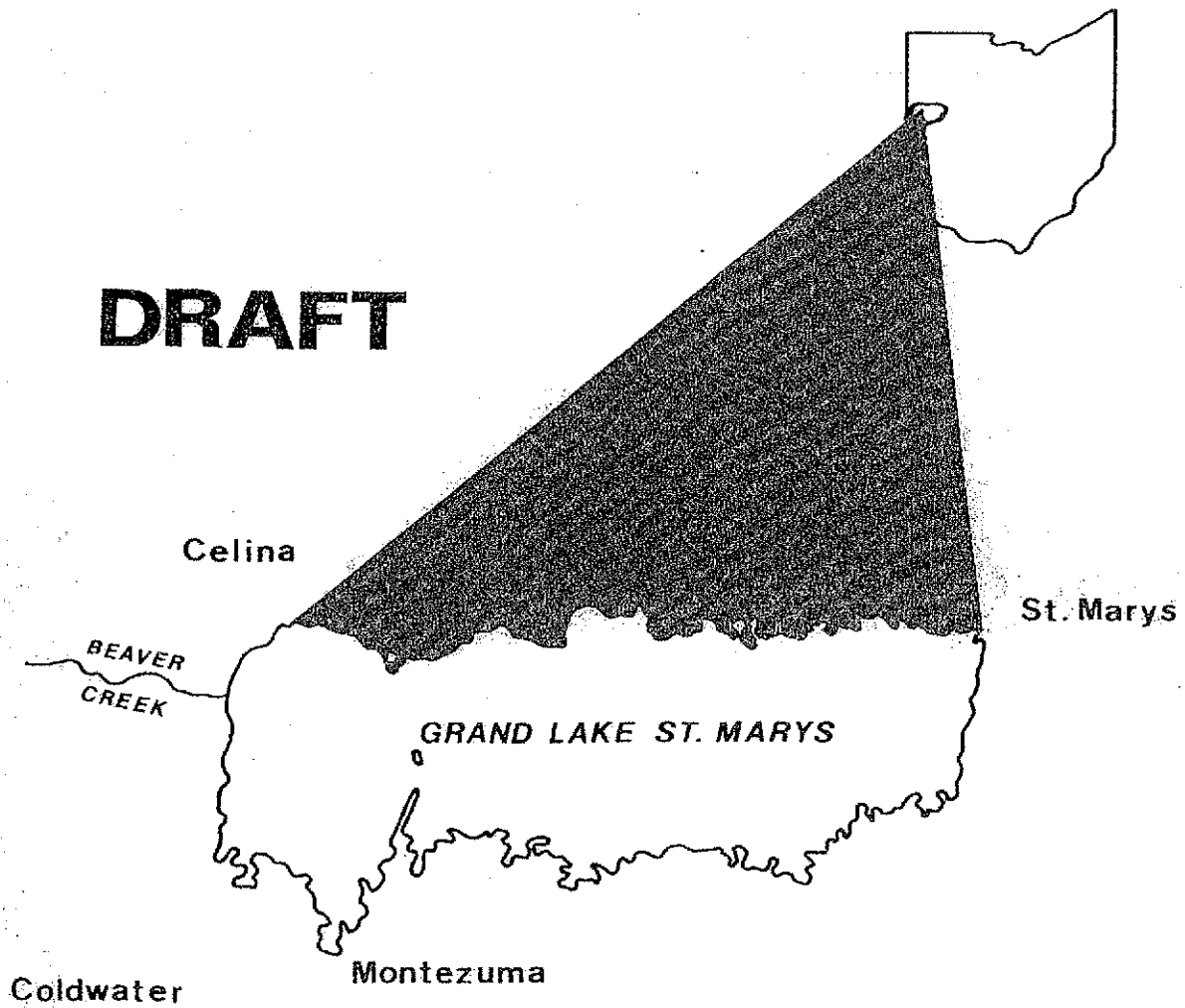
EXHIBIT NO. 30 Western Embankment. Celina, Ohio, at top and public land development in lower left corner. (Dec. 1978)

PLATES


VICINITY MAP
SCALE IN MILES
0 50 100 200
GRAND LAKE
OHIO
COLUMBUS
INDIANAPOLIS
CINCINNATI
INDIANA
ILLINOIS
OHIO
LOUISVILLE
FRANKFORT
KENTUCKY
TENN.
GRAND LAKE ST. MARYS
St. Marys
Celina
Coldwater
Fort Recovery
New Bremen
Minster
Spencerville
Versailles
Union City
LAKE LORAMIE
ALLEN CO.
AUGLAIZE CO.
MERCER CO.
DARKE CO.
SHELBY CO.
Wabash River
St. Marys River
N&W R.R.
NYC R.R.
PENN. R.R.
LEGEND
PRIMARY STUDY AREA
GENERAL STUDY AREA
WATERSHED
SCALE IN MILES
2 0 2
WABASH & ST. MARYS RIVER BASINS
GRAND LAKE, ST. MARYS, OHIO
GENERAL MAP
SCALES AS SHOWN
LOUISVILLE DISTRICT
APRIL 1981

GRAND LAKE ST. MARYS OHIO

DRAFT



Survey Report for Flood Control and Allied Purposes

Volume 1 of 2 Main Report

Ex 3

CORPS OF ENGINEERS

MAY 100

Grand Lake St. Marys, Ohio

MAIN REPORT

Volume 1 of 2

Survey Report
for
Flood Control
and
Allied Purposes

Louisville District Corps of Engineers
Department of the Army

May 1981

SYLLABUS

The purpose of this study was to investigate flood and related water resource problems in the vicinity of Grand Lake St. Marys in Ohio to determine the need for and feasibility of improvements to solve these problems.

The principal areas of concern included flood damage, water quality, and recreation problems. Priority flood problem areas are on the south shore of Grand Lake St. Marys and along Beaver Creek, the western outlet channel of the lake. The Grand Lake St. Marys shore flood problem is caused by the inability of the 10.6-mile long westerly outlet channel to discharge sufficient flood flows to keep pace with inflow to the lake during peak periods plus the effect of wind setup and wave runup on low-lying developed areas when lake levels are high.

Beaver Creek flood problems are caused by a combination of a limited flood control capability of Grand Lake St. Marys, poor surface drainage, low stream gradient, constrictions to flow, and high stream stages for a long period of time which cause inadequate outlet conditions for numerous artificial agricultural drains.

Lake water quality has been declining in recent years. Four separate water quality problems have been identified as causing the deterioration. Bacterial contamination from human sources threatens body contact recreation, particularly in areas of greatest development. The rich nutrient content of the lake results in excessive algal growth which causes taste and odor problems. Water clarity is reduced by algae and suspended sediment, resulting in unattractive conditions for recreators. Accumulation of sediment, eroded from upland areas, and unprotected shoreline have reduced the lake depth.

A range of structural and nonstructural flood damage reduction measures were examined. Nonstructural measures investigated for Beaver Creek are not viable solutions because of the agricultural character of the flood plain. Structural measures considered for Beaver Creek including detention basins, diversion, clearing and cleaning, channel improvements, and agricultural levees were determined to be economically infeasible.

Nonstructural flood plain management measures generally will not improve the flood problems for existing structures on the south shore, but regulations adopted by local governments either voluntarily or as required by participation in the Flood Insurance program could be used to reduce damages to future development. Structural measures such as groins and shoreline levees (dikes) are not perceived to be economically feasible. Fixed breakwaters can be effective in reducing shoreline flooding and erosion, but economic benefits are derived primarily from the potential for increased visitation and not from flood damages reduced.

After having examined various alternatives for modifying the operation of Grand Lake St. Marys, it is concluded that the current operating procedures for lake regulation provide an appropriate balance in minimizing flood damage for Beaver Creek and lake shore and in maintaining a desirable recreation pool.

Lake water quality problems related to nutrient and algae control appear better resolved through reduction of nutrient loads to the lake and in particular control of agricultural and livestock waste sources rather than by in-lake treatment approaches.

Emphasis should be placed on the control of erosion and critical soil loss areas in the watershed and unprotected shoreline areas. An extensive lake-wide dredging program, besides being cost prohibitive, would result in no significant improvement in water quality or flood control storage. In-lake dredging of selected near-shore zones as is currently being performed should be continued for improving lake access and boater safety, public land development, and to keep pace with the current rate of sediment accumulation and redistribution.

No recommendations are made for Corps of Engineers construction projects, nor is there a specific plan selection for short-term implementation by other agencies. It is recommended that the report be made available to Federal, State and local government agencies and regional clearinghouses which have an interest in the control and development of water and related land resources in the area affected by the study.

GRAND LAKE ST. MARYS

SURVEY REPORT FOR FLOOD CONTROL AND ALLIED PURPOSES

AUGLAIZE AND MERCER COUNTIES, OHIO

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May 1981

GRAND LAKE ST. MARYS

SURVEY REPORT FOR FLOOD CONTROL AND ALLIED PURPOSES

AUGLAIZE AND MERCER COUNTIES, OHIO

THE STUDY AND REPORT

PURPOSE AND AUTHORITY

The purpose of this study was to investigate flood and related water resources problems and needs of the Grand Lake St. Marys area and describe the various alternatives considered to help solve the problems.

This report has been prepared in response to Section 217 of the Flood Control Act of 1970 (Title II, Public Law 91–611), dated 31 December 1970, concerning flood control and allied purposes, including channel and major drainage improvements, and floods aggravated by or due to wind or tidal effects.

The State of Ohio, Department of Administrative Services, Division of Public Works, studied possible diversion of greater flows through the eastern embankment outlet and canal system and also repair measures for the Grand Lake lock, St. Marys Feeder Canal, the Kopp Creek culvert, and the aqueduct over the St. Marys River. The project, as yet, has not been funded for construction.

The Ohio Water Development Authority had a report prepared in June 1977 entitled, "Grand Lake Regional Sewer System Facilities Plan," which was a planning study for the conveyance and treatment of sanitary wastes generated within the Grand Lake Regional Sewer System planning area.

The U. S. Environmental Protection Agency developed information on nutrient sources, concentrations and impact on the lake as part of a report entitled, "Report on Grand Lake St. Marys, National Eutrophication Survey."

RESOURCES AND ECONOMY OF THE STUDY AREA

ENVIRONMENTAL SETTING AND NATURAL RESOURCES

The Grand Lake St. Marys study area is situated in Mercer and Auglaize Counties in west-central Ohio on the low watershed divide between the Wabash and St. Marys Rivers (Maumee River Basin) as shown on the General Map, Plate 1.

Grand Lake is formed by a dam at its west end on Beaver Creek and a dam at its east end on Chickasaw Creek which drains to the St. Marys River via the St. Marys Feeder Canal. The impoundment covers the low watershed divide forming a lake with a surface area of some 21 square miles at approximately 870.5 mean sea level (msl). The lake is approximately eight miles in length east to west and averages over two miles in width north and south with a shore line of approximately 55 miles. Average depth of the lake is 6.8 feet. The total drainage area to the lake is some 112.1 square miles, of which over 18 percent is lake surface. Its principal tributaries are Coldwater, Upper Beaver, Prairie, Chickasaw, Little Chickasaw and Barnes Creeks, all entering from the south. The State of Ohio owns the lake, together with a few small parcels of lakefront property. Lake operation is by the Ohio Department of Natural Resources and the Ohio Department of Public Works.

The Ohio Division of Wildlife operates the St. Marys Fish Hatchery and the Mercer County Waterfowl Refuge at the lake. Several areas along the lake are operated as part of the Grand Lake St. Marys State Park. The lake is surrounded by a combination of agricultural, recreational, permanent and seasonal residential, and urban land uses. Beaver Creek, the western outlet channel, descends gradually through agricultural lands of Mercer County before merging with the Wabash River. Principal urban areas include Celina and St. Marys, with 1980 populations of 9,127 and 8,368, respectively. The study area is approximately 100 air miles due north of Cincinnati, Ohio, and 95 air miles northwest of Columbus, Ohio.

The project study area is in the Tills Plain Section. The topography is gently rolling with elevations ranging from highs of 910 feet NGVD to approximately 850. The terrain falls generally toward the lake which has a normal water surface elevation of 870.5 feet NGVD.

The agricultural land adjacent to Beaver Creek is predominantly Defiance–Wabasha silty clay loam which is a very poorly drained soil occupying low lying, level and depressional positions on flood plains. Drainage is difficult to establish due to a lack of suitable outlets on the nearly level topography. Soils in the lake watershed are dominantly in the Blount–Pewamo and Blount–Glynwood soil associations. These soils are nearly level to sloping, somewhat poorly to very poorly drained silty clay loam or clay loam glacial till which have poor bearing values, are subject to occasional flooding and are generally unsuitable for septic tank systems. Agricultural productivity is moderate to moderately high, and although naturally poorly drained, provide good farming when properly drained with tile.

The climate of the area is continental with warm summers and is characterized by abundant precipitation, fairly long growing seasons, and wide ranging annual and daily temperature. During January, the coldest month, the average daily temperature is 27° F., and in July, the warmest month, the average daily temperature is 73° F. Average annual precipitation is 37.5 inches, with rainfall distributed fairly evenly throughout the year. Showers and thunderstorms furnish much of the precipitation during the growing season. Heaviest rains occur in June. Frost-free days average 160 days. The normal rainfall is such that lake water level is relatively stable except during drought and heavy rainfall periods.

Grand Lake St. Marys is far from being a clear lake because of algal growth, turbidity and sediment entry. The proportion of pollutants in the lake has been aggravated by increased agricultural development and population growth. Despite the algal condition of the lake, it is a good warmwater fishery and is used exclusively for recreation and as a municipal/industrial water supply.

Much of the land in the Grand Lake St. Marys watershed is agricultural. Mercer and Auglaize Counties are among the most important agricultural counties in Ohio with cash grain farming dominated by corn and soybeans as the major farm enterprise.

Livestock operations (beef, dairy, swine and poultry) are also major farm enterprises. particularly in the lake watershed.

Less than 10 percent of the land in the Grand Lake St. Marys watershed area remains wooded. Forest areas are comprised of small, isolated woodlots surrounded by corn—soybean dominated farming. Travel corridors for wildlife are, to a large extent, limited to stream corridors. Some mammal species remain common, such as muskrat, raccoon, oppossum, fox and gray squirrel, cottontail rabbit and whitetail deer, although destruction of lakeshore wetlands, the removal of fencerows and large woodlots, and residential development has had adverse impacts upon a number of mammalian species. The area has been one of the best locations in Ohio for observing a diverse group of birds. Because of the lake's large surface area and the excellent wetland habitat surrounding the lake, it has become an important concentration area for waterfowl. The area lies within the Mississippi Flyway, a major north—south migratory route for many passerine species. As such, thousands of migratory ducks and geese use the lake as a resting area during spring and fall migrations.

Endangered or threatened species such as the Eskimo curlew, bald eagle, and the American peregrine falcon migrate through Ohio, but sitings in the area are very rare. The range of one endangered mammal, the Indiana bat, is known to include the study area.

There are no documented archeological sites, either prehistoric or historic, in the Grand Lake general study area and no surveys have been undertaken on lands included in the Grand Lake study area; however, undocumented reports have indicated possible sites in or near Celina and St. Marys. There is a high potential for the existence of undocumented prehistoric and historic archeologic sites, especially in the vicinity of the Beaver Creek—Wabash River confluence; lands on a ridge extending towards Erastus along Beaver Creek; lands adjacent to Montezuma Bay; and lands bordering Chickasaw Creek and other creeks tributary to the lake. A total of 248 historically or architecturally significant sites have been documented in the Grand Lake study area. Of these, three are listed in the National Register of Historic Places, one has been nominated to the National Register, and another is in the process of being nominated.

Grand Lake St. Marys came into being as a reservoir to supply water for the Miami–Erie Canal. Construction started in 1837 and was completed in 1845 at a cost of approximately $528,000 (Clark, 1960). The then 17,500-acre reservoir was for many years the largest man-made body of water in the world. With a current estimated surface area of 13,920 acres, it is the largest inland water body in the State of Ohio. The lake has a long and interesting history and played an important part in the development of the Northwest Territory. The St. Marys River served as a vital link between the Great Lakes and the Ohio River via the Miami–Erie Canal. The lake once supported a vast commercial fishery. The canal era, however, was short-lived as much of the business of transporting goods was taken over by the expanding railroads. The area experienced another boom in the late 1890's when oil was discovered and for a time the lake was dotted with oil derricks. Today a pile of rocks near the center of the lake marks the spot of the last producing well. The lake has gained growing popularity among recreationists and sportsmen since 1915 when the General Assembly of the State of Ohio passed an act through which this body of water and adjacent lands owned by the State were dedicated and set apart forever for the use of the public, as public parks or pleasure resorts.

Today the lake exists primarily for recreation purposes and is a favorite spot for thousands of vacationists from Ohio and neighboring states. It is also the principal water supply for Celina, Ohio, and St. Marys, Ohio, uses lake water for cooling purposes at their power plant. Primary recreational activities at the lake include boating, fishing, picnicking, swimming, winter sports, and camping. Several areas along the lake are operated as part of the Grand Lake St. Marys State Park. Grand Lake St. Marys Park is located along the northeast shore of the lake and provides recreational activities such as camping, fishing, hiking, picnicking, swimming, and boating. Approximately 500,000 persons visit the park annually. In addition, the Ohio Division of Wildlife operates the St. Marys Fish Hatchery located at the extreme eastern edge of the lake. The Division also operates the 1,400-acre Mercer County Waterfowl Refuge at the southwest section of the lake which provides a haven for migrating as well as nesting Canada geese. Thousands of birds stop at this refuge during spring and autumn migrations.

The lake is fairly heavily used, having at least six major marinas, one State campground, a 4–H camp, and two church camps. Fishermen abound during early spring. Hunters vie for licenses and blind privileges during early winter. There are three public beaches on the lake and hundreds of private beach areas.

HUMAN RESOURCES AND ECONOMIC DEVELOPMENT

Out of 88 counties, Mercer County ranks 56th and Auglaize 51st in Ohio county populations with 1980 populations of 38,242 and 42,461, respectively. While there are no large urban developments in Mercer and Auglaize Counties, those areas that are urbanized are located on or around the Grand Lake St. Marys rim, where most of the population lives. Celina, in Mercer County, and St. Marys, in Auglaize County, are the two most populated areas in the vicinity of Grand Lake St. Marys with 1980 census populations of 9,127 and 8,368, respectively. The Villages of Coldwater (population 4,000) and Montezuma (population 270) are also in the study area.

Between 1950 and 1960 the population of the lake area, including Celina and Franklin Township in Mercer County, and St. Marys and Jefferson Township in Auglaize County, increased by 24.4 percent. This compares to a national increase of 18 percent during the same period. However, from 1960 to 1970, the U. S. population increased by approximately 14.3 percent, while that of the lake area increased by only 8.1 percent. For the total period from 1950 to 1970, the U. S. population rose by 34.9 percent, while the lake area population grew by a comparable 34.5 percent.

From Memorial Day to Labor Day, the seasonal vacation population of Grand Lake St. Marys increases by approximately 20,000 persons, nearly matching the permanent population (23,500).

Most of Celina and St. Marys is residential, with the major portion of homes being single family. The land surrounding the lake is predominantly agricultural and open land except those areas immediately adjacent to the lake. A great portion of the lake's drainage area to the south is classified as prime farmland. The land immediately adjacent to the lake consists of many private and commercial settlements, used mostly for recreational purposes. Cottages, campgrounds, and trailer parks are found around the lake, with highest concentrations on the south side. Adjacent to the lake are several permanent, year-round residential subdivisions.

Land around the lake is presently unzoned, and current growth has been random, with no efforts made to control lot sizes or land use. Consequently, developed land abuts areas of undeveloped agricultural land. Because of its attractiveness for recreational use, the land immediately adjacent to Grand Lake St. Marys is anticipated to be used largely for residential and recreational purposes in the future.

In 1970, the labor force of the two-county study area was 29,068, or about 39 percent of the total population. Of this number, 2.6 percent was unemployed, considerably below unemployment levels statewide and nationally.

The major sectors of employment during 1970 were manufacturing (40 percent), service industries, including government and education (19.4 percent), wholesale and retail trade (19.2 percent), construction (5.3 percent), and agriculture, forestry and fisheries (8.1 percent). Mining activities accounted for less than 1 percent of the two-county work-force. Sizeable increases in the manufacturing, trade, and services sectors, with declining numbers in agricultural, forestry, and fishery occupations are typical of the state-wide employment trends in recent decades.

Agriculture and industry promote a successful economy in the study area. Mercer County is one of the leading agricultural producers in Ohio and ranks second only to Drake County in cash receipts. In 1970 the county contained about 2,000 farms, with acreage totalling over 289,000. Industrial development has also helped Mercer and Auglaize Counties to remain economically sound.

Per capita income in 1970 was $2,450 in Mercer County and $2,668 in Auglaize County. During the decade 1970 to 1980, per capita income was projected to rise to $3,580 in Mercer County and to $3,760 in Auglaize County, or 41 percent in both counties. From 1980 to 2000, per capita income levels are expected to show steady gains of some 74 percent in both Mercer and Auglaize Counties. By 2020, the expected per capita income for Mercer County is $10,116 and $10,626 for Auglaize County. These per capita income figures, unadjusted for inflation, indicate about a three-fold increase in levels between the present and the year 2020 in both counties.

The permanent population of the Grand Lake St. Marys study area and vicinity is projected to increase 34 percent from 21,700 in 1970 to 29,095 by 2000. This compares to a projected State-wide population increase of 24 percent during the same period. The population growth in the urbanized and urbanizing areas of both counties (Celina and St. Marys) are expected to be 14 percent lower (20 percent) than the overall population growth rate of the study area. Permanent population growth along the perimeter of the lake will be limited by space and basic service facilities, yet it is anticipated that the perimeter will support a great deal more than the present population. The summer seasonal resident population is projected to increase 54 percent from 17,600 in 1970 to 27,050 in 2000.

PROBLEMS AND NEEDS

The purpose of this section is to define and discuss the water and resource problems, needs and opportunities in the study area, including the status of existing plans of various Federal and non-Federal agencies and improvements desired by local interests. The study authority has indicated that the major water resource problem to be addressed is flood damages but as is true in most areas, there are general needs and desires for additional outdoor recreational opportunities and enhancement and preservation of the existing natural environment.

STATUS OF EXISTING PLANS AND IMPROVEMENTS

Beaver Creek

A Beaver Creek improvement project has been planned by Mercer County and the State of Ohio. The restoration program encompasses a 10.6-mile reach of Beaver Creek and includes clearing and cleaning the channel of flow restrictive debris and shoals together with reshaping the channel cross section and replacement of tile drain outlets. Beaver Creek was last restored in a similar improvement project in 1951 but was not followed by a regular maintenance program. The project cost estimate of approximately $500,000 was tentatively to be shared equally with $250,000 funding by the State of Ohio and matching funds by the Board of Mercer County Commissioners but the state share, to date, has not been funded.

Soil Conservation Service

The Soil Conservation Service (SCS) constructed three single purpose floodwater retarding structures to provide flood protection to 19.3 square miles of the 125-square-mile watershed of the Wabash River upstream of its junction with Beaver Creek. This PL–566 project named "Upper Wabash Watershed," included about 30 miles of major channel improvement on the Upper Wabash River main stem and tributaries upstream of the city of Fort Recovery. Flood plains not protected by this project include the Wabash River main stem downstream of Fort Recovery to the Ohio–Indiana state line and along the entire length of Beaver Creek below Grand Lake St. Marys and was the subject of additional SCS studies. The proposed structural measures include a multiple purpose flood prevention–water quality control structure, a multiple purpose flood prevention–recreation structure, two miles of multiple purpose flood prevention–drainage channel with six drainage pumps, and 13.4 miles of flood prevention channel improvements (Beaver Creek). Costs were estimated at $4,136,500 (1969 dollars) but the project has not been constructed because of lack of a local sponsor.

Grand Lake Regional Sewer System

This is a Public Law 92–500, Section 201 project for U.S. EPA construction grants to build a $14 million-plus, sewage collection and sewage treatment plant expansion and upgrading system for portions of Mercer and Auglaize Counties immediately adjacent to the lake. The original plan divided the lake area sewer system into two portions at the Mercer–Auglaize County line and conveys the Auglaize County flow to the existing St. Marys wastewater treatment facility and the Mercer County flow to the existing Celina wastewater treatment facility. The primary objective of this plan is the protection of Grand Lake St. Marys by elimination of human waste loads to the lake, especially the high coliform content.

The project has met with local opposition because of high costs. The Farmers Home Administration and U.S. EPA have tentatively withdrawn loan or construction grant approval pending additional studies and review for a modified lower-cost project or other alternative wastewater management plans.

Grand Lake/Miami and Erie Canal

The Ohio Department of Administrative Services, Division of Public Works, has had prepared a plan to provide greater flow capacity through the St. Marys feeder canal (the Grand Lake eastern outlet channel) together with significant repair of the eastern embankment lock structure, the Kopp Creek culvert, and the aqueduct over the St. Marys River. A major part of the plan calls for lowering the east spillway crest elevation to that of the west spillway crest elevation in order to "provide an east/west split of uncontrolled discharge capacity which is proportional to the drainage areas contributing runoff to the lake." To date the $951,500 improvement project has not been funded for construction.

FLOOD PROBLEMS

Flooding has been reported for years, not only around Grand Lake St. Marys, but also along Beaver Creek, the lake's natural outlet channel. Periodic flooding of primarily agricultural land along Beaver Creek is attributed to a combination of factors including a very limited flood control capability of Grand Lake St. Marys, poor surface drainage, low stream gradient (1.5 feet per mile), high stream stages which cause inadequate outlet conditions for numerous artificial agricultural drains, and constrictions to flow from vegetation on the banks, shoals, and debris throughout the entire 10.6-mile reach. Flooding problems along Beaver Creek are from both overbank inundation and subsurface saturation as a consequence of long periods of near bankful flow in the flat gradient channel. Peak discharges from the lake's western outlet are not great enough to cause instantaneous flooding, and are less than would be experienced without the lake. However, it often requires several weeks of steady outflow to pass flood runoff from the lake. This condition is sufficient to keep Beaver Creek near bankfull for long periods of time and is damaging to agricultural operations, particularly in the spring and early summer in the flood plain.

Periodic flooding occurs along the south shore of the lake where the topography and developments are generally at a low elevation. The flooding is attributed to many factors including poor natural drainage plus a high water table, and to a high lake level combined

with wind-induced wave action which causes water to runup on the shore with subsequent damage to residential buildings and contents. In most years, the lake level does not exceed one foot above west spillway crest (870.75 NGVD), but this rise is sufficient to cause flood damage on the south shore when the effects of wind setup, seiche effect and wave runup are considered. The recreation-oriented developments around the lake tend to make any lowering of the water surface undesirable.

Lake pool elevation 871.75 was identified as the water surface elevation, together with wind-induced wave action where lake shore flooding begins.

Limited data has restricted the analysis of historical flood events. However, the storms which occurred in March 1913, and were centered near Bellefontaine, Ohio, produced the flood of record for a majority of long–term gaging stations in both northeastern Indiana and southwestern Ohio. The 5–day rainfall total was 11.1 inches at Bellefontaine which is approximately 40 miles southeast of Grand Lake. Available water surface elevation records for the Grand Lake pool began in March 1927 and provide an indication of additional flood periods. The maximum pool level of recorded data occurred on 15 January 1930 at elevation 872.83. The Ohio Division of Parks and Recreation records also note an absence of gate operations during this high water period. This lack of outlet openings produced the maximum attainable pool structurally possible from available inflows. The peak lake inflow, during the period of recorded data, was estimated to be nearly 12,000 cfs. This event occurred on 18 May 1927 and was the result of a high intensity storm of short duration and low volume. This storm produced a peak pool elevation of 871.75 feet NGVD.

Table 1 presents 11 of the 12 observed annual events which exceeded elevation 871.75 for the period of record. Seven of the 12 events occurred during the recreation season.

Local residents and farmers along Beaver Creek were interviewed and reported significant flood events during January 1949, December 1957 through January 1958, March through April 1964, March 1965 and May 1972. Several lesser floods were reported during the June through November months when crop losses are greatest. No gaged data of historical floods are available for Beaver Creek.

TABLE 1

HISTORICAL LAKE POOL ELEVATIONS

Observed Data

Date	Peak Pool Elevation	Days Above Elev. 871.75	Peak Mean Daily Outflow
	(feet)		(cfs)
Jan 1930	872.83	18	300
May 1943	872.67	24	330
Apr 1972	872.67	32	310
Apr 1938	872.42	19	550
Feb 1950	872.42	24	520
Apr 1978	872.17	37	380
Jan 1949	872.08	19	260
Apr 1957	872.08	23	550
Jun 1958	871.92	11	380
May 1933	871.92	5	490
Nov 1972	871.92	9	510

Flood Damages

The areas under consideration include Beaver Creek downstream from the lake and portions of the developed lake shore. The extent of flood damages has been identified by developing hydrologic and field data which considered such aspects as stream characteristics, lake releases, extent and character of the drainage basin and flood plain, projected future characteristics in the case of Beaver Creek and lake levels, wind and wave action and character of shoreland in the case of southshore flooding. These data were used in developing estimated present and future flood damages. Damages were developed for stream reaches and developed shoreland areas shown on Plate 2 in order to identify damage centers.

The Beaver Creek flood damage study extends from its confluence with the Wabash River upstream to the western outlet of Grand Lake St. Marys, a stream distance of about 10.6 miles. Table 2 shows the monetary damages that could be expected to result from the occurrence of three specific flood events (a flood that occurs on the average of once in 5 years, a flood that occurs on the average of once in 10 years, and a 100-year frequency flood). Table 3 provides the average annual equivalent damages that can be expected for each stream reach.

The southshore flood damage study area extends from west of Montezuma Bay (Zeb's Landing) eastward to Barnes Creek (Southmoor Shores) and includes most of the shoreland development in between. Flood damages for the lake shoreline area are attributed to a high lake level combined with wave action and wind setup.

Flood damage surveys were made for selected residences along the shoreline areas. Commercial establishments were not evaluated since most are located either at elevations out of reach of flooding or sufficiently distant from the shore, such that damages are virtually non-existent. The total value of all residences along the southshore is estimated to be $6,000,000. Present annual damages to residences in the form of structure and content damage are estimated to be $150,200 for approximately 142 private shoreline properties (Table 4).

TABLE 2

DAMAGE FOR OCCURRENCE OF SELECTED FLOOD HEIGHTS
BEAVER CREEK, MERCER COUNTY, OHIO
(1980 Conditions and Price Levels)

Reach	Upper Limit of Reach: Geographic	Upper Limit of Reach: Stream Mile	Item	Damage for Specific Flood Height ($1,000): 5-Year	10-Year	100-Year
BC–1	Gause Road Bridge	4.75	Acres	865	985	1,401
			Crop	12.7	14.4	18.3
			Noncrop	9.9	17.6	21.6
			Transportation Facilities	1.5	2.5	8.1
			Public Utilities	5.5	7.1	9.1
			Subtotal Damages	29.6	41.6	57.7
BC–2	Grand Lake Western Embankment	10.6	Acres	1,250	1,338	1,833
			Crop	18.3	18.9	21.6
			Noncrop	2.4	4.0	10.6
			Transportation Facilities	1.4	3.1	11.9
			Public Utilities	2.3	4.3	15.4
			Subtotal Damages	2.4	30.3	59.5
TOTAL ALL REACHES			Acres	2,115	2,323	3,234
			Crop	30.9	33.2	40.0
			Noncrop	12.3	21.6	32.2
			Transportation Facilities	2.9	5.6	20.0
			Public Utilities	7.8	11.4	25.1
			TOTAL	53.9	71.8	117.3

TABLE 3

AVERAGE ANNUAL DAMAGES
BEAVER CREEK
(Present 1979 Conditions)

Damage Category 2/	Reach 1/ BC-1	Reach 1/ BC-2	Damage Totals
Crop	$30,850	$32,350	$63,200
Non-Crop	9,700	3,200	12,900
Transportation Facilities	1,400	1,310	2,710
Public Utilities	3,950	2,240	6,190
Totals	$45,900	$39,100	$85,000

1/ See Plate 2.
2/ Crop – for major crops produced; corn, soybeans and hay
Noncrop – agricultural properties such as siltation of tiles, debris removal, land erosion and repair, surface ditch maintenance, farm roads and levees.
Transportation facilities – roads, fills, bridges, culverts.
Public utilities – after flood maintenance of telephone, gas and electric, and other public utility services.

TABLE 4

AVERAGE ANNUAL DAMAGES
SOUTH SHORE OF
GRAND LAKE ST. MARYS

Location 1/	Estimated Number of Properties Subject to Damages	Estimated Annual Damages 2/
1	10	$ 10,680
2	31	32,500
3	39	42,610
4	14	14,940
5	6	6,900
6	18	15,750
7	12	15,000
8	7	7,480
9	5	5,340
Totals	142	$150,200

1/ See Plate 2
2/ Structure and contents damage

WATER QUALITY PROBLEMS

Based on local observations and on actual data collected on Grand Lake St. Marys, lake water quality has been declining in recent years. This can be seen through increased siltation and algae blooms. Previous studies have shown that the primary contributors to the decline in lake water quality are from phosphorus and sediment. As the water quality declines, the quality of the recreational experience the lake will support will also decline.

The Grand Lake St. Marys area has been the object of several water quality related studies in the past few years. The lake is used primarily as a recreational facility and is administered by the Ohio Department of Natural Resources. Its recreational uses include boating, fishing, and body contact water activities such as skiing and swimming. Another important use is as a water supply source for the City of Celina.

The lake is classified as an exceptional warm water habitat, a public water supply, and as bathing waters. Its tributaries are classified as warm water habitats.

Because the lake has three designated uses, no one set of State water quality criteria is exclusively applicable to it. In the case where several sets of criteria exist for the same body of water, the most stringent criteria apply.

The water quality of Grand Lake St. Marys has been examined in connection with its eutrophication problems. The lake experiences massive algal blooms several times each year, and taste, odor, and fish-tainting problems with the water have been reported frequently. In a survey conducted by the U.S. Environmental Protection Agency on Grand Lake St. Marys, algal productivity was found to be phosphorus-limited during the spring and summer and nitrogen-limited in the fall. The estimated phosphorus loading of the lake (0.49 $g/m^2/yr$) was 1.8 times greater than the commonly accepted eutrophic loading limit of 0.28 $g/m^2/yr$.

In addition to the U.S. EPA study, the Mercer–Auglaize Environmental Research Association monitored water quality in the Grand Lake St. Marys area from 1973 to 1975 at ten locations. In general, the data support the high nutrient loadings found during the U.S. EPA study, but it also indicated significant bacterial pollution of the lake. The average fecal coliform concentrations from 1972 to 1975 exceeded the state water quality criteria for bathing waters (200 coliform/100 ml) at all ten sites sampled. A Master's thesis by James P. Loughran (1973) entitled, "The Analysis of Tributary Outfalls as Possible Sources of Micro–biological Contamination of Grand Lake-St. Marys," concluded that the bacterial pollution of the lake was severe enough to warrant action discouraging its use for primary body contact recreation. Data presented in this thesis indicated that bacterial contamination of the lake was from both human and animal sources, although the relative magnitude of each of these sources was not identified.

The bacterial contamination of the lake has been attributed to the Mercer Wildlife Refuge on Montezuma Bay; however, considering the large number of persons that visit the lake annually and the extensive use of septic tanks in many unsuitable areas along the south shore, it is probable that a large part of the lake's microbiological contamination is due to human waste.

Severe taste and odor problems have been reported with the water of Grand Lake St. Marys. People living around the lake frequently complain of a musty odor in the air and the City of Celina experiences taste and odor problems with both the raw water it withdraws from the lake and with finished water distributed to its customers. Odorous compounds of biological origin known to taint water supplies were reported by A. A. Rosen, et. al in 1970 as being found in Grand Lake St. Marys. These compounds include geosmin and 2–methylisoborneol, which are produced by certain strains of actinomycetes. Although geosmin is characteristically associated with the musty odor of heavy algae blooms in reservoirs, data indicated that 2–methylisoborneol constituted 68 percent of the odor from Grand Lake. In a 1964 taste and odor study of Celina's water supply (Grand Lake) conducted by Finkbeiner, Pettis & Strout, Ltd. algae, either directly or indirectly, were identified as responsible for the majority of the taste and odor problems.

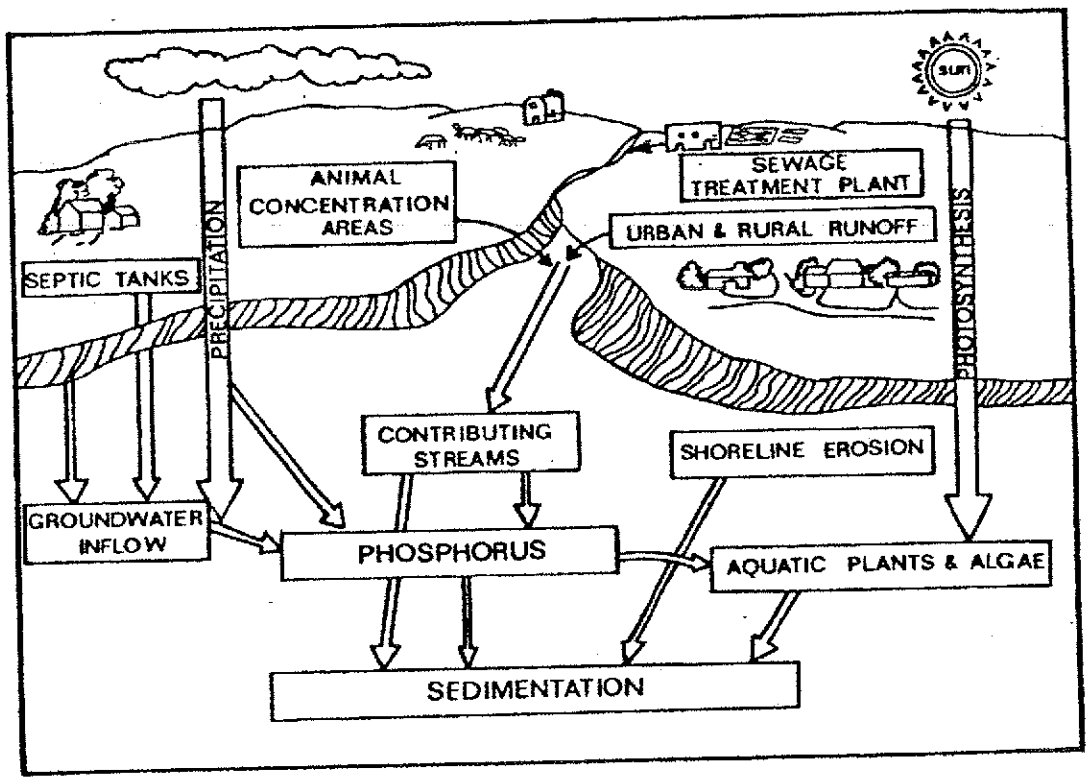
More recent studies undertaken by Finkbeiner, Pettis & Strout, Ltd. in August 1980 on Grand Lake St. Marys centered on water quality adjacent to greatest development and on parameters indicative of human wastes. The investigation confirmed previous studies of lake pollutant loadings and showed that human wasteload originating from lake shore development continues to degrade lake water quality. Bacterial counts confirmed the presence of sewage, creating a problem which at peak use periods affects the entire lake.

In summary, the primary water pollution problems in Grand Lake St. Marys is the eutrophication of the lake as described above. The main water quality problems are associated with nuisance algae blooms and inadequate sewage treatment. Taste and odor problems in the lake have been linked to the algae blooms, which also interfere with recreation and water supply uses. Other information indicates significant bacterial pollution of the lake.

Other than in Grand Lake St. Marys, water pollution problems are associated with Beaver Creek. During dry periods, the flows in the upper reaches of Beaver Creek essentially cease and the only flow in Beaver Creek is the effluent from the Celina wastewater treatment plant. This has resulted in serious water quality problems in the creek, including high levels of suspended solids and nutrient concentrations and low dissolved oxygen. Facilities plans are presently being prepared for improvements to the Celina wastewater treatment plant that will alleviate this problem.

Sources

The drawing below shows a conceptualization of phosphorus and sediment pollution sources which contribute to lake water quality problems.



Phosphorus input sources have been categorized as either "point" or "non-point" sources for purposes of estimating total annual phosphorus loadings to the lake.

Point sources are those which discharge effluent at known locations and include one municipal sewage treatment plant (St. Henry) and 17 small premanufactured (package) treatment plants surrounding the lake, each of which discharge effluent with varying degrees of treatment directly or indirectly to the lake.

Non-point sources include phosphorus from such diverse sources as precipitation, agricultural and livestock areas, waterfowl, septic tank-soil absorption systems, and direct urban and suburban runoff. Phosphorus contained in rainwater falling directly on the lake surface is generally uncontrollable and the ability of algae to utilize the phosphorus is still in

question with researchers. Cropland and animal concentration areas (feedlots) both contribute nutrients and sediments through runoff and erosion. The high concentration and number of waterfowl at Grand Lake has been suspected of contributing phosphorus and bacterial contamination of the lake. Although the concentration of septic tank-soil absorption systems around the lake is generally known, they are considered non-point sources because pollution from them seeps into the lake over a dispersed area. Urban and suburban runoff contributes pollutants after rainfall events from residential areas and streets.

Finally, erosion of watershed lands, streambanks and shoreline contribute sediments which cause turbidity and phosphorus-bound particulate matter which causes the proliferation of odor and taste-producing algae throughout the lake.

Annual Phosphorus Loads

It is estimated that approximately 33,000 kilograms of total phosphorus are currently contributed to Grand Lake on an annual basis. The estimated phosphorus loading rate of 0.49 gram per meter square per year to the lake is nearly 1.8 times greater than the commonly accepted loading limit. This means that Grand Lake St. Marys can be considered eutrophic. The excess nutrient concentration results in increased biological activity and culminates in nuisance algal growths, reduced oxygen content, and noxious tastes and odors. With these conditions the lake may become unacceptable as a source of water supply and recreation.

Of the total phosphorus loading, it is estimated that, on the average, approximately 15,000 kilograms are removed from the lake annually via Beaver Creek and the St. Marys Feeder Canal. At the current estimated rates of phosphorus input and output, approximately 18,000 kilograms of the total phosphorus accumulates annually in the lake.

Several sources of phosphorus which were thought to be significant, specifically septic tank systems and waterfowl, are contributing only small quantities of phosphorus to the lake.

The estimated percentage contributed by each source is identified in Table 5. The most significant contribution of phosphorus to Grand Lake St. Marys and to the rapid rate of eutrophication of the lake appears to be from non-point sources or rural, primarily agricultural land and livestock concentration areas.

TABLE 5

ESTIMATED ANNUAL
TOTAL PHOSPHORUS LOADINGS FROM SPECIFIC SOURCES
GRAND LAKE ST. MARYS, OHIO

Source	Kilograms	Percentage of Total
Precipitation	780	2.3
Waterfowl (Geese)	216	.6
Animal Concentration Areas (Feedlots)	7,500	22.6
Agricultural/Rural Land	21,000	62.9
Municipal Point Source (St. Henrys)	1,449	4.3
Domestic Point Sources	746	2.2
Septic Tank-Soil Absorption Systems	610	1.8
Direct Urban and Suburban Runoff	1,088	3.3
Totals	33,389	100.0

EROSION AND SEDIMENT PROBLEMS

Soil erosion and sedimentation pose major problems to lakes and streams. In bulk, sediment is the greatest single water pollutant nationwide and is no exception at Grand Lake St. Marys. The introduction of sediment to the lake occurs as part of natural watershed processes. However, man's activities which have dictated the land use and manipulated the vegetative cover have greatly accelerated this process over a long period of time by removing protective vegetation from the watershed. The effect of erosion-induced sediment accumulation in the lake is realized in many ways. Physically, turbidity caused by suspended and resuspended sediments decreases light penetration and thereby affects photosynthesis which in turn may reduce oxygen production. Sediment accumulation is suspected of destroying fish spawning areas; curtailing recreational activities, especially boating; reducing aesthetic values; and creating shallower areas which cause an increase in biological activity. Besides the physical effects of sedimentation, fine-grained suspended solids composed predominantly of clays have a high absorption capacity. Sediments may bind or immobilize pollutants and remove them from the water. On the other hand, if the sediments are overloaded with pollutants, they may be released to the water column. In the Grand Lake St. Marys watershed, most soils being of the silty clay loam type would absorb pollutants, particularly phosphorus carried to the lake. The release of these nutrients can also be increased when bottom sediments are stirred up by power boats, carp and other bottom scavengers. Evidence exists which supports the occurrence of these changes at the lake.

Erosion has been identified in six categories of concern to lake users: farm drainage erosion, streambank erosion, lake shoreline erosion, channel erosion, island erosion and dredge spoil erosion.

Farm Drainage Erosion

Erosion of the soils in the lake's watershed consists of moderate sheet erosion. Nearly all waters observed entering the lake have considerable amounts of suspended silt. Watershed erosion from primarily agricultural lands, includes washoff of soils and farm chemicals

dissolved in the runoff. Soil erosion creates economic problems because fertile soil and components are depleted from the surface. Soil erosion creates environmental problems because suspended and dissolved solids affect water quality, sedimentation and shallowing of the lake, and bottom dwelling organisms. Significant improvements in lake water quality are tied to reducing suspended sediment loading from the lake's agricultural drainage basin.

Streambank Erosion

Streambank erosion occurs in the study area although this type of erosion is considered moderate. Soils notable for erosion problems — Blount and Glynwood — occur throughout the lake watershed. The most notable streams having erosion problems include Coldwater, Burntwood, and Chickasaw Creeks. Coldwater Creek banks have developed serious erosion problems due to runoff scour which increases sediment load delivered to the lake.

Lake Shoreline Erosion

Lake shoreline erosion is caused by a number of factors including wind-driven waves, boat wake attack, high water, and winter ice. In general, the north, east and west shores of the lake have adequate bank protection through use of seawalls and riprap. Although a few exceptions are noted along inlet channels and embayments, shoreline erosion problems are limited to the southshore. It is reasonable to state that developed shoreline is protected and undeveloped shoreline is not. Bank erosion along the undeveloped southshore areas is the most dramatic in the study area, with approximately 5-foot vertical drops and uprooted trees observed nearly throughout. Some riprapping of these mostly State—owned areas has been undertaken, but the success of any such program is limited by access problems and funding. The rate of shoreline erosion has not been quantified because of a lack of long-term survey data; however, the amount of unprotected shoreline is estimated at 60,000 linear feet, or 11.3 miles. This represents some 23 percent of the total lake shoreline.

Channel Erosion

This erosion problem results from a combination of factors and affects boat channels, boat basins, and natural inlets in the lake. The shallow depth makes the channel banks susceptible to wave scour. Rapid surface runoff erodes soils and results in silt deposition in natural inlets. Prop wash and boat wakes, together with a general lack of coarse gravels and rock or bottom vegetation contribute to the erodibility of channels and other bottom features.

Island Erosion

Existing islands in the lake are especially susceptible to ice and wave-induced erosion because of their small size and exposure from any side. Except for Safety Island, most all island formations are generally unprotected from these effects. The contribution of sediment to the lake is considered minor compared to other erosion sources, but they are the most susceptible to erosion and should be preserved for their intended long-term use as waterfowl areas.

Dredge Spoil

Dredged spoil material placed in unprotected rows and left unprotected erodes quickly back into channels and into other parts of the lake. Unprotected dredge rows are suspected of contributing sediment back into the lake and channels where turbidity is increased for long periods of time. Contained spoil areas for dredge materials are warranted in a large water body such as Grand Lake St. Marys which is subject to high wind and wave activity.

Summary

Erosion of the unprotected shoreline, streambanks, and upland areas in the watershed contributes to the rate of sediment accumulation in the lake. The estimated annual loading of sediment to Grand Lake St. Marys from tributary streams and upland areas is approximately 26,000 tons. No estimate was made as to the amount of eroded shoreline island or dredge spoil material which accumulates in the lake annually.

Although sedimentation does not appear to be seriously depleting the lake storage, the material accumulates in places where it is especially noticeable and troublesome. Sediment accumulations are most prevalent around the perimeter of the lake where water velocity is low. The combination of shallow water and wind-induced wave action creates circulation patterns capable of eroding and transporting sediments in the lake.

The general problem categories of flooding, lake water quality, and erosion/sedimentation impact on several other water-related problems that exist at the lake. These include: shallowness, siltation, taste and odor, and wind and wave problems, all of which impact on the quality of the recreational experience, water supply, and fish and wildlife resources.

FISH AND WILDLIFE NEEDS

According to the U. S. Fish and Wildlife Service the natural productivity of desirable fish and wildlife resources has declined at Grand Lake St. Marys over the last 75 years. During the early years up to 1900 the lake was used as a very successful commercial fishery with dominant fish being black bass, sunfish, perch and catfish. Between 1890 and 1900, several droughts lowered the lake level considerably causing heavy fish kills, stump and snag removal, and the disappearance of aquatic vegetation. When the lake refilled after the drought, wave action and turbidity increased and the lake changed from a relatively clear, cool body of water to a turbid, warmwater area with increased wave action. The fish population changed to less desirable species (carp, white crappie, bullhead and channel catfish). Since the time the lake was turned over for recreational purposes, in the 1930's, many attempts were made to improve fish habitat, and in recent years fishing has improved greatly. Several decades of intensive efforts were made to replicate earlier conditions which contributed to the lake's excellent fishery resources. This included regulation of angling during spawning seasons, rough fish removal, stocking of fish, and habitat improvement. Despite these efforts, returning the fishery population to its former condition has not been accomplished.

Since the formation of Grand Lake St. Marys, the changes of the fishery population has been as drastic as the changes which occurred to its aquatic environment. With a more degraded condition of water quality and diminished fishery habitat, populations of more desirable sport fish have decreased. Nevertheless, a good warmwater fishery is maintained which provides fishing enjoyment for many thousands of sport fishermen.

Current wildlife habitat populations in the Grand Lake St. Marys area are very much dependent on cover and nesting habitat. Intensive farming in the watershed has resulted in the destruction of necessary habitat to maintain a high density of upland wildlife. The area still provides adequate wetland habitat to make it important for waterfowl population, but this condition must be maintained or enhanced.

With continued development around the lake, the quality and quantity of the existing resource base is expected to erode. The problem is complex; however, degraded water quality and degraded fish and wildlife habitat are two key factors which account for the resource losses. The U. S. Fish and Wildlife Service further concludes that associated wetlands are vital segments in Grand Lake's resource production and perpetuation and will be further jeopardized if reduced or committed to non-resource use.

GENERAL RECREATION NEEDS

The State of Ohio Comprehensive Outdoor Recreation Plan indicates significant deficiencies in realizing the recreational potential for boating, camping, sailing, swimming, and picnicking in the Mercer and Auglaize County area. The Plan, for example, states that the study area "has not developed its full potential because of lake siltation and pollution problems, lack of adequate lands to balance water area and unconsolidated land ownership surrounding the lake." Although a large portion of the lake's 50-mile shoreline has been developed for water–associated recreation, including lakeside residences, public and private beaches and docks, and public park areas, a comparison of visitor numbers at other lake facilities in a 60-mile radius region generally indicates that Grand Lake St. Marys is underutilized. A smaller than usual amount of boating occurs for such a volume of water

as this. The reasons are many and varied, but water-related problems including shallowness, siltation, pollution, submerged objects, odors and wind and wave problems create difficulties with the existing and potential recreational use. Lowering of the lake level, for any reason, is considered a detriment by recreation interests. As discussed in "Water Quality Problems" another detriment to recreation is the periodic growth of blue-green algae in Grand Lake St. Marys.

Review of other study area problems and needs indicated that there was a need to include opportunities for improvement, restoration, or enhancement of overall water quality of the lake as a planning objective as well as erosion control and sedimentation control. All of these objectives are oriented toward enhancing and increasing the potential of water-oriented outdoor recreation opportunities.

IMPROVEMENTS DESIRED

State and local officials and organizations have from time to time since 1970 expressed, through meetings, correspondence, and minor reporting efforts, their desires for improvements to problems in the areas of flood control, drainage, water quality, erosion and water-related recreation. Local interests cite lake water quality problems including adverse odor and taste caused by frequent widespread blue-algae blooms, severe wave action, shallow lake water depths, and erosion as problem areas of primary concern. The State of Ohio, Department of Natural Resources, has indicated that erosion control, pool level control, and nutrient-algae control are the State's primary concerns as related to the lake's primary purpose which is water-related recreation. Local concerns would like to have the water quality improved and the lake level stabilized to enhance recreation potential and control flooding of portions of the lake perimeter. Downstream farmers along the lake's western outlet channel, Beaver Creek, seek relief from periodic field flooding caused by restrictive channel conditions, low stream gradient, inadequate tile outlets and releases from the lake.

Planning Objectives

The primary objectives of this survey investigation were to report to Congress an inventory of the publicly identified water and related resources problems and needs in the study area and to investigate a range of feasible alternatives for resolving water-related problems that may be implemented individually or collectively by local, state, and Federal agencies. The general overall objective is to determine what, if any, feasible, economic measures could be undertaken to restore and enhance Grand Lake St. Marys and its environs as a viable water resource.

For the Beaver Creek and lake shore area, specifically, planning objectives were established to provide for problems and needs which were identified. The authorization for this investigation made particular reference to the flood problems at Grand Lake St. Marys. Therefore, flood control for the south side of the lake and for Beaver Creek was established as a primary planning objective.

FORMULATION OF ALTERNATIVES

The following section is intended to identify and discuss the range of alternatives considered for the three general problem categories of flooding, lake water quality and erosion/sedimentation and the two main problem areas: Beaver Creek and Grand Lake St. Marys. Each alternative discussion contains information where applicable on: description, impacts and effects, costs, economic data and comments on economic, technical, and institutional feasibility. Table 6 is the list of possible measures initially developed. The first subsection, Initial Screening, offers comments on those alternatives which have not been given detailed consideration. The second subsection offers a summary of alternatives worthy of more detailed consideration.

INITIAL SCREENING

Beaver Creek Flooding

Natural Impoundments (Alternative IA.3).

Few natural impoundments exist, either naturally or as might be modified, outside of Grand Lake St. Marys itself, to retard peak flows entering from the uncontrolled drainage area of Beaver Creek. Therefore, this alternative was given no further consideration.

TABLE 6

ALTERNATIVES CONSIDERED

I. DOWNSTREAM FLOODING (BEAVER CREEK)

A. Measures to Modify Flooding Prior to Reaching Critical Damage Areas

1. Detention Basins in Lake Watershed
2. Diversion to St. Marys River via Fourmile Creek
3. Natural Impoundments (NS)
4. Weather Modifications (NS)
5. Lake Regulation

B. Measures to Modify Flooding at Critical Damage Areas

1. Channel Modification
   a. Clearing, Cleaning and Snagging
   b. Channel Enlargement
2. Agricultural Levees
3. Pre-Flood Emergency Action (Flood Fighting) (NS)

C. Measures to Modify Actual Damages (Prevention)

1. Flood Proofing (NS)
2. Permanent Evacuation (NS)

D. Measures to Modify Individual Economic Losses while Permitting Major Damages

1. Flood Forecasting and Temporary Evacuation (NS)
2. Flood Insurance (NS)

II. LAKESHORE FLOODING

A. Measures to Modify Flooding Prior to Reaching Critical Damage Areas

1. Detention Basins in Lake Watershed
2. Diversion to St. Marys River via Fourmile Creek
3. Spillway/Outlet Modification
4. Natural Impoundments (NS)
5. Lake Regulation (NS)

B. Measures to Modify Flooding at Critical Damage Areas

1. Reduce Wind Set-up (Breakwaters, Groins)
2. Protect Low-Lying Areas (Shoreline Levees)

C. Measures to Prevent Actual Damages

1. Flood Proofing (NS)
2. Permanent Evacuation (NS)
3. Structure Relocation (NS)
4. Flood Proofing Future Structures (NS)
5. Flood Plain Management-Future Development

D. Measures to Modify Individual Economic Losses while Permitting Damages

1. Temporary Evacuation (NS)
2. Flood Insurance (NS)

III. LAKE WATER QUALITY IMPROVEMENT

A. Measures to Reduce Nutrient Inflow (External Source Controls)

1. Treatment of Wastewater Inflows (Point Source Controls)
2. Control of Non-Point Sources
   a. Agricultural Land Management
   b. Livestock Waste Management
   c. Runoff Treatment
   d. Other Non-Point Source Controls

B. Measures to Disrupt Internal Nutrient Cycles (In-Lake Controls)

1. Dredging
2. Destratification/Aeration
3. Nutrient Inactivation/Precipitation
4. Dilution/Flushing
5. Drawdown
6. Lake Bottom Sealing

C. Measures to Accelerate Nutrient Outflow

1. Biotic Harvesting of Algae, Aquatic Plants, Rough Fish

D. Measures to Control Erosion and Sedimentation

1. Shoreline, Streambank and Watershed Erosion Control Measures
2. Sedimentation Ponds

NS – refers to nonstructural protection measures.

Weather Modifications (Alternative IA.4).

The effectiveness of identifying and then modifying potential storm centers is not sufficiently accurate at this time to warrant further consideration.

Pre-flood Emergency Action (Alternative IB.3)

There are no established physical emergency actions that can be effectively employed by landowners because potential flooding problems are not localized, but extend throughout the Beaver Creek reach.

Flood Proofing and Permanent Evacuation (Alternative IC.3,-.4).

Since few structures are located along the Beaver Creek reach and none are affected, this alternative is not an alternative to the primarily agriculturally-related flood problems.

Floodplain Zoning, Land Use Regulation (Alternative IC.3).

These alternatives offer little opportunity by themselves along Beaver Creek since major damages occur to cropland and no change or variance in this existing land use is expected in the future.

Flood Forecasting and Temporary Flood Evacuation (Alternative ID.1).

Flood forecasting information is and will continue to be used in the Beaver Creek reach, but the predictive capability of the method in a drainage/lake system such as exists at Grand Lake St. Marys makes this an ineffective solution in reducing flood damages. Temporary evacuation is not a realistic solution to rural, agricultural flood damage problems.

Flood Insurance (Alternative ID.2).

Insurance does not prevent flood damage or future losses, but indemnifies a policy holder for financial losses suffered during a flood. Insurance available through the National

Flood Insurance Program does not cover growing crops, or livestock, and therefore is not available for agricultural crop damages. The Federal Crop Insurance Act of 1980 (FCIA), however, offers farmers new alternatives for reducing crop production risks from natural disasters such as flooding. For the 1981 crop year farmers may elect Agricultural Stabilization and Conservation Service (ASCS) disaster payments, Federal Crop Insurance Corporation (FCIC) payments, or both, depending upon whether their FCIC premiums are subsidized. Beginning in 1982 the ASCS disaster payment program will be discontinued. Disaster payments will be replaced by a crop insurance program which permits farmers to select the level of protection desired and pay a corresponding premium. Mercer and Auglaize Counties will offer the new crop insurance program in 1981 and 1982. Since this Federal program is available to affected farmers, no further evaluation is necessary in this study.

Lake Shore Flooding

Natural Impoundments (Alternative IIA.4).

Few natural impoundments exist either naturally or as might be modified to retard peak flows entering from the lake's watershed. Those that do exist have insufficient capacity to result in flood damage reduction to lake shore property.

Floodproofing Existing Dwellings (Alternative IIC.1).

This involves the modification of dwellings by waterproofing or raising them to prevent floodwater intrusion. Waterproofing measures such as closures and wall structures placed in contact with affected frame-type dwellings are not considered practical or effective protection from the hydrostatic and uplift pressures exerted by waves nor would they provide a secure watertight seal for the crawl space and dwelling at and above the first floor elevation. It has been determined that due to the expense and scope of the requirements inherent in waterproofing, it is also not cost effective as a primary solution.

Permanent Evacuation (Alternative IIC.2).

This alternative involves the purchase of all properties affected, which at the flood damage level, involves some 131 to 142 properties. The alternative was found to be undesirable and economically infeasible. It would require abandonment of desirable shoreline property. The economic analysis showed unfavorable benefit-to-cost ratios of 0.48 and 0.45 with and without conversion of vacated lands to recreation, respectively, making the alternative economically impractical.

Structure Relocation (Alternate IIC.3).

This alternative was eliminated from further consideration since, even though most dwellings are relocatable, most effected structures are not primary dwellings, the desirable recreation objective would be lost and unfavorable benefit-to-cost ratios of 0.77 and 0.76 resulted with and without conversion to recreation, respectively.

Floodproofing Future Facilities (Alternative IIC.4).

As will be discussed below, Mercer County, as a participant in the National Flood Insurance Program, will be required eventually to adopt ordinances or other controls to regulate land use and construction within the 100-year flood plain (land area inundated once per hundred years, on the average). With this alternative, future development would additionally be required to be floodproofed to the level of the standard project flood, which is a flood representing the critical flood runoff volume and peak discharge that may be expected from the most severe combination of meteorologic and hydrologic conditions that are considered reasonably characteristic of the hydrologic region involved. Floodproofing would consist of elevating future buildings on pads or piles, constructing dikes, providing watertight closures and anchorage systems, waterproofing, or using any such method designed to resist inundation. Because expenses would be borne by individual property owners, the increased costs of floodproofing may tend to discourage development in the flood plain. This plan, however, would not protect existing development, and the economic and individual costs of floodproofing new and replacement structures may prove to be excessive.

Temporary Evacuation (Alternate IID.1).

This alternative, while questionable in regard to levels of damages prevented or reduced, does offer a principal means of protecting the personal safety and personal property aspects of risks associated with the type flooding at Grand Lake St. Marys. To be effective, a flood warning system, which gages the critical parameters of lake levels, wind velocity and wind direction, would need to be utilized to signal the threat of flooding. The effectiveness of an evacuation plan and response of the community to it cannot be accurately predetermined and consequently neither can potential flood damage reduction.

Flood Insurance (Alternative IID.2).

Flood insurance does little or nothing to prevent or reduce damages from flooding, but rather indemnifies the insured property owner against economic loss. Participation in the National Flood Insurance Program is a local option in which Mercer County is enrolled in the first or "emergency" phase and limited Federally subsidized coverage is available to all property owners. A Flood Insurance Study (F.I.S.) to convert from the emergency to the "regular" phase has not been scheduled for Mercer County as of February 1981. Auglaize County was identified by the Federal Emergency Management Agency as having flood-prone areas but to date the county has chosen not to participate in the program. Since this Federal program is available to the local governments, no further evaluation in this study is deemed necessary.

Flood Plain Management, Future Development

Zoning, subdivision regulations, and building codes for the lake shore flood plain could be accomplished on the basis of the flooded area. Ordinances could be developed that would allow only certain types of development in different flood zones. Developments such as parks, etc., which will not impede flow or be easily damaged may be permitted. Residential and commercial development could be permitted in areas subject to flooding, but not required for flowage provided that improvements were constructed or flood proofed to provide protection to the levels of protection specified by the public agencies involved. Although this approach will not improve the flood problem for existing construction,

it will help to eliminate or greatly reduce the damages that would have otherwise occurred for future construction. This is particularly important in the study area in light of the potential for increased future development from implementation of centralized wastewater management alternatives. Regulations adopted by local governments either voluntarily or as required by participation in the Flood Insurance Program are considered to be one of the more practical non-structural measures that could be used to reduce future damages.

Lake Water Quality Improvement Alternatives

Lake water quality restoration measures considered but deemed inappropriate for various reasons are described as follows:

Destratification/Aeration (Alternative IIIB.2).

This is a restorative technique applicable to lakes in which the hypolimnion, (the bottom third layer in a stratified lake) is essentially devoid of oxygen. The objective is to artificially increase oxygen levels by mechanical means, thereby promoting the oxidation of organic substances and enhancing biotic distribution. The method is not a viable alternative for Grand Lake St. Marys since (1) oxygen levels in the lake are generally high from top to bottom, (2) the lake does not stratify because of its shallow depth, and (3) the technique would not restore the lake since it treats the symptoms rather than the source.

Nutrient Inactivation/Precipitation (Alternative III 3B.3).

This restorative technique is the physical addition to the lake of some type of chemical or inert material which absorbs or chemically bonds with soluble phosphorus and removes it from the water column. Chemicals such as aluminum sulfate are used to control nuisance algae and plant growth by settling nutrients to the bottom and making them unavailable to plants. Although relatively new as a lake restoration technique, it is essentially an extension of existing wastewater and water supply treatment technologies. The effectiveness of this in-lake treatment process is doubtful at Grand Lake St. Marys for several reasons: (1) the lake is well mixed throughout its depth and the chemical flocs formed would probably not

settle to the bottom as would be required, but would remain in suspension and be shifted to lake shore areas; (2) addition of chemicals such as aluminum sulfate (alum) to lake water would impact adversely on existing water treatment; (3) tremendous amounts of materials would be required (1,500 tons every three years) at a cost of $232,000 per year, and (4) long-term impacts on fish and wildlife are unpredictable.

Dilution/Flushing (Alternative IIIB.4).

Another lake water quality improvement alternative investigated involves replacing the nutrient-rich lake water with nutrient-poor (higher quality) water from another source. The technique is used to prevent algae and plant growth by releasing excess nutrients from the lake. Several factors make this method impracticable for use at Grand Lake St. Marys. First, there is no adequate, dependable supply of dilution water in the region that can replace the lake contents. Second, groundwater is high in minerals, and would not be suitable unless treated prior to introduction to the lake. Thirdly, a low-nutrient water source is not available in proximity to the lake. Surface water supplies such as the St. Marys River and nearby Lake Loramie are undependable, expensive sources.

Drawdown (Alternative IIIB.5).

Drawdown is a technique used for water quality improvement in which the lake level is drawn down to expose and consolidate bottom sediments. It accomplishes several objectives including controlling rooted aquatic vegetation and stabilizing bottom sediments to prevent nutrient release from them. It also results in deepening the lake and increasing lake volume through sediment consolidation and/or removal after the drawdown. The method, however, has several drawbacks which make it unsuitable at Grand Lake St. Marys. It would be difficult to release water from the lake at a greater rate than inflow without causing some flooding downstream in Beaver Creek. There are inadequate outlet facilities to accomplish the drawdown over a short period of time. There would be a loss of recreation, and fish and wildlife resources. More importantly, there would be a significant reduction in now dependable water supply for Celina, severe aesthetic loss, and potentially offensive odors for an extended period of time.

Lake Bottom Sealing (Alternative IIIB.6).

It may be more feasible to prevent nutrient release from sediments by covering the sediments rather than by dredging or drawdown. Sealing, using such methods as covering sediments with polyethylene sheets, sand, clay or flyash, was examined but eliminated from further consideration since cost and material availability would prohibit its use on a lake of this size. In addition, not enough is known as to the permanance and stability of the treatment and the effects these sealants have on bottom living organisms and fish spawning areas.

Biotic Harvesting (Alternative IIIC.1).

Algae harvesting by mechanical means has been considered as an alternative for improving water quality, but is impractical at Grand Lake St. Marys because of the large lake surface area and widespread dispersal of algae blooms. Aquatic plant harvesting has also been discarded because of a lack of concentration of growth at the lake. The few aquatic plant areas that do exist should be preserved as habitat for bottom organisms, young-of-the-year fish, and wildlife. Harvesting of rough fish such as carp, which release nutrients by disturbing bottom sediment, has not been sufficiently studied to evaluate its impact on water quality and expected nutrient reductions.

ALTERNATIVES CONSIDERED IN DETAIL

This subsection discusses alternatives given active and more detailed consideration either because they have been suggested by local, regional and state interests, or because they would appear to have technical merit.

Flood Control

Structural plans considered for Beaver Creek and lake shore together, included detention basins, diversion and spillway/outlet modifications. In addition, non-structural reservoir regulation alternatives were examined. Structural plans considered for Beaver Creek

alone included channel improvement alternatives (cleaning, clearing and snagging; and channel enlargement), and agricultural levees. Structural plans considered for lake shore alone included breakwaters, groins and shoreline levees.

Detention Basins on Tributaries (Alternative IA.1).

Detention basins refer to structures in which runoff from the lake's watershed would be stored in the basin during peak flood flows and released downstream to the lake as soon as conditions permit. The purpose is to reduce flood damage on the lake rim and store runoff that would otherwise be released through the lake to Beaver Creek. The ultimate objective is to prevent the lake level from rising more than one foot above west spillway crest. This elevation, 871.75, is the start of lake shore flood damage. With this plan, detention reservoirs would be constructed on four tributary streams, namely Coldwater, upper Beaver, Chickasaw, and Little Chickasaw Creeks, as shown on Plate 3, controlling areas of 9.3, 18.9, 15.3, and 6.6 square miles, respectively, for a total of 50.1 square miles or 45 percent of the total lake drainage area. Studies determined that those sites were not economically feasible to adequately reduce Beaver Creek and lake shore flooding and the costs of such a system would greatly exceed benefits. Total cost for constructing the four reservoirs was estimated at $14,800,000; average annual costs would total about $1,400,000. Considering that average annual equivalent damages are $235,000 for Beaver Creek and lake shore, this alternative would not be economically feasible. Adding recreation and sediment control benefits to the plan would still not result in a favorable project.

Diversion to Fourmile Creek (Alternative IA.2).

A plan consisting of diverting excess flow from the lake to another basin was also considered. The primary objectives were to reduce flood damages along Beaver Creek by allowing outflows from the lake in proportion to the historic drainage areas of the lake (59 percent Wabash River Basin, 41 percent St. Marys River Basin) and also prevent the lake level from rising more than one foot above the existing west spillway crest elevation which is the start of lake shore flood damages (elevation 871.75). This plan consisted of diverting lake overflows to the St. Marys River via Fourmile Creek as shown on Plate 4. The plan requires a new outlet structure and approximately 2 miles of deep-cut channel connecting the lake pool, through a portion of the State Park west of Villa Nova, to Fourmile Creek near U.S. Route 33. Total first cost of this plan is estimated at $3,500,000 and

average annual costs total $299,000. Since total annual costs exceed potential annual flood damage reduction benefits for both Beaver Creek and lake shore ($235,000) the diversion plan was eliminated from further consideration.

Spillway/Outlet Modification (Alternative IIA.3).

This subject has been addressed in a report prepared in August 1979 for the Ohio Department of Public Works as previously discussed under "Status of Existing Plans and Improvements." The plan as proposed includes replacement of the existing east bank bulkhead with a new concrete ogee spillway having the same crest elevation as the present west spillway (870.75) and channel improvements providing greater flow capacity through the St. Marys Feeder Canal. According to the report the proposed modification provides for a west/east split of lake outflow equivalent to 59/41 percent which is the percentage of Grand Lake St. Marys drainage area tributary to the Wabash and St. Marys River Basins. The modification, according to the report, results in: (1) decreases in the outflows to Beaver Creek, (2) approximately the same maximum lake elevation, and (3) greater increases in east outflow to the St. Marys Feeder Canal.

The modification is expected to decrease outflows to Beaver Creek but of such low magnitude (on the order of 5 cfs and 15 cfs for 25-year, and 100 recurrences, respectively) as to result in negligible flood control impacts on Beaver Creek. In addition, because the expansive lake surface is capable of storing large volumes of inflow, the modified east spillway, though giving a large increase of east outflow, creates only a slight decrease in lake levels (on the order of 0.1 inch) thereby providing no measurable flood control impacts on the south shore.

Lake Regulation (Alternative IA.5).

Several plans for modifying the operation of Grand Lake St. Marys for flood control were investigated. The objective of this alternative is to reduce flood damages along the lake shore and Beaver Creek, as well as providing greater flexibility and dependability in obtaining and maintaining a stable seasonal recreational pool level.

A regulation schedule or plan of operation was apparently non-existent during the early years. However, after examining a 51-year record of pool elevations, it has been

noted that there has been increasing emphasis on lake regulation during the last 15 to 20 years, with a corresponding emphasis for recreation and agricultural considerations. The existing "rule curve" includes a one-foot drawdown from recreation pool elevation 870.75 beginning the first of November. However, after the one-foot of flood storage is attained, minimal effort is exercised to maintain elevation 869.75 through the winter months. A practice of impounding some excess runoff early in the calendar year, to aid in attaining recreation pool by late March or early April, appears to prevail.

Alternatives considered in this study have included variations in (1) winter pool drawdown which would provide additional flood control storage, (2) initiation of pool filling to attain recreational pool requirements, and (3) controlled releases from the west spillway outlet to reduce flood damages along Beaver Creek and also south shore. Development, analysis and evaluation of hydrologic and hydraulic relationships of observed conditions for the period of record, existing operation schedule, and the variations of drawdown, filling, and releases revealed that the current operating procedures for lake regulation as followed by the State of Ohio provide an appropriate balance in minimizing flood damages for Beaver Creek and lake shore and maintaining a desirable recreation pool.

Clearing, Cleaning and Snagging (Alternative 1B.1.a.).

This channel improvement alternative consists of removal of flow-obstructing objects such as debris, logjams, shoals and bank vegetation for the purpose of restoring the channel to provide better hydraulic characteristics for Beaver Creek. Some excavation and reshaping would be required in addition to extensive replacement of tile outlets. Stump removal would not be included in order to preserve streambank stability and fish and wildlife habitat to the extent possible. This alternative, while being the least costly of channel improvements, was found to be the least effective in reducing flood flow heights and provides only short-term solutions since new growth and obstructions require that the operation be repeated at some later time. Total first cost of this alternative for 9.6 miles of channel improvement is $1,000,000. Average annual costs would total $97,000. Annual flood damage reduction benefits from the alternative would amount to $38,000. Since annual costs exceed annual benefits, this alternative is economically infeasible.

Channel Enlargement (Alternative IB.1.b).

This alternative was investigated for the purpose of increasing the Beaver Creek carrying capacity while lowering creek stages for better tile outlet discharge. The plan seeks to reduce agricultural flood damages. Two channel sizes were investigated. The smaller channel would have a bottom width of 40 feet at the upstream limit and 65 feet at the downstream limit. Total capital costs would be $1,610,000 and average annual costs would be $228,000. Annual flood damage reductions would be $70,800 making the alternative economically infeasible. The larger channel would have a bottom width of 60 feet at the upstream limit and 70 feet at the downstream limit. Total first cost is $5,342,000 and average annual costs would be $523,000. Average annual benefits of $77,100 are considerably lower than average annual costs making this alternative economically infeasible.

Agricultural Levees (Alternative IB.2)

Agricultural levees provide a possible means of reducing agricultural flood damages related to overbank flows. The plan examined consisted of 12.5 miles of levee, as shown on Plate 5, affording a 10-year level of protection for 1,148 acres along Beaver Creek. Total first costs are estimated at $4,000,000 with average annual costs of $308,000. Annual benefits attributed to the plan in the form of damages prevented amount to $60,700. Since average annual costs exceed average annual benefits, this alternative is economically infeasible.

Breakwaters (Alternative IIB.1).

The use of breakwaters at Grand Lake St. Marys was considered primarily as a measure to reduce shoreline flooding caused by wind set-up. Flooding of the shoreline due to wind set-up has been shown to be possible, particularly if the lake level is high. Breakwaters also have potential to reduce shore erosion by dampening wave impact forces and they can also improve water quality by reducing lake turbidity. For recreation, breakwaters could create stillwater areas for boating, thereby increasing boater safety, and providing access to deeper water for fishermen. Breakwaters also provide an obstruction to ice movement.

MERCER COUNTY
RELATOR LAND PARCELS

☆ DONER, ET AL

NUMBER	PARCEL	OWNER	TOWNSHIP
1	42-000200.0000	ADAMS RICHARD L & NANCY L	Washington
2	42-000600.0000	ADAMS RICHARD L & NANCY L	Washington
3	26-045300.0000	GAUCHER FARMS INC	Jefferson
4	42-077000.0000	GAUCHER FARMS INC	Washington
5	26-011000.0000	DONER WAYNE ET AL	Liberty
6	26-011700.0000	DONER WAYNE ET AL	Liberty
7	26-012000.0000	DONER WAYNE ET AL	Liberty
8	26-012500.0000	DONER WAYNE T	Liberty
9	26-012500.0000	DONER WAYNE T & JANET K	Liberty
10	26-041200.0100	EMBERSON LAWRENCE J & JOYCE A	Jefferson
11	26-041200.0000	EBBING STANLEY M & VICKI L	Jefferson
12	26-041200.0100	EBBING STANLEY M & VICKI L	Jefferson
13	26-040000.0100	ELLER CARMEN N & JILL K	Jefferson
14	26-041200.0000	GAUCHER HAROLD CONNIE/D & MARY C	Jefferson
15	42-004000.0000	GARRODS EMERY J ESTATE & TRUSTEES	Washington
16	26-041400.0000	HIGHLEY ROBERT E & PATRICIA L	Jefferson
17	42-000300.0000	HIGHLEY ROBERT E & PATRICIA L	Washington
18	42-000300.0100	HIGHLEY ROBERT E & PATRICIA L	Washington
19	26-040000.0700	HINES JAMES C & CARLY A	Jefferson
20	26-040000.0700	JOHNSMAN DANIEL W	Jefferson
21	26-024700.0000	JOHNSMAN DAVID & JOSEPH TRUSTEES	Jefferson
22	26-000900.0100	JOHNSMAN JOSEPH LEE & JOHNSMAN DAVID ALDEAN	Jefferson
23	26-000900.0100	JOHNSMAN JOSEPH LEE & JOHNSMAN DAVID ALDEAN	Jefferson
24	26-000300.0000	JOHNSMAN LEROY J & RUTH TRUST	Jefferson
25	26-017400.0000	KARR JEAN A TRUSTEE & BANDOTTOM WILLIAM J	Liberty
26	26-017000.0000	KARR JEAN A TRUSTEE & BANDOTTOM WILLIAM J	Liberty
27	26-000200.0000	KNAPKE CRAIG M & ANGELA M	Liberty
28	26-000600.0000	KNAPKE CRAIG M & ANGELA M	Liberty
29	26-000400.0000	KNAPKE MARK L TRUSTEE	Liberty
30	26-000300.0000	KNAPKE TIMOTHY ALAN	Liberty
31	27-010000.0000	KROGER THOMAS L & CONSTANCE	Jefferson
32	27-010000.0000	KROGER THOMAS L & CONSTANCE	Jefferson
33	42-000300.0000	RUSH GARNELL DEAN	Washington
34	42-000300.0000	RUSH MARK L	Washington
35	26-017400.0100	RUSH MARK/BRIAN EMC	Liberty
36	26-046000.0000	LAIN LINDA S ETAL	Liberty
37	26-000600.0000	MCDONOUGH DAVID J & DEBORAH A	Jefferson
38	26-027000.0000	MCNEILAN DAVID J	Jefferson
39	26-027000.0000	MCNEILAN DAVID J	Jefferson
40	26-027000.0000	MCNEILAN DAVID J & LAURA S	Jefferson
41	26-027000.0000	MCNEILAN LAURA J	Jefferson
42	26-052000.0000	MOSER CHARLES J	Jefferson
43	26-052000.0000	MOSER CHARLES J	Jefferson
44	26-052000.0100	MOSER CHARLES J	Jefferson
45	42-011000.0000	MEYER JEROME L & MARY L	Washington
46	42-011000.0000	MEYER JEROME L & MARY L	Washington
47	42-011000.0000	MEYER JEROME L & MARY L	Washington
48	26-014000.0000	POST OPAL L	Liberty
49	26-014000.0000	POST OPAL L	Liberty
50	26-013000.0000	POWELL JERRY & BETTY	Liberty
51	42-014000.0000	POWELL JERRY & BETTY TRUSTEES	Washington
52	42-000300.0000	POWELL JERRY & BETTY TRUSTEES	Washington
53	42-014000.0000	POWELL JERRY & BETTY TRUSTEES	Washington
54	42-000300.0000	POWELL MARY LEONE ETAL	Washington
55	42-000300.0000	POWELL MARY LEONE ETAL	Washington
56	26-013000.0100	POWELL THOMAS L & BRENDA S	Liberty
57	42-014000.0100	POWELL THOMAS L & BRENDA S	Washington
58	42-013000.0000	SAUNDERS TIMOTHY ETAL (FUTURISTOM??)	Washington
59	42-015000.0000	VOSS CARL W & LUCILLE W	Washington
60	42-000300.0000	SCHROEDER DOROTHY K	Washington
61	26-000700.0000	SEARSHOP ROBERT E & DONITA B	Jefferson
62	26-000700.0000	SEARSHOP ROBERT E & DONNIE	Jefferson
63	26-011000.0000	SEARSHOP ROBERT E & DONNIE	Jefferson
64	26-000700.0000	SEARSHOP ROBERT E & RONNIE	Jefferson
65	26-013000.0000	SHEETS DUANE R	Liberty
66	26-013000.0000	SHEETS DUANE R	Liberty
67	26-011000.0000	SHEETS RODNEY E	Liberty
68	26-011000.0000	SHEETS RODNEY E & LINDA	Liberty
69	26-044000.0000	SIEFRING JOTT	Jefferson
70	26-044000.0100	SIEFRING JOTT	Jefferson
71	26-044000.0200	SIEFRING JOTT	Jefferson
72	42-000300.0100	SIEFRING MARK	Washington
73	42-000300.0000	SIEFRING MARK & RONALD	Washington
74	26-042000.0000	SUHR DAVID J & RITA K	Jefferson
75	26-000000.0000	SUHR DAVID J & RITA K	Jefferson
76	26-042000.0100	SUHR RITA MAY	Jefferson
77	26-042000.0100	SUHR RITA MAY	Jefferson
78	26-013000.0000	SUTTER CARL A & SUZITA A	Liberty
79	26-013000.0000	THOMAS GALE A & MELDA D	Liberty
80	42-000300.0100	WISEMAN JERRY & VICKI	Washington
81	26-014000.0000	2 FARMS INC	Jefferson
82	26-014000.0000	2 FARMS INC	Jefferson
83	26-052000.0000	ZUMBERGE CHARLES ETAL	Jefferson
84	26-051000.0000	ZUMBERGE CHARLES ETAL	Jefferson
85	26-052000.0000	ZUMBERGE CHARLES ETAL	Jefferson
86	26-014000.0000	ZUMBERGE JOHN (PZ)	Jefferson
87	26-004000.0000	MUHLENKAMP WILLIAM	Liberty
88	26-000000.0000	MUHLENKAMP WILLIAM	Liberty

☆ POST, ET AL

NUMBER	PARCEL	OWNER	TOWNSHIP
89	26-041100.0000	BAUGHER RICHARD L & PATRICIA	Jefferson
90	26-043000.0000	BAUGHER RICHARD L & PATRICIA	Jefferson
91	26-024000.0000	LIKE TERRY L & THERESA R	Liberty
92	26-000000.0000	LIKE TERRY	Liberty
93	26-000000.0000	LIKE TERRY L & THERESA R	Liberty
94	26-013000.0000	LIKE TERRY L & THERESA R	Liberty
95	26-013000.0000	LIKE TERRY L & MINNITA R	Liberty
96	26-024000.0000	MINCH DAVID W TRUSTEE	Liberty
97	26-024000.0000	MINCH DAVID W TRUSTEE	Liberty
98	26-013000.0000	POST FAMILY TRUST	Liberty
99	26-013000.0000	POST FAMILY TRUST	Liberty
100	26-024000.0000	POST FAMILY TRUST	Liberty
101	26-000000.0000	ZUMBERGE STEPHEN J & VIRGINIA A TRUST	Jefferson
102	26-051000.0000	ZUMBERGE STEPHEN J & VIRGINIA A TRUST	Jefferson
103	26-052000.0000	ZUMBERGE STEPHEN J & VIRGINIA A TRUST	Jefferson
104	26-040000.0000	ZUMBERGE STEPHEN J & VIRGINIA A TRUST	Jefferson

☆ GAS LEASING

NUMBER	PARCEL	OWNER	TOWNSHIP
105	27-010000.0000	GAS LEASING & RENTAL INC	Jefferson

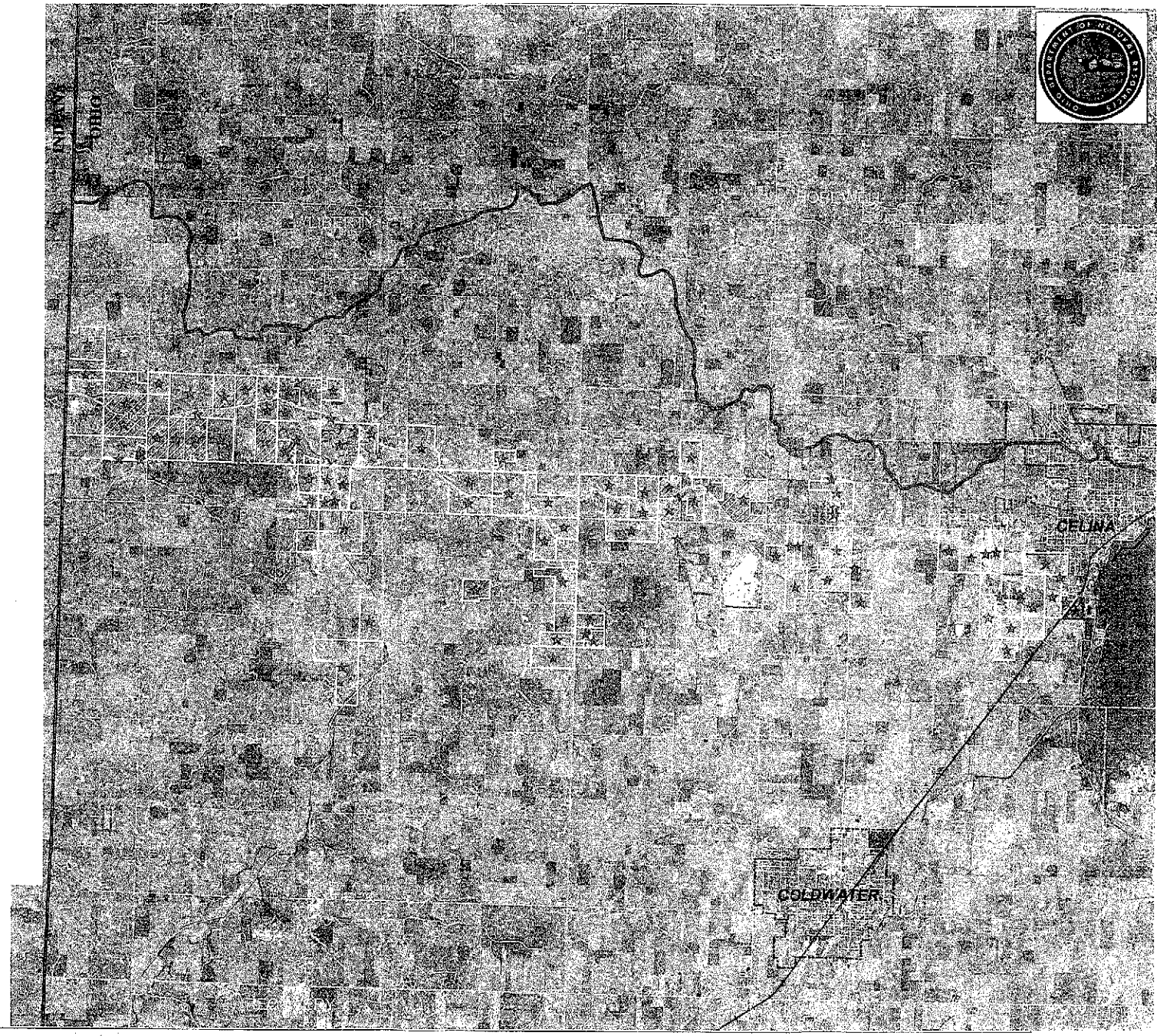
N
W E
S

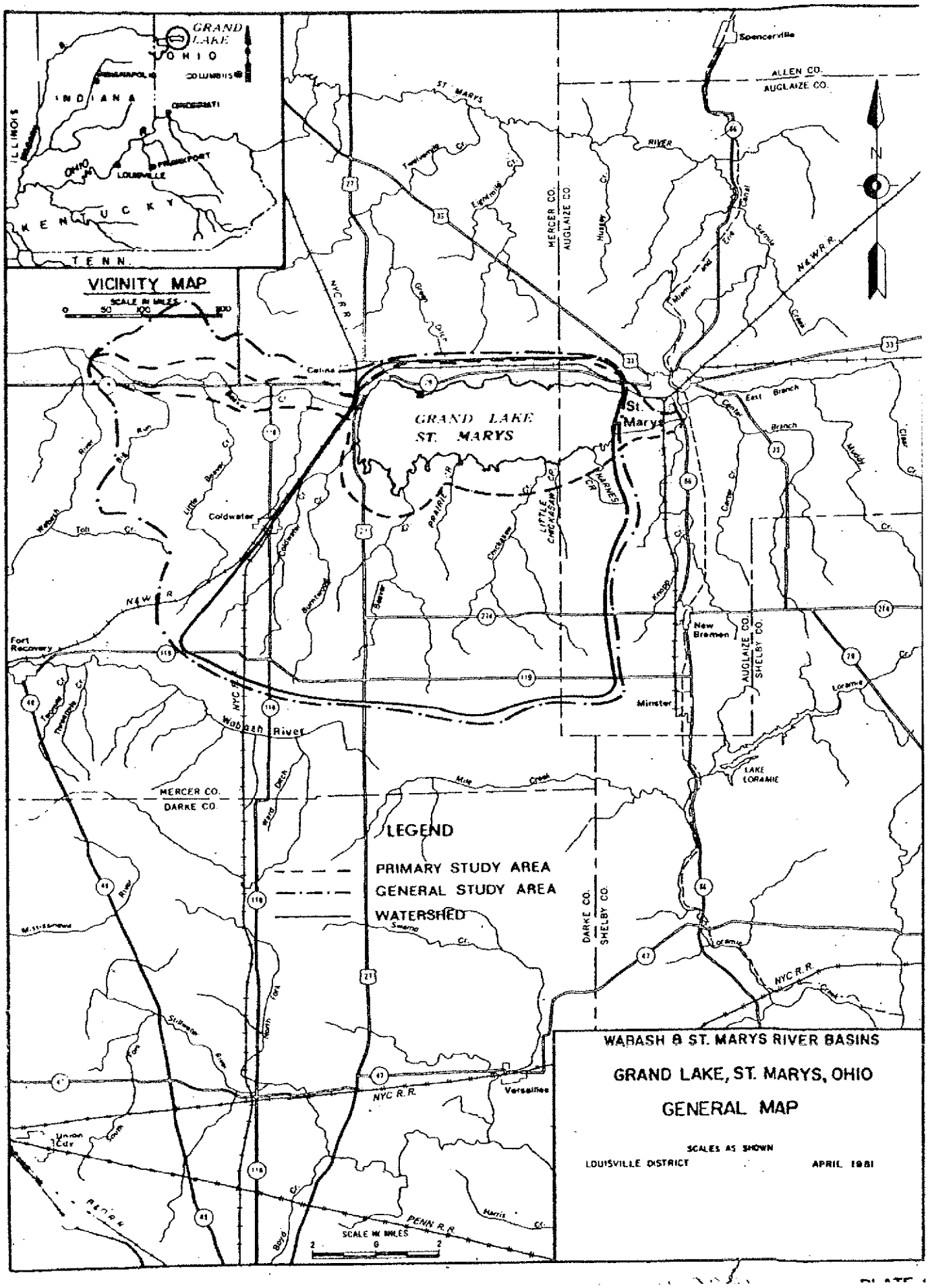
Respondent 4

PRIMED-Bayshore, N. J.

1 0.5 0 1 Miles

2006 Mercer County aerial imagery, Mercer County Auditor
2006 Mercer County Auditor parcel data
National Hydrography Dataset for Ohio, 2006, USGS
Watershed boundary, NRCS, 1998
Township / City boundary, ODOT, 2007
Map: GIMS Services, ODNR, April 27, 2010




GRAND LAKE
OHIO
COLUMBUS
INDIANA
INDIANAPOLIS
CINCINNATI
ILLINOIS
OHIO
LOUISVILLE
FRANKFORT
KENTUCKY
TENN.
VICINITY MAP
SCALE IN MILES
0 50 100 200
Spencerville
ALLEN CO.
AUGLAIZE CO.
ST. MARYS
RIVER
MERCER CO.
AUGLAIZE CO.
N&W R.R.
NYC R.R.
Celina
St. Marys
GRAND LAKE
ST. MARYS
Coldwater
Fort Recovery
New Bremen
Minster
AUGLAIZE CO.
SHELBY CO.
Wabash River
MERCER CO.
DARKE CO.
LAKE LORAMIE
LEGEND
PRIMARY STUDY AREA
GENERAL STUDY AREA
WATERSHED
DARKE CO.
SHELBY CO.
Versailles
PENN R.R.
SCALE IN MILES
2 0 2
WABASH & ST. MARYS RIVER BASINS
GRAND LAKE, ST. MARYS, OHIO
GENERAL MAP
SCALES AS SHOWN
LOUISVILLE DISTRICT
APRIL 1981

PLATES

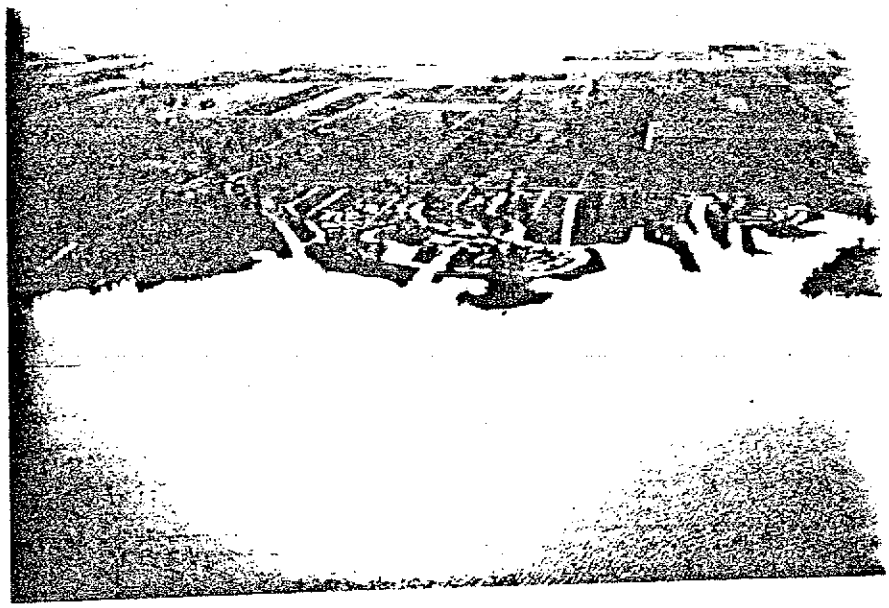


EXHIBIT NO. 29 South shore developments (Moorman Road, Bayview) and adjacent agricultural lands. (Dec. 1978)

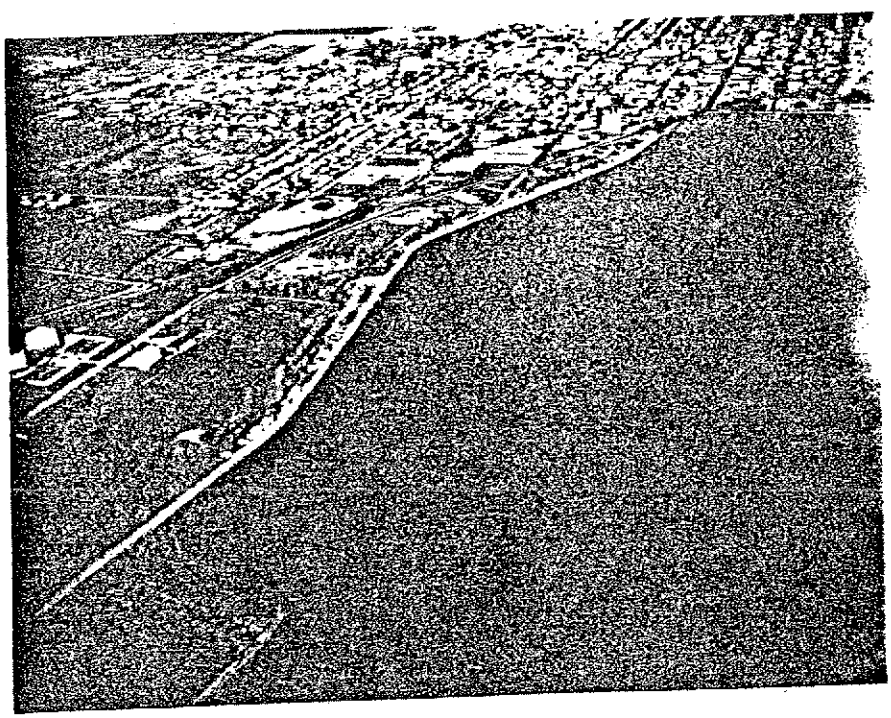


EXHIBIT NO. 30 Western Embankment. Celina, Ohio, at top and public land development in lower left corner. (Dec. 1978)

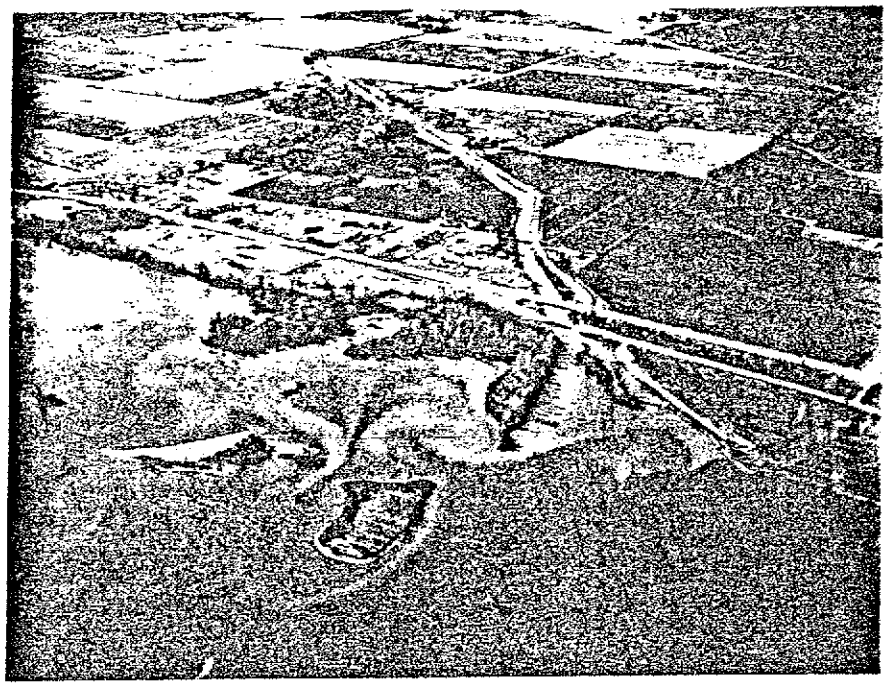


EXHIBIT NO. 27 Mouth of Coldwater Creek at southwest corner of lake. Sediment input to the lake. (Dec. 1978)

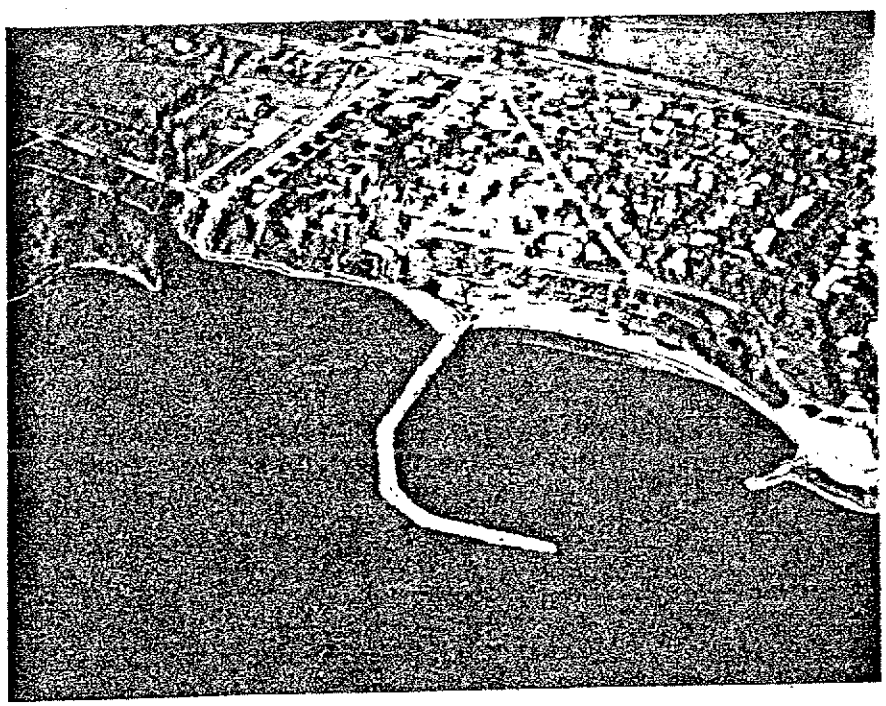


EXHIBIT NO. 28 Beach at State Park on north shore showing good example of protection from wave action. (Dec. 1978)

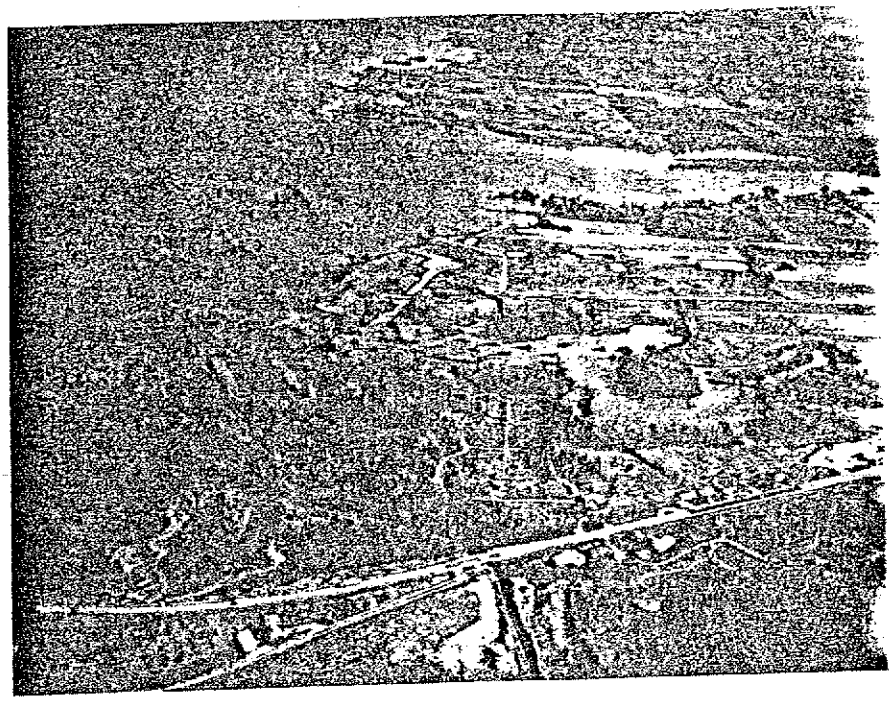


EXHIBIT NO. 25 View of Mercer County Waterfowl Refuge, Route 703 in foreground, Montezuma Bay in background. (Dec. 1978)

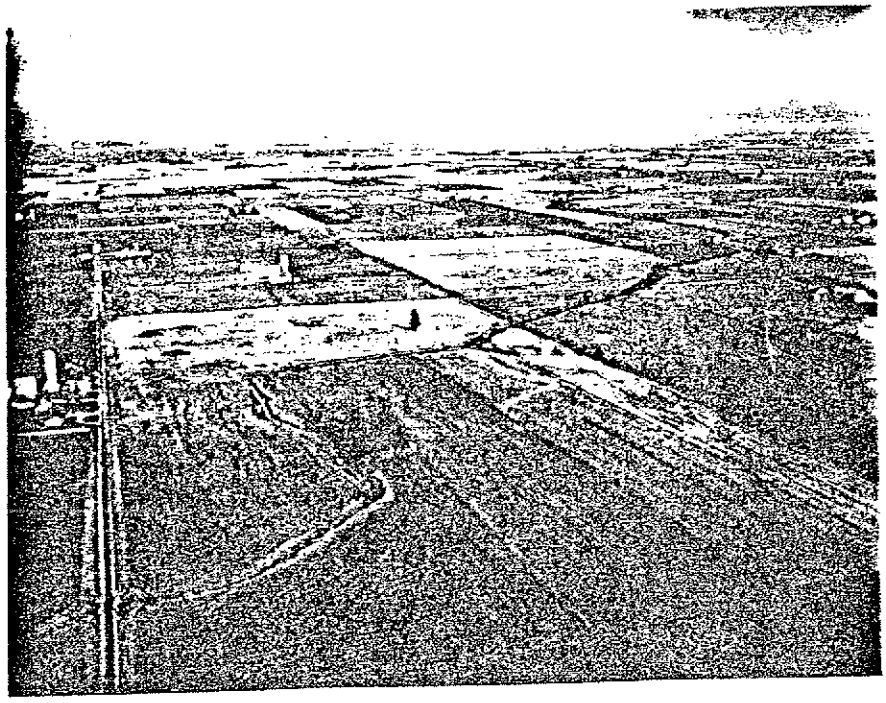


EXHIBIT NO. 26 Chickasaw Creek winding through prime agricultural land south of the lake. Lake on the horizon. (Dec. 1978)

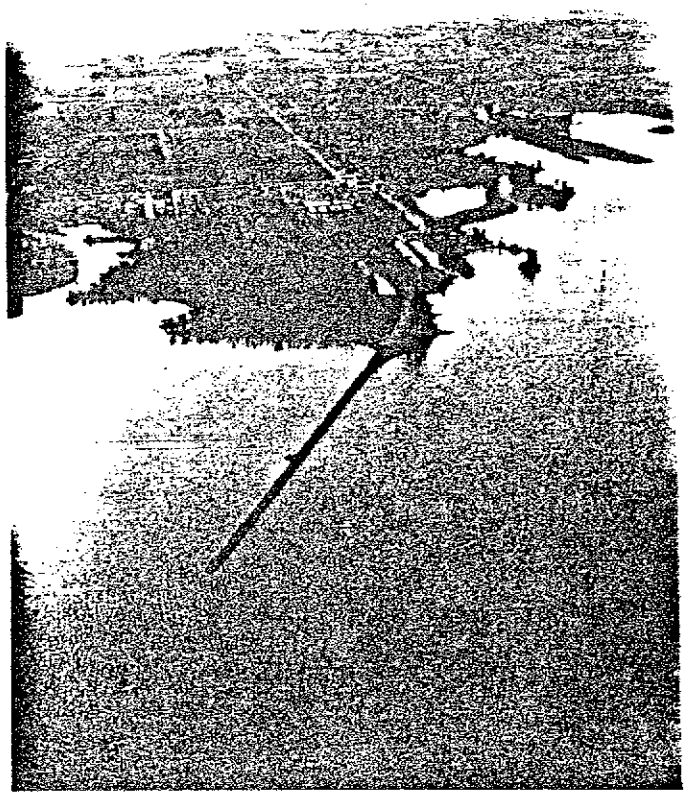


EXHIBIT NO. 23 Windy Point Pier and Recreation Area (Dec. 1979)

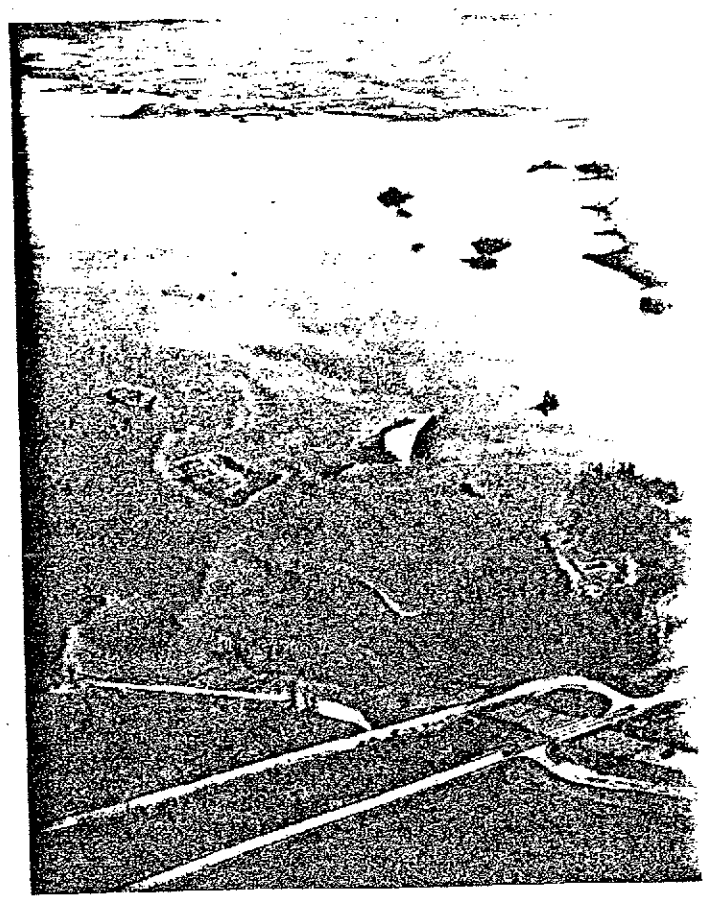


EXHIBIT NO. 24 Southwest corner of lake at mouth of Coldwater Creek. (Dec. 1979)

EXHIBIT NO. 21 Wave action and shallow lake areas on north shore, Vicinity of Holiday Park. (Dec. 1979)

EXHIBIT NO. 22 Chickasaw Creek winding through farmland. Lake is on the horizon. (Dec. 1979)

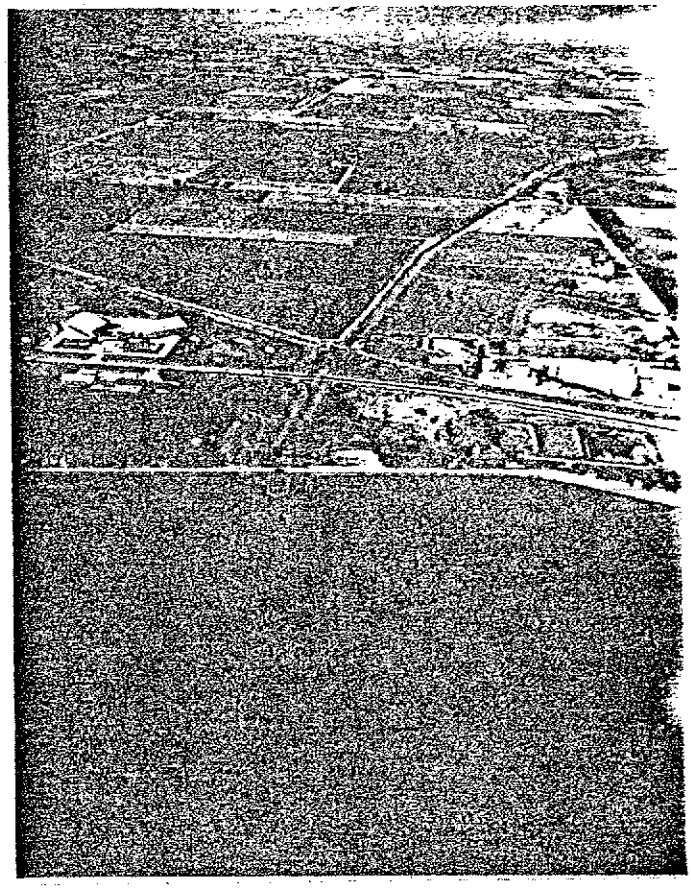


EXHIBIT NO. 19 Western Embankment and Beaver Creek Outlet Channel. (Dec 1979)

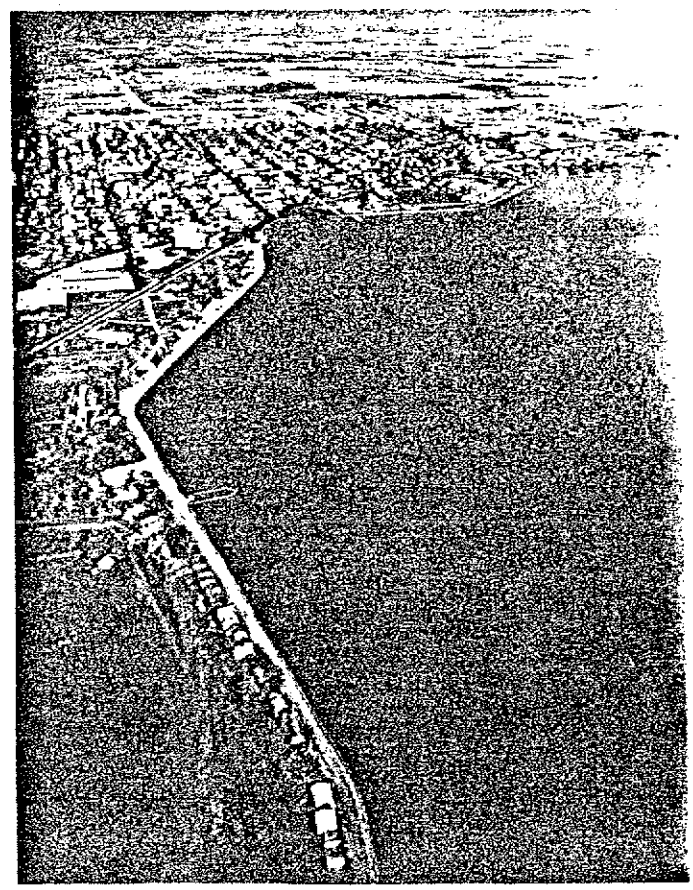


EXHIBIT NO. 20 Western end of Grand Lake and City of Celina (Dec. 1979)

Of the many types of fixed and floating breakwater concepts available, two types in each category were selected as being applicable to the Grand Lake St. Marys wave situation. Fixed breakwaters examined include diked dredge islands, suitably contained, and rubblemound breakwaters since both represent the least expensive of fixed breakwaters, materials are available locally, and the shallow lake depth and wave situation are conducive to their use. Floating breakwaters examined include rigid floating concrete and flexible floating tire breakwaters, since the former has had application in similar wave environments and the latter has received considerable attention as an inexpensive alternative for reducing wave action in inland lakes.

It was found that to be effective for flood reduction, an extensive, complex and costly breakwater system would be required to realize significant reductions in wave action over the entire lake. Segmented, longitudinal fixed breakwaters (Plate 6, Figure 6A) oriented parallel to and close to shore have a greater potential for alleviating or reducing south shore flooding and erosion problems. Floating breakwaters would have little value for reduction of wind set-up at the shore but would assist in reducing wave-induced shoreline erosion.

Costs of breakwaters depend on several factors including location, orientation, and spacing in the lake. Order of magnitude costs have been developed based on a configuration which parallels the shore. It is estimated that costs to parallel the south shore with breakwaters would be $8,000,000 for dredge islands, $18,000,000 for rubblemound breakwaters, $12,000,000 for floating concrete breakwaters, and $2,000,000 for a floating tire system.

Based on the cost analysis conducted in this study, a single breakwater is not expected to produce enough of an effect on wave heights, shore erosion, or water quality to result in measurable direct or indirect monetary benefits. An extensive series of breakwaters would be required before benefits based solely on improvements to these problems could be realized. The most significant benefits to be realized would be for recreation with respect to boating and fishing in the form of income potential due to increased or restored lake visitation.

Groins

Groins are structures similar to rubblemound breakwaters, but connected to and somewhat perpendicular to land (Plate 6, Figure 6B). It was determined that because of the northerly exposure of the southshore, groins, connected to and in a northeasterly orientation to the southshore, may not be effective in alleviating the worst problem conditions resulting from wave action. They are not expected to achieve the desired impact of shoreline protection and from a benefit standpoint are not perceived to be economically feasible.

Shoreline Levees (Alternative IIB.2).

The concept of constructing shoreline levees for the purpose of protecting against flooding from high water levels, wind set-up and waves was also considered (Plate 6, Figure 6C). Two levee heights, 2 feet and 5 feet, were selected to provide protection from storms producing high water levels and winds up to 50 mph.

Two levee layouts were examined. The first retains total channel access by construction of the levee to follow the existing shoreline. The second minimizes levee length by cutting across boat access channels. Plate 7 shows a typical system conceptualized for the developed area west of Moorman Road.

There are many problems with this approach, the most notable of which are: aggravated upland drainage and ponding problems, disruption of privately owned waterfront property, reduction in access to open water and to boat docks, obstruction to lake view, and considerable rights-of-way across private property are necessary. Costs would be extremely high to protect all affected developed areas and are not cost effective for the expected level of reduced damages. Benefit to cost ratios for either of the approaches are less than 1.0 indicating that shoreline levees are infeasible.

Lake Water Quality Improvement Alternatives

Treatment of Wastewater Inflows (Alternative IIIA.1).

The deterioration of lake water quality is attributed, in part, to contamination by domestic wastewaters. A great portion of homes, resorts, and other public and private facilities surrounding the lake are not currently connected to public facilities and, therefore, use individual on-site systems (septic tanks) or small package treatment plants. Both methods have severe shortcomings when located near an impoundment because of improperly treated sewage seeping or discharging into the lake. Two disposal approaches were examined in dealing with wastewater inflows. The first involves elimination of all septic tank and package plants surrounding the lake and providing for collection, treatment and disposal of effluent directly to the lake. The method would require very high levels of treatment, at great expense, to remove excess nutrients prior to discharge to the lake. The second approach is to collect, divert, and treat domestic wastewater away from the perimeter of the lake such that no effluent would be allowed to discharge to the lake.

A regional sewage facilities plan for the developed immediate areas surrounding the lake has been prepared by Finkbeiner, Pettis & Stroud, Ltd. Wastewater would be collected and treated at plants in Celina at St. Marys with effluent discharged other than directly to the lake. Elimination of septic tank systems and numerous point source discharges through local management solutions utilizing the conventional collection and treatment alternative was seen as a positive step toward reducing pollutants to the lake and in particular bacteriological pollution emanating from human sources.

The contribution of nutrients from 20 domestic wastewater treatment plants that currently discharge directly or indirectly to the lake is minor, being approximately 2 percent of the total load entering the lake on an annual basis. This nutrient discharge will have a negligible impact on the long-range overall water quality of the lake with respect to phosphorus load and concentration. Likewise, phosphorus input to the lake from faulty septic tank-soil absorption systems close to the lake are contributing only small quantities of phosphorus to the lake (less than 2 percent). The implementation of a regional sewage system that encompasses the south shore is expected to reduce the existing phosphorus loading to Grand Lake by less than 10 percent and little improvement in the

phosphorus concentration or trophic state of Grand Lake St. Marys would be anticipated as a result. (This may not be the critical concern, however, since the primary water quality improvement associated with the proposed sewage system is the reduction of bacterial pollution to the lake.)

Although the planned $14,000,000 regional sewerage project is seen to be a positive step toward reducing pollutants to the lake and in particular bacteriological pollution emanating from human sources and would effect a lifting on the currently imposed construction ban, a major unresolved question is whether centralized collection and treatment of wastewater, as planned, is justified because of the financial burden it places on its residents due to the high costs of collecting wastewater from each dwelling, especially along the south shore where houses are scattered.

Studies to re-evaluate regional sewerage needs to include modifying the scope of the existing plan; alternative and innovative on-lot systems, either on an individual household or group of households basis; and upgrading or converting existing treatment plants to include tertiary treatment and chlorination, are necessary but beyond the scope of this study. Federal funding is available to local governments through the Public Law 92–500, Section 201 Construction Grants Program to facilitate such studies.

Agricultural Source Controls (Alternative IIIA.2a)

Soil erosion, migration of phosphorus and other nutrients from cropland, barnyard runoff, and the application of manure on frozen ground are all problems in the Grand Lake watershed affecting water quality. To a large extent, the problems of eutrophication in the lake are the result of intensive agricultural land use within its watershed. Estimates are that 26,000 tons of sediment and 23 tons of total phosphorus reach the lake annually from agricultural areas. This phosphorus loading represents approximately 60 percent of the total annual load reaching the lake from all sources. From the standpoint of types of crops being grown, surface susceptibility to erosion is high, with 60 to 70 percent of the cropland area being planted in low density row crops, mainly corn and soybeans. In addition, farmers have been applying increasing amounts of phosphate fertilizer throughout northern Ohio. In Mercer and Auglaize Counties, there has been an approximate doubling of available phosphorus values for field crops between 1961 and

1976: from 30 pounds per acre to 51 pounds per acre in Mercer County and from 21 pounds per acre to 44 pounds per acre in Auglaize County. Reduction in phosphate yields to streams in the Grand Lake St. Marys watershed will, therefore, require controlling not only the loss of sediment from cultivated lands, but also the rate of fertilizer applications.

The use of agricultural land management has as its primary objective the abatement of soil and nutrient loss. From the standpoint of Grand Lake and its identified problems, the consequential benefits that can potentially be realized are (1) a reduction in sediment load, (2) a reduction in nutrient input, and (3) improved water quality. No significant adverse environmental impacts on the lake should occur as a result of improved agricultural practices.

A number of agricultural conservation practices are available for promoting and enhancing long-term productivity of the soil. Although few of these practices were originally developed to improve water quality, these practices are now recognized as being beneficial to water quality and soil protection as reflected in new cost-sharing programs. Conservation practices available through cost-sharing programs include: conservation tillage; establishing hay or rotation pasture; improving permanent hay or grass stands; stripcropping, terraces; diversions; winter crop cover; shaping and seeding critical soil loss areas; sediment retention, erosion or water control structures; stream protection and soil waterways. In general, the following cultivation techniques appear most suitable for the Grand Lake St. Marys watershed: delayed plowing and residue management, cover or green manure crops, minimum tillage, and no-till planting.

The purpose of the cost-sharing programs is to encourage landowners to install conservation practices to protect and preserve the land for future use. The proper use of the practices and costs involved are dependent upon detailed conservation planning for individual farm units, taking into account the needs and objectives of the individual landowner, and are beyond the scope of this study. Likewise, total benefits and costs to be realized in the Grand Lake St. Marys watershed by the implementation of various agricultural waste management and conservation techniques cannot be specified. However, both Mercer and Auglaize Counties rank high as preferred areas for agricultural management practices.

Potential benefits to individual landowners include increased crop yields, long-term reduction in topsoil and nutrient losses, decreased fertilizer requirements, and potential reductions in labor if fewer operations are involved.

In general, costs to individual landowners would exceed these benefits, but Federal and/or State cost-sharing could shift the balance to favor implementation and reduce the economic burden. Indirect monetary benefits to "downstream" users would be difficult to ascertain, but would include increased lake usage due to water quality improvements.

If all cropland in the watershed could be managed to satisfy Soil Conservation Service-designated maximum allowable erosion rates (T–factors), the following estimates of improvement could be realized:

- Gross erosion could be reduced from the current 4.28 tons per acre per year to 2.05 tons per acre per year, a 52 percent reduction

- The annual sediment load to Grand Lake could be reduced from 0.428 tons per acre to 0.205 tons per acre, a 52 percent reduction

- The annual phosphorus load to Grand Lake could be reduced by 9.6 tons, or 40 percent of the estimated total phosphorus load to the lake.

- Long-term water quality improvement.

- Increase in productivity and crop yield for some agricultural land management alternatives.

Livestock Waste Management (Alternative IIIA.2b)

Potential pollution of water courses as a result of livestock operations is particularly critical in the Grand Lake St. Marys watershed due to the widespread presence of animal feedlots. Animal concentration areas are a problem when rainfall runoff carries manure with high concentrations of suspended solids, nutrients, bacteria, and oxygen-demanding materials into surface water.

There are approximately 12,000 animal units producing 236 tons of total phosphorus per year in the lake's watershed. A conservative estimate is that 5 percent of produced phosphorus will be exported to a watercourse if livestock operations are located within 3,000 feet of a receiving stream. Approximately seventy (70) percent of the livestock are so located. Therefore, the annual phosphorus load to Grand Lake as a result of livestock operations is estimated to be 8.3 tons. If discharges from livestock operations can be completely eliminated, a 35 percent reduction in the annual nutrient input to the lake can be realized and result in reduced phosphorus concentrations in the lake.

Proposed State of Ohio Regulations call for zero pollutant discharge from some pollutant sources and minimizing pollution potential for all "concentrated animal feeding operations." Most of the livestock operations in the Grand Lake St. Marys watershed will be subject to the regulations.

The State of Ohio has developed a Livestock Waste Management Guide which helps the livestock operator to make decisions in choosing and operating a livestock waste handling system which controls pollution. In addition, primary benefits to the livestock operator are increased value of manure for crop production, an increase in feed efficiency, and potentially reduced labor requirements. Typical capital investment costs for dairy cows, beef cattle, and swine (the predominant watershed livestock types) are $200 per head, $100 per head, and $20 per head, respectively. Typical annual operating costs per head are: dairy cows, $50; beef cattle, $25; and swine, $5.00. In general, costs to the individual owner/operator exceed benefits. Cost sharing could shift the balance and encourage implementation. Indirect benefits would be to downstream water users, including increased lake usage due to improvement in lake water quality.

Treatment of Tributary Inflows (Alternative IIIA.2c)

This is a method of treating tributary flow with chemical flocculents with the objective to remove phosphorus and suspended sediment by settling them out prior to inflow to the lake. Facilities would be required on each of the five major tributaries to the lake. Several problems exist with this approach, however. Chemical treatment is limited by the extreme fluctuations in flow rate and the need to vary the chemical rate. While actual chemical

addition has a relatively low cost due to low phosphorus concentrations, the process produces sludge that would cause environmental and water quality concerns and facilities for its removal would be cost prohibitive. Treatment facilities would be required capable of treating 43 million gallons per day which is, by comparison, twelve times the design flow rate for the Celina Sewage Treatment Plant, and is therefore physically and economically infeasible by a wide margin.

Other Non-Point Source Controls

Precipitation Phosphorus Control

Precipitation contributes an estimated 780 kilograms of phosphorus or 2.3 percent of the annual total to Grand Lake St. Marys. This phosphorus originates principally outside the lake basin from such sources as wind-induced soil erosion, industrial ash, smoke, certain mining activities, and the addition of organic phosphates to gasoline. It takes the form of particulate phosphorus carried by wind and other input processes which is later removed by rainfall and other precipitation. In general, it can be said that the phosphorus content of direct precipitation on the lake surface, besides being small as compared to other sources, is not manageable or controllable by man. In addition, the availability of phosphorus in rainfall to algae is still in question with researchers.

Goose Population Control

Less than one percent of the total annual phosphorus load to the lake is attributed to waterfowl (primarily geese), but the amount available to the lake system is considered insignificant. Therefore, any program recommending a reduction in waterfowl population on Grand Lake by hazing or hunting is expected to have little impact on lake water quality.

Urban and Suburban Runoff Control

Direct urban and suburban runoff in areas directly adjacent to the lake contributes approximately 3 percent of the total phosphorus load to the lake. In addition, fertilizers, pesticides, detergents, oil, grease, salts, domestic animal wastes, and street litter are carried through ditches directly to the lake. Property owners can have a positive effect on water

quality by reducing the amount of pollutants in stormwater runoff to the lake. This can be accomplished by minimizing fertilizer and pesticide applications, composting yard debris, frequent street cleaning, and using low phosphate detergents.

Dredging (Alternative IIIB.1).

A widespread dredging of Grand Lake St. Marys has been considered since in-lake dredging addresses more planning objectives than any other alternative. In addition to deepening the lake for the benefit of recreation uses, dredging is a potential lake restoration technique for improving water quality by removing the accumulated products of degradation (phosphorus-enriched sediment) from the lake system. It has been determined that Grand Lake St. Marys contains high concentrations of sediment-bound phosphorus. In shallow lakes such as Grand Lake St. Marys, nutrient release from the sediments by wind-generated mixing, boat motors, and bottom scavengers can be a major source of excessive nutrients. Thus, dredging to expose a nutrient-poor layer can, in theory, result in nutrient concentration reductions in the water column. Potential secondary considerations from dredging include decreasing wind-generated wave action and lake shore erosion, improving lake level fluctuations, and improving water-related recreation.

With regard to water quality, the results of modeling the lake system under various scenarios and conditions of external load reductions, sediment mixing (with and without), spoil disposal (in-lake and out-of-lake), and dredging (no dredging, 3 feet of dredging), have indicated that no significant improvements in the phosphorus concentration and related biologically-oriented nuisance condition (proliferation of algae) can be expected from the dredging of bottom sediments at Grand Lake St. Marys. In fact, some degradation of water quality could result if the dredged spoil material is contained within the lake. In-lake disposal appears to be the only practical method since the flat topography and lack of suitable sites inhibit disposal on the watershed. The primary reason for a negative impact on water quality is that any projected wide-scale dredging operation would either remove an insignificant depth of sediment over the entire lake, thereby exposing more of the same phosphorus-laden sediment, or as removing all the accumulated sediment from an inconsequential portion of the lake as is now being done. The analysis of the movement of sediment in the lake due to wind and resultant bottom transport have shown that no significant reduction of suspended sediments can be expected, even for the extreme

case of 3 feet of sediment removal, and, therefore, no noticeable improvement in water quality can be expected as a result of the alleviation of wind-mixing effects by dredging.

With regard to physical improvements due to dredging, flooding of downwind shorelines due to long period set-up of the water surface could be reduced by a wide-scale dredging program, but in conflict with this, results indicate that the existing severe wave action is expected to be aggravated further by extensive dredging of the lake bottom. A similar conclusion is reached regarding erosion of the lake shoreline. Even though wind set-up impacts on the erosive process, a greater concern is intense wave action and the overtopping of erosion control structures. Lake bottom dredging intensifies short-period waves and would be detrimental to shoreline erosion.

Long-term fluctuation in lake levels will not be significantly influenced by dredging. If anything, the situation would be aggravated if dredge spoil is contained within the lake because as the surface area is reduced, the change in water level resulting from a unit increase or decrease in water volume is greater.

The major benefits of a wide-scale dredging program at the lake are associated with water-based recreation. These would include increased boater access to extended portions of the lake, improved boater safety by elimination of shallow (and stumped) areas, enhancement of fish habitat and related recreational fishing in the long-term. Additionally, dredging has the potential for extending wildlife areas by the creation of dredge islands or other new landforms from dredge spoil materials.

The two major constraints to dredging are (1) proper containment and disposal of huge volumes of dredged materials and (2) economic feasibility.

As mentioned earlier, in-lake disposal appears to be the only practical method since the flat topography and lack of suitable sites inhibit disposal on the watershed. A large-scale, lake-wide dredging program, however, may be cost prohibitive. Costs and volumes for comparison are given as follows:

Average Lake Depth, Feet	Cost to Achieve Average Lake Depth	Dredged Material Volume Million Cubic Yards
4	$13,200,000	6.6
6	37,200,000	18.6
8	88,600,000	44.3

An estimated $135,000,000 would be required to remove an average of 3 feet of sediment throughout the lake to achieve an 11-foot average lake depth.

Dredging would have negligible direct monetary impact on nuisance south shore flooding, erosion, and wave attenuation; however, improvements in water-based recreation as a result of a wide-scale dredging program would provide indirect monetary benefits from increased lake usage. A direct benefit of a dredging program would be increased revenue generated from the sale of dredge islands, peninsulas, or other newly created land forms to offset the cost of dredging.

Erosion and Sedimentation Control Alternatives

Erosion control alternatives were investigated for unprotected shoreline, streambanks, and upland areas of the lake watershed.

Shoreline Erosion Protection

In addition to breakwaters previously discussed, other alternatives to eliminate or reduce shoreland erosion are the traditional uses of riprap, gabions, bulkheads (Plate 8, Figures 8A, 8B, 8C) or concrete fabriform mats. Each of these structural measures has the beneficial effect of reducing erosion, protecting against loss of shoreland, and reduction in sediment load to the lake. Of these methods, bulkheads and concrete mats would impair drainage behind them. All methods would contribute somewhat to reductions in access to open water and boat docks, require land to establish desired slope at the shore and cause localized disruption during construction.

In general, shoreline erosion problems are limited to the southshore where bank erosion occurs along the undeveloped shore reaches. Some attempt has been made to riprap these publicly-owned areas, but the success of any program is limited by access problems.

Complete protection of 60,000 feet of currently unprotected, irregular southshore areas would cost $1.62 million for riprap, $2.5 million for gabions, $3.6 million for bulkheads, and $3.74 million for concrete mats. Use of these measures, however, are more cost effective than near shore breakwaters. Treatment of privately-owned shoreline is the responsibility of the owner. Unprotected public shoreline is the responsibility of the State of Ohio.

Streambanks

Tributary streambanks have the lowest protected length among the four categories (streambank, channels, lake shore, and islands) at Grand Lake and therefore, appear the most susceptible to the disposal of erodible material to the lake. Retardation of streambank erosion would be beneficial in stabilizing land bordering the tributary and reducing sediment load to the lake. While the dominant sediment load is watershed soil loss, streambank erosion could increase in the future with progressive development and urbanization of the watershed. This is of particular concern on Coldwater Creek due to the high current and projected rates of development around the municipality of Coldwater. The range of typical costs to completely protect accessible portions of seven tributaries are estimated as follows:

	Feet	(Least Cost) Riprap	(Greatest Cost) Concrete Mats
Coldwater Creek	18,000	$486,000	$1,120,000
Chickasaw Creek	15,000	405,000	936,000
Little Chickasaw Creek	6,000	162,000	374,000
Prairie Creek	9,000	243,000	936,000
Barnes Creek	6,000	162,000	374,000
Monroe Creek	4,000	108,000	250,000

Coldwater Creek should be given priority streambank protection due to high potential for upstream development which will increase peak flow rates and promote erosion of banks.

Watershed Soil Erosion

Conservation practices available through government cost sharing programs include among others: establishing hay or rotation pasture, improving permanent hay or grass stands; strip cropping; terraces; minimum or no tillage practices; winter crop cover; sediment retention structures; erosion control structures; stream protection; sod waterways; grass buffer strips between crops and waterways. The purpose of these conservation measures is to protect and preserve the land for future use and would be effective in controlling sediment and nutrients from entering the streams which drain to the lake. The proper use of the practices and costs involved are dependent upon detailed conservation planning for individual farm units, taking into account the needs and objectives of the individual land owner. Locations where priorities should be given to specific agricultural practices are the Coldwater Creek, Beaver Creek, and Chickasaw Creek watersheds.

Sedimentation Ponds

These physical structures have been considered to reduce the amount of sediment and nutrients entering the lake. The purpose of the ponds is to provide a containment area in which flowing water is slowed long enough to settle large amounts of suspended and settleable particulate matter during runoff events thereby reducing the sediment load to downstream water bodies and providing for easier removal of the collected matter. In addition, sediment ponds would remove nutrients attached to the captured sediments. The long-term effect of these ponds is improvement of the lake's water quality. Adverse impacts of sedimentation ponds are the creation of localized nuisance conditions (weeds), threat of possible washout, need for currently productive land, long-term commitment to operation and maintenance for periodic cleanout and disposal of sediment.

Depending on the design retention time required, estimated total cost of seven sedimentation basins (one each of the major tributaries to the lake) is on the order of $1,280,000 for 4-hour retention and $6,220,000 for 20-hour retention.

DISCUSSION

The purpose of this section is to discuss the more pertinent findings in the related problem categories examined in the Grand Lake St. Marys survey investigation.

FLOODING, BEAVER CREEK

1. Periodic flooding of agricultural land along Beaver Creek is attributed, in part, to a limited flood control capability of Grand Lake St. Marys, poor surface drainage, low stream gradient, inadequate outlet for numerous artificial agricultural drains, and constrictions to flow from vegetation on the banks, shoals, and debris throughout 9.6 miles of the 10.6-mile reach.

2. Flooding problems along Beaver Creek are due to both overbank inundation and subsurface saturation as a consequence of long periods of near bankfull flow in the flat gradient channel.

3. Peak discharges from the Grand Lake St. Marys western outlet are not great enough to cause instantaneous flooding, and are less than would be experienced without the lake. The lake does provide some limited flood control, but extends the period of bankfull flow in Beaver Creek. Current regulation practices for the Grand Lake St. Marys western outlet will reduce natural peak discharges from excessive runoff to a modified condition. Lake outflows are maintained, when structurally possible, to reduce natural Beaver Creek flows to a maximum bankfull flow. Lake storage capacity is estimated to be 1-3/4 inches of runoff (based on total contributing drainage area including the lake) from elevation 869.92 to elevation 870.75 (west spillway crest). Additionally, from elevation 870.75 to one foot above west spillway crest an estimated 2-1/4 inches of runoff storage is available. To deplete stored waters at a net outflow rate of 150 cfs will require approximately 35 days

and 46 days for the 1-3/4 inches and 2-1/4 inches of runoff, respectively. Therefore, the flood control capability of Grand Lake is considered limited.

4. Flood damages to crop, non-crop, transportation facilities, and public utilities in the Beaver Creek reach from its confluence with the Wabash River upstream to the western outlet of Grand Lake St. Marys is estimated at $85,000 annually. Of this total, approximately 74 percent is damage to major crops produced -- corn, soybeans, and hay.

5. Non-structural flood protection measures considered that would modify damage susceptibility, such as weather modification, pre-flood emergency action, flood proofing, evacuation, flood plain zoning, land use regulation, flood forecasting and flood insurance, are not viable solutions because of the agricultural character of the Beaver Creek flood plain.

6. Structural plans considered for Beaver Creek, including detention basins, diversion to another basin, clearing and cleaning, channel improvement and agricultural levees, were all found not to be cost effective means for reducing flood damages along Beaver Creek. This finding is based on Federal cost analysis procedures which tend to reflect higher costs than would locally sponsored projects.

7. The Ohio Public Works proposal to release a greater proportion of lake peak inflows to the St. Marys River Basin through modification of the eastern embankment outlet works and channel is expected to decrease outflows to Beaver Creek, but of such low magnitude as to result in negligible flood control impacts on Beaver Creek.

FLOODING, SOUTH SHORE

1. Periodic flooding occurs along the south shore of Grand Lake St. Marys where the topography and developments are generally at a low elevation. The flooding is attributed to many factors including poor natural drainage plus a high water table, and to a high lake level combined with wind-induced wave action which causes water to run up on the shore with subsequent damage to residential buildings and contents. In most years, the

lake level does not exceed one foot above west spillway crest, but this rise is sufficient to cause flood damages on the south shore.

2. Present annual damages to residences in the form of structure and contents damage are estimated to be $150,000 for approximately 142 private shoreline properties.

3. Non-structural measures such as permanent or temporary evacuation, relocation, flood plain zoning, subdivision regulation, and building codes were considered alternatives to existing impacted properties, but were eliminated from further consideration because these flood plain measures have negligible effects on reducing flood damages to structures currently in the flood plain.

4. Flood proofing, involving waterproofing or raising structures to prevent flood water intrusion, is inhibited by the predominance of single-family frame structures on individual lots and is not cost effective as a primary solution to reducing or eliminating south shore flood damages.

5. The considered structural alternatives such as detention basins, diversion, and shoreline levees are not cost effective methods of preventing or alleviating south shore flood damages.

6. Several plans were examined for modifying the operation of Grand Lake St. Marys in order to reduce flood damages along the lake's south shore and Beaver Creek, as well as for providing greater dependability in obtaining and maintaining the seasonal recreational pool level. It was found that the current operating procedures for lake regulation, consisting of maintaining a lake level about 10 inches below the west spillway crest during the winter months and closing the gates on 15 March for refilling provide an appropriate balance in minimizing flood damages and maintaining a desirable recreation pool.

7. Periodic flooding of the shoreline due to wind setup has been shown to be possible, particularly if the lake water level in Grand Lake is high. Therefore, relief, under these conditions, could be provided by strategic placement of fixed breakwaters such as dredge islands or rubblemound breakwaters. Floating breakwaters would have no effect on wind setup.

8. A fixed breakwater system that spans the length of the south shore is perceived to be an appropriate technical solution for alleviating both south shore erosion and flooding problems due to wave action, but an extensive series of breakwaters about 40,000 feet long and close to shore would be required before benefits based solely on improvements to these two problems could be realized.

9. Fixed breakwaters are not perceived to be economically feasible solely from a flood damage reduction benefit standpoint, but from a recreational usage, water quality and physical improvement standpoint, an expenditure for construction of a properly designed breakwater system would be preferred to the dredging that could be done for the same amount.

10. A fixed breakwater system parallel to the south shore could prove more beneficial for shoreline erosion and flooding problems due to wave action than a groin system placed somewhat perpendicular and connected to the south shore.

11. The Ohio Public Works proposal to release a greater proportion of lake peak inflows to the St. Marys River Basin through modification of the eastern embankment outlet works and channel is expected to create only a slight decrease in lake levels (on the order of 0.1 inch), thereby providing no measurable flood control impacts on the lake south shore.

LAKE WATER QUALITY

1. Lake water quality has been declining in recent years. Four separate water quality problems have been identified as causing the deterioration. Bacterial contamination from human sources threatens body contact recreation, particularly in areas of greatest development. High nutrient concentrations result in severe blooms of algae which cause taste and odor problems. Water clarity is reduced by algae and suspended sediment, resulting in unattractive conditions for recreators. Accumulation of sediment, eroded from upland areas, and unprotected shoreline has reduced the lake depth.

2. The lake's ambient total phosphorus concentration of 178 micrograms per liter (ug/l) remains well above 15 ug/l, the generally accepted threshold level for algal blooms in northern lakes. Continuing nuisance growth of algae in the lake indicates that the problem of cultural eutrophication needs to be resolved.

3. The present phosphorus loading rate of 0.49 gram per square meter of lake surface per year is nearly 1.8 times the rate commonly considered as a dangerous eutrophic rate indicating that phosphorus inputs should be reduced or minimized to slow the cultural aging of the lake.

4. Approximately 33,000 kilograms of total phosphorus are currently contributed to the lake on an annual basis from all sources. Of this total approximately 45 percent is removed from the lake annually via Beaver Creek, the St. Marys feeder canal, direct fish harvest, and absorption into lake sediments. At current estimated rates of phosphorus input and output, approximately 18,000 kilograms of total phosphorus accumulate annually in the lake.

5. Total annual phosphorus loadings to Grand Lake St. Marys from specific sources are estimated as follows:

	Total Phosphorus		Percent
	Pounds	Kilograms	of Total
Precipitation	1,720	780	2.3
Waterfowl (geese)	475	216	.6
Animal Concentration Areas (feedlots)	16,540	7,500	22.6
Agricultural Runoff	46,305	21,000	62.9
Municipal Point Source (St. Henry)	3,195	1,449	4.3
Domestic Point Sources	1,646	746	2.2
Septic Tanks	1,345	610	1.8
Direct Urban and Suburban Runoff	2,394	1,088	3.3
Total	73,620	33,389	100.0

6. Several sources of phosphorus input which were previously thought to be significant, specifically septic tank systems and waterfowl, are contributing only small quantities of phosphorus to the lake.

7. The most significant contribution of phosphorus to the lake appears to be from non-point sources or rural, primarily agricultural land and livestock concentration areas. These areas contribute an estimated 86 percent of the total annual phosphorus load to the lake.

EROSION AND SEDIMENTATION

1. The shoreline in several areas around the lake, particularly State-owned lands along the south shore, is undergoing moderate erosion and needs stabilization. Until lake banks are stabilized and lake fluctuations are controlled, turbidity levels in the lake, due in part to shoreline erosion, will continue to remain high.

2. Erosion of unprotected shoreline areas contributes to the turbidity level of the lake but only when heavy wave action is present. At these times turbidity levels are raised considerably in the immediate area of the erosion, but it is doubtful that the complete stabilization of the lake's shoreline would reduce the turbidity and sedimentation of the lake by any appreciable degree. The major cause of turbidity and sedimentation at Grand Lake is the introduction and subsequent resuspension of sediment from thousands of acres of eroding farm land located in the drainage basin above the lake.

3. The rate of streambank erosion is currently not excessive even though the streambanks of the tributaries to Grand Lake have the lowest percentage of protected length among the four categories of streambank, shoreline, island, and dredge spoil. However, streambank protection can become important in the future and streambank erosion rates could be significantly increased as progressive development and urbanization cause increases in peak discharge rates in the tributaries.

4. Streambank erosion is of particular concern in Coldwater Creek (due to the high current and projected rates of development around the municipality of Coldwater) where noticeable widening of downstream reaches has already occurred.

5. To a large extent, the problems of sedimentation and water quality problems (eutrophication) in the lake are the result of intensive agricultural land use within its watershed. It is estimated that 26,000 tons of sediment and 23 tons of total phosphorus reach the lake annually from agricultural areas. From the standpoint of types of crops being grown, surface susceptibility to erosion is high, with 60 to 70 percent of the cropland area being planted in low density row crops, mainly corn and soybeans.

6. Erosion and sediment loads from boat access channels around Grand Lake St. Marys are not a severe problem since these channels are not subjected to the erosive forces of streamflow and waves, and a large percentage of boat channel lengths has already been protected from boat wake attack. The potential effects of channel erosion are better handled by individual property owners using protection measures similar to streambank protection.

7. Existing islands, although especially susceptible to ice and wind-induced wave erosion because of their small size and exposure from any side, contribute minimally to both the annual sediment load to the lake and the overall recreational usage of the lake. What is in question, however, is the preservation of these islands for their intended long-term use as waterfowl areas.

8. In the case of existing islands, alternatives for preventing continued erosion include retrofitting shore protection measures, allowing the natural loss of the islands to proceed, or developing a large scale plan related to creation of large dredged material containment areas that could include the existing islands within protected dikes.

9. Grand Lake St. Marys is currently a eutrophic water body and can be expected to remain as such until an approximate 60 percent reduction in the annual phosphorus load is realized. This percent reduction is quoted with reservation since the high degree of wind-induced resuspension of nutrient-rich bottom sediments limits the use of generally accepted trophic state criteria.

10. Lake water quality will not be improved by dredging of bottom sediments. In fact, some degradation of water quality could result if the spoil material is contained within the lake. Water quality problems and physical problems would not be significantly impacted by an extensive lake-wide dredging program. The extent of dredging required for large-scale recreation improvement is cost prohibitive.

11. Reducing the nutrient load to the lake is the most effective measure for improving lake water quality. Because of a lack of permanent phosphorus loss to the sediments, and because phosphorus does not appear to be readily available for release into the lake due to the aerobic nature of the lake water, the reduction in the steady-state concentration of total phosphorus in the lake water is proportional to the reduction in the loading rate.

12. Within three years of a reduction in nutrient loads, the total phosphorus concentration in Grand Lake is expected to reach approximately 90 percent of its new steady-state value.

13. The contribution of nutrients from 20 package domestic wastewater treatment plants that discharge directly or indirectly to the lake is minor, being less than 2.5 percent of the total load. The discharge of the treated sewage from these plants will have a negligible impact on the long-range overall water quality of the lake as far as phosphorus load and concentration is concerned. The major concern with these point discharges, according to recent studies (August 1980 by Finkbeiner, Pettis and Strout, Ltd.) is related to high bacteriological concentration which at peak week-end periods of use affect the entire lake. Likewise, potential phosphorus migration from 500 permanent and 169 seasonal septic tank-soil absorption systems is estimated at less than 2 percent of the total phosphorus loading to the lake and is, therefore, considered to be a minor contribution.

14. The implementation of a regional sewage system along the south shore is expected to reduce the existing phosphorus loading to Grand Lake from septic tank systems and domestic point sources by less than 10 percent. Little improvement in the phosphorus concentration or trophic state of Grand Lake would be anticipated as a result of elimination of this source alone. This is not the critical concern, however, since the primary water quality improvement associated with the sewage system is the public health-related reduction in bacterial pollution to the lake.

15. A major unresolved question is whether collection and centralized treatment of wastewater generated along the lake shore, as has been proposed by ongoing Section 201 planning, is feasible because of the financial burden it places on its residents due to the high cost of collecting wastewater from each dwelling, especially where houses are scattered.

16. If all cropland in the watershed could be managed to satisfy Soil Conservation Service designated maximum allowable erosion rates (T–factors), the following estimates of improvements could be realized:

- Gross erosion rates could be reduced from the current 4.28 tons per year to 2.05 tons per acre per year, a 52 percent reduction.

- The annual phosphorus load to Grand Lake could be reduced by 9.6 tons, or 40 percent of the estimated total phosphorus load to the lake.

- Long-term water quality improvement.

- An increase in productivity and crop yield for some agricultural land management alternatives.

17. Agricultural management practices are technically feasible, but results would vary with the practice and individual sites to be treated.

18. Both Mercer and Auglaize Counties rank high as preferred areas for agricultural management practices.

19. The annual phosphorus load to Grand Lake as the result of livestock operations is estimated to be 7,500 kilograms.

20. If discharge from livestock operations can be completely eliminated, a nearly 25 percent reduction in the total annual nutrient input to the lake can be realized and result in reduced phosphorus concentrations in the lake.

21. A mechanism exists, through State of Ohio Regulations, for zero pollutant discharge from some pollutant sources and minimizing pollution potential for all "concentrated animal feeding operations;" however, in general, costs to the individual owner/operator exceed benefits. Public cost sharing is available to assist in offsetting costs because some benefits are to the general public.

22. Treating tributary inflows, directly, with the objective to remove phosphorus and suspended sediment is cost prohibitive.

23. According to estimates in this investigation, less than one percent of the total phosphorus load is attributed to migrating and nesting geese and the amount available to the biological system is judged to be insignificant. Any program recommending a reduction in goose population on Grand Lake St. Marys would have little impact on water quality.

24. Urban and suburban runoff in the Grand Lake St. Marys watershed originates from the Village of Coldwater, portions of Celina adjacent to the lake, and developed direct drainage areas surrounding the lake. The phosphorus loading from these areas makes up an estimated three percent of the total phosphorus loading to the lake.

CONCLUSIONS

The following conclusions have been reached as a result of the Corps of Engineers investigation at Grand Lake St. Marys. The conclusions and subsequent recommendations reflect Corps of Engineers judgments regarding desirable future actions and priorities, not necessarily limited by existing feasibility or authorizations.

BEAVER CREEK FLOODING

Channel clearing and cleaning is the most cost effective measure for reduction of flood damages along Beaver Creek.

LAKE SHORE FLOODING

Nonstructural measures such as raising structures in—place and temporary evacuation in combination with a flood warning system may best reduce structural flooding problems as exist along the south shore.

Shoreline erosion and property damage can effectively be reduced by measures such as rubblemound breakwaters. Consideration should be given to a demonstration project utilizing a partial fixed breakwater system or islands along an affected south shore area.

PHOSPHORUS REDUCTION

Continued efforts should be directed toward phosphorus reduction from sewage wastes. This can be accomplished by regional collection, treatment and disposal outside the lake watershed or by improved on—lot and "package" plant alternatives or a combination of solutions. Because of the relatively high cost of installation of a centralized sewerage

system, the Ohio Water Development has received a grant from the U. S. Environmental Protection Agency to perform additional facility planning and consider alternatives to the proposed centralized system. From the point of view of best lake water quality management, discharge of all sewage effluent to some point outside the lake watershed would be the preferred alternative.

SEDIMENT REDUCTION

Shoreline protection utilizing a combination of protective measures (riprap placed over a thickness of filter material) and no action (allowing the shore to assume a natural angle of repose) offers the best opportunities with priority areas as follows:

1. Portions of Montezuma Bay
2. North exposure reaches of the Mercer County Waterfowl Refuge shore
3. West of Prairie Creek
4. West of Moorman Road
5. West of Behm Road (Duckfoot's Landing)
6. East and west of mouth of Chickasaw Creek
7. Area between South Shore Acres and Channel Isle
8. West of Barnes Creek
9. East embankment recreation area.

Streambank protection should be utilized where erosion is occurring through such measures as streambank fencing, grading and seeding of banks, or rearranging pasture and cropland with priorities in Coldwater Creek and Chickasaw Creek.

Erosion and sediment control practices, in accord with Soil Conservation Service and Ohio Department of Natural Resources standards and specifications, should be utilized at all construction sites.

In-Lake disposal of dredged material appears to be the most practical method of disposal. Riprap should be placed along shoreline facing the lake with additional consideration

given to one or two large islands constructed to serve as breakwaters and then several small islands constructed behind them (riprap shoreline of large islands only).

SEDIMENT CONTROL AND PHOSPHORUS REDUCTION

Management methods for runoff control should be employed in the following areas:

1. Efficient fertilizer and pesticide application – lakeshore residents; areas adjacent to the lake including cropland areas.

2. Composting yard debris – lakeshore residents; areas adjacent to drainageways to the lake.

3. Frequent street sweeping – developed areas adjacent to the lake (Celina, Montezuma, north and south shore); Coldwater.

4. Use of low phosphate detergents – north shore from Harbor Point to Lakeland Beach, Northwood and Sandy Beach; southshore from Village of Montezuma to Southmoor Shores.

5. Reduce sediment and phosphorus loads from agricultural areas by "best management practices" implemented under traditional soil conservation programs.

6. Bring all agricultural land under Soil Conservation Service criteria for allowable soil loss.

7. Investigate measures to increase funding levels of current conservation programs.

8. Consider legislation at the State level to enforce standards to reduce soil loss.

9. Conservation practices should be promoted in the lake watershed through State and Agricultural Stabilization and Conservation Service cost-sharing programs.

10. A detailed inventory of the potential sediment, phosphorus, and animal waste pollution problem areas should be conducted in the lake watershed to more accurately determine the extent of the problem.

11. The practice of conservation tillage and ultimately no–tillage should be encouraged in the lake watershed on properly drained soils.

12. Animals should be housed on or above an impervious base. In no case should runoff from livestock areas be allowed to discharge directly to waterways of the watershed. Methods such as frequent waste removal and storage, direct application to land, manure storage facilities, interceptor trenches, holding ponds and fenced waterways should be encouraged.

13. Priority areas for livestock waste management practices are those within 3,000 feet of waterways where an estimated 70 percent of animal concentration areas are located.

14. Grass buffer strips between row crops and waterways should be encouraged in areas adjacent to Prairie, Coldwater, Chickasaw, Barnes and upper Beaver Creeks.

15. Existing wetlands should be preserved to aid in filtering out nutrients and sediments; priority areas are Chickasaw, Prairie and Barnes Creeks, and small wetlands adjacent to animal concentration areas or critical soil/nutrient areas.

16. Close cooperation is considered necessary between the U.S. Fish and Wildlife Service, the Ohio Department of Natural Resources, and the Corps of Engineers in determining and evaluating suitable dredge spoil sites and project design.

17. The Dredging Operations Technical Support (DOTS) team, an activity of the Environmental Laboratory of the Waterways Experiment Station, U.S. Army Corps of Engineers, Vicksburg, Mississippi, should be consulted as a possible means of assisting the State in preparing a long–range dredging plan for the lake.

18. In-lake dredging should be limited to selective dredging of nearshore zones for lake access, boater safety improvements, and public lands development.

19. The conclusions reached with regard to sediment control and phosphorus reduction provide the basis for consideration of a Section 314 Clean Lakes project.

TENTATIVE RECOMMENDATIONS

Based on the conclusions contained in this report and following coordination with pertinent Federal, State and local interests, whose comments and responses generally concur in the study conclusions, it is recommended that the Corps of Engineers give no further consideration, at this time, to providing improvements in the interest of flooding, water quality, and other water and related resources at Grand Lake St. Marys, Ohio.

EXHIBITS

EXHIBIT NO. 1 Aerial view Grand Lake St. Marys

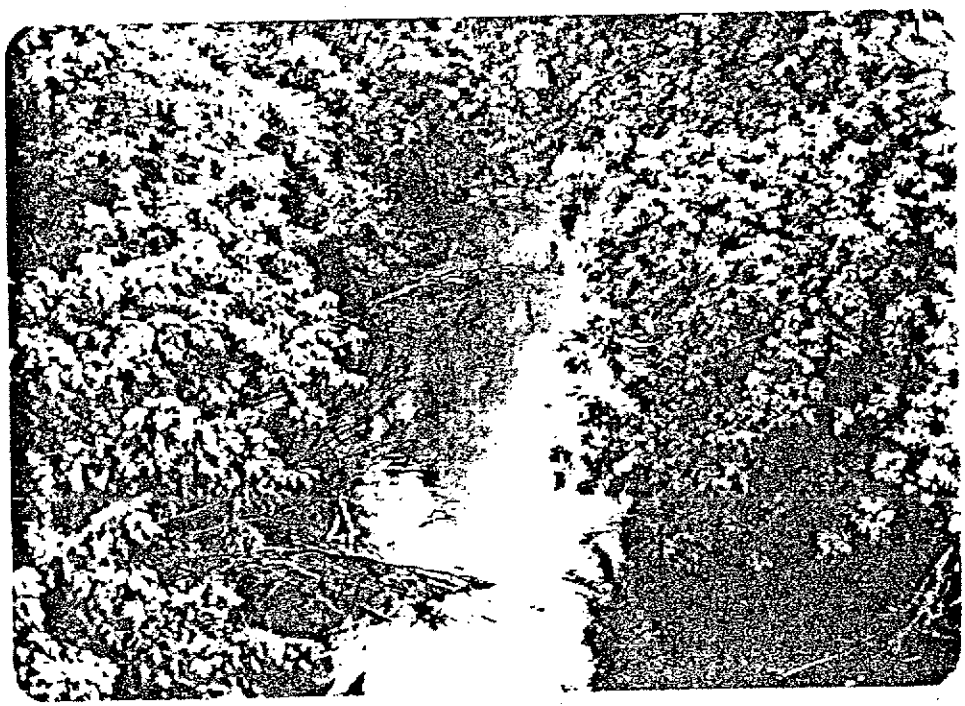


EXHIBIT NO. 2 View of Beaver Creek west from Meyers Road Bridge (April 1979)

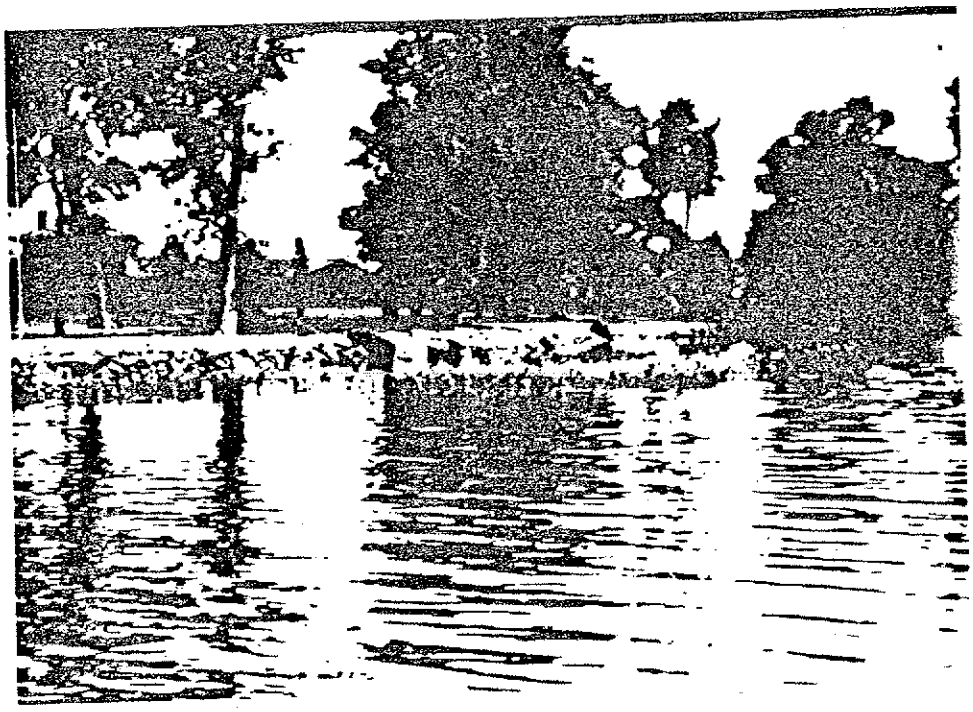


EXHIBIT NO. 3 Low-lying developed area on south shore. Some riprap bank protection. (1979)

EXHIBIT NO. 4 East embankment recreation area showing sloughing banks, the result of waves over-topping riprap. (1979)

EXHIBIT NO. 5 View looking north along east embankment recreation area showing riprap and sloughing banks. (1979)

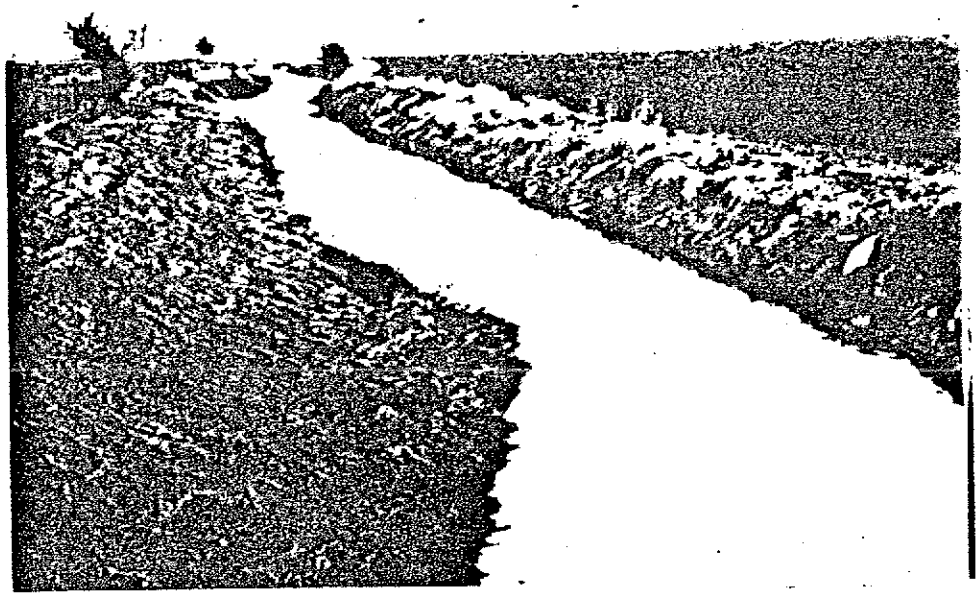


EXHIBIT NO. 6 Little Chickasaw Creek at S.R. 219 showing eroding banks 3,000 feet from lake. (1979)

EXHIBIT NO. 7 Eroding dredge spoil site, south shore. (1978)

EXHIBIT NO. 8 Severe bank erosion on State-owned south shore lands.

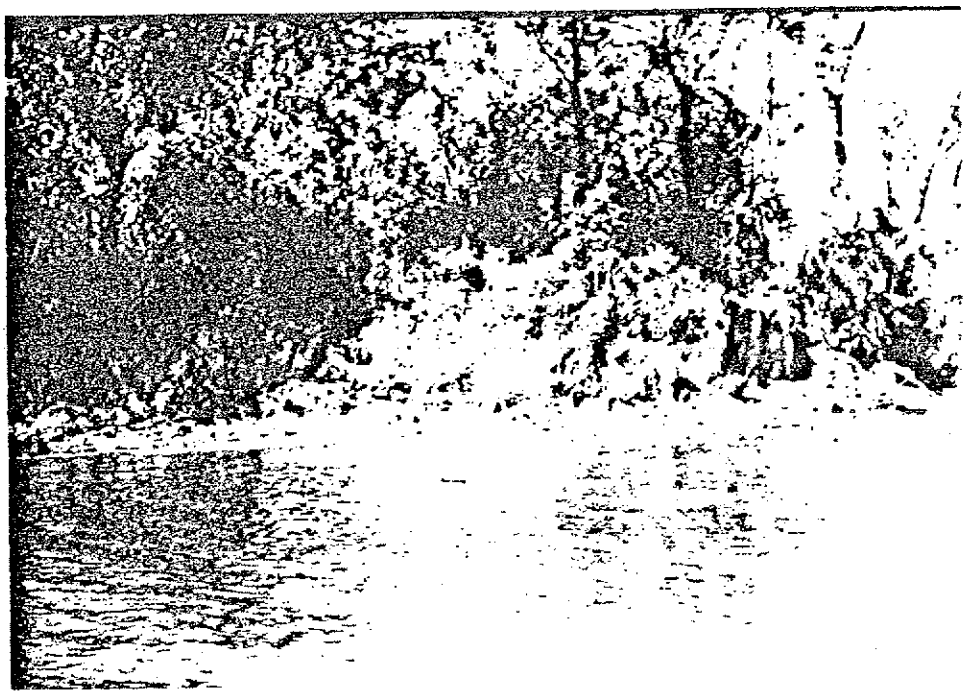


EXHIBIT NO. 9 Severe bank erosion on lake south shore channel inlet. (1979)

EXHIBIT NO. 10 Boat access channels requiring frequent maintenance dredging. (Dec. 1978)

EXHIBIT NO. 11 View of cleared portion of Beaver Creek approximately one mile from lake outlet. (1979)

EXHIBIT NO. 12 Grand Lake State Park on north side near Villa Nova. (1979)

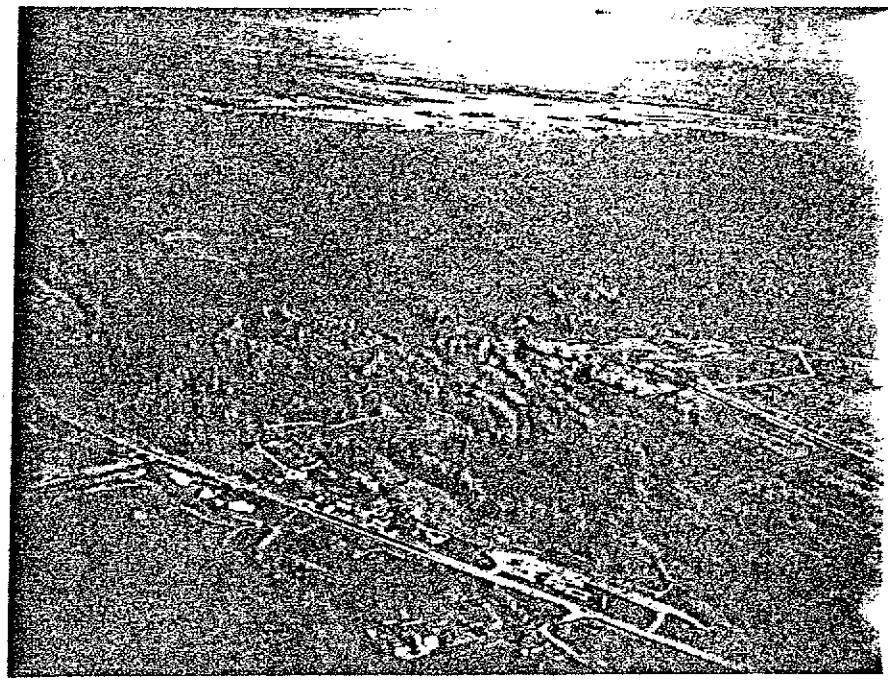


EXHIBIT NO. 13 Mercer County Waterfowl Refuge in Lower Southwest Corner of Grand Lake St. Marys. (Dec. 1979)

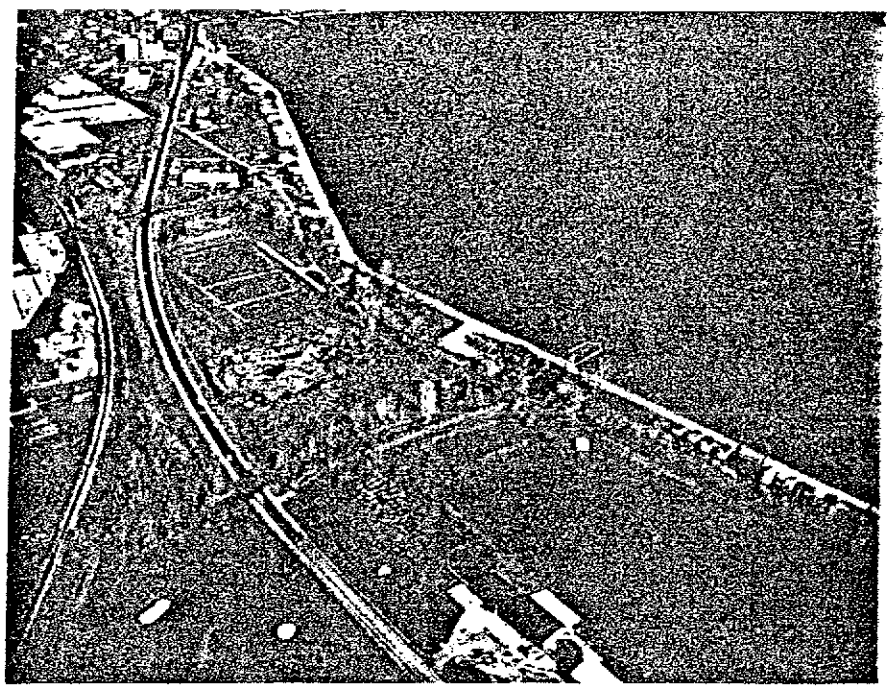


EXHIBIT NO. 14 Western Embankment and Beaver Creek Outlet Channel, City of Celina to the north. (Dec. 1979)

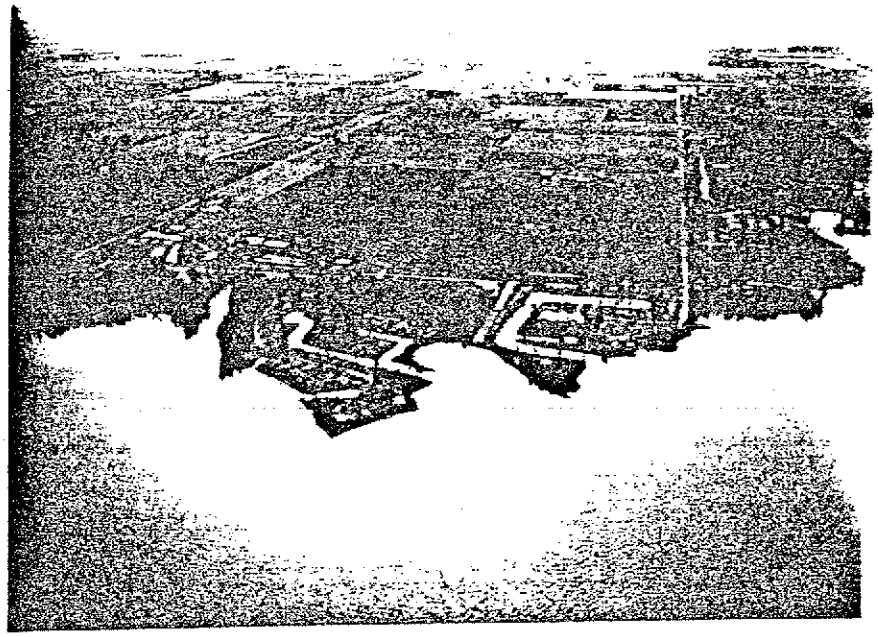


EXHIBIT NO. 15 Development and agricultural lands to the south, east of Windy Point Pier. (Dec. 1979)

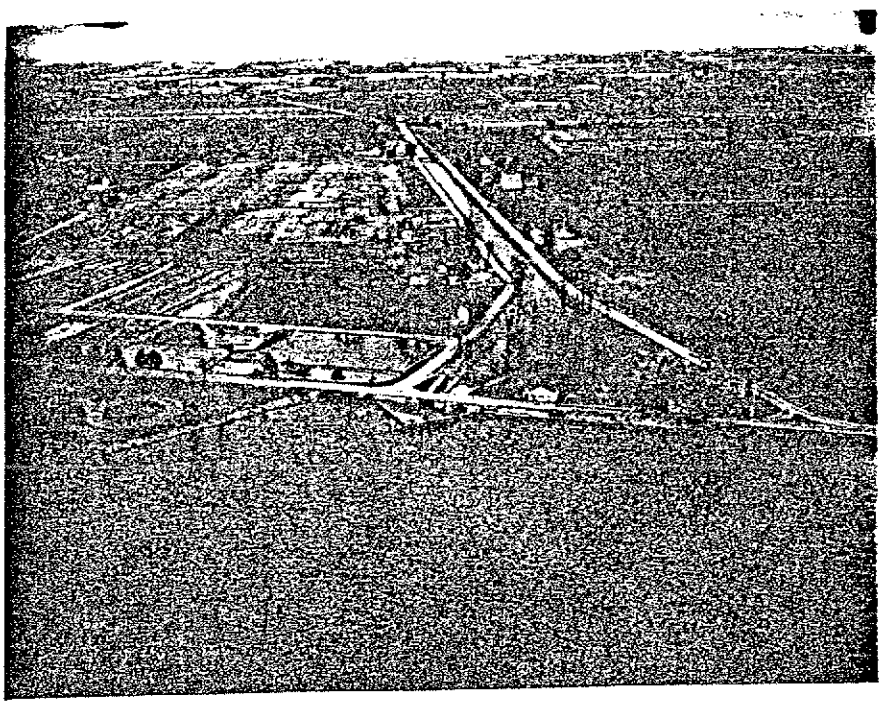


EXHIBIT NO. 16 East Embankment Outlet, St. Marys Feeder Canal and Fish Hatchery. (Dec. 1979)

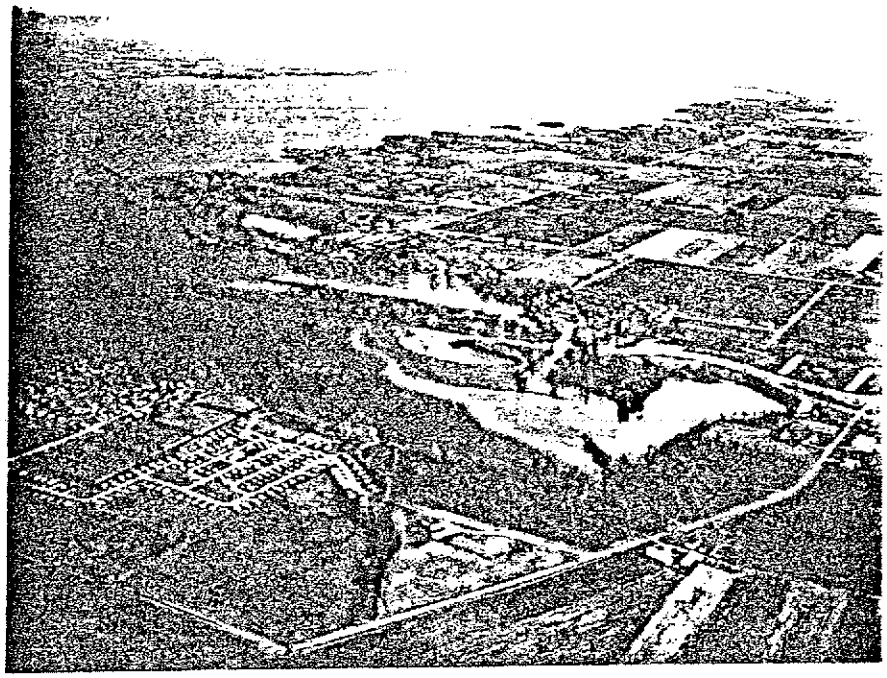


EXHIBIT NO. 17 Grand Lake St. Marys looking to northeast, Montezuma Bay in foreground. (Dec. 1979)

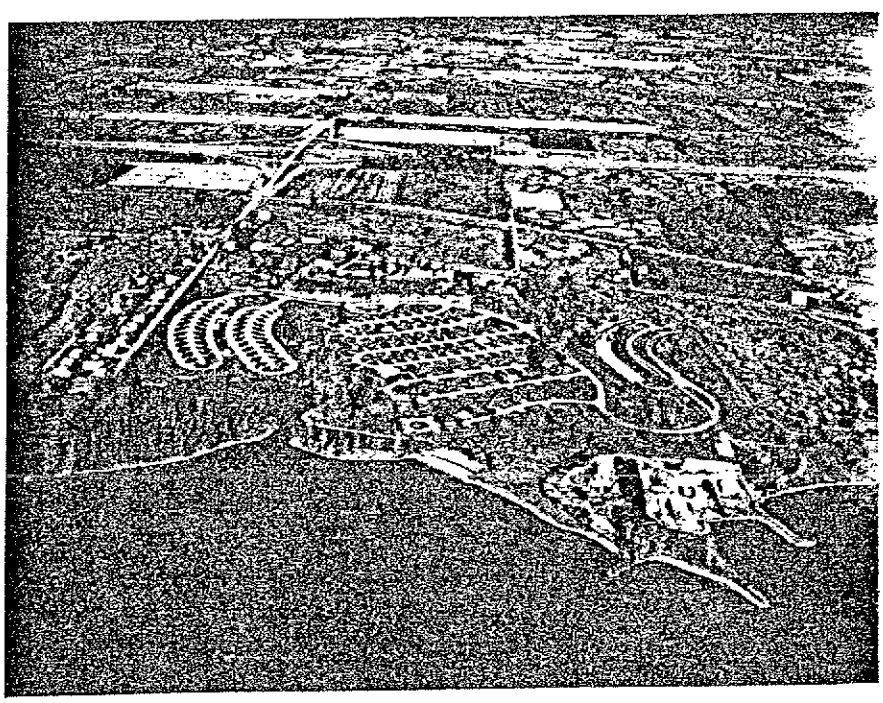


EXHIBIT NO. 18 State Campgrounds and Beach on north shore. (Dec. 1979)

MERCER COUNTY
RELATOR LAND PARCELS

☆ DONER, ET AL

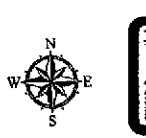
NUMBER	PARCEL	OWNER	TOWNSHIP
1	42-0037000.0000	ADAMS RICHARD L & NANCY L	Washington
2	42-0038000.0000	ADAMS RICHARD L & NANCY L	Washington
3	28-0410000.0000	BAUCHER FARMS INC	Jefferson
4	42-0017000.0000	BAUCHER FARMS INC	Washington
5	28-0110000.0000	DONER WAYNE ET AL	Liberty
6	28-0110000.0000	DONER WAYNE ET AL	Liberty
7	28-0110000.0000	DONER WAYNE ET AL	Liberty
8	28-0110000.0000	DONER WAYNE T	Liberty
9	28-0110000.0000	DONER WAYNE T & NANCY K	Liberty
10	28-0410000.0000	DWENKER LAWRENCE J & JOYCE A	Jefferson
11	28-0410000.0000	FIERING STANLEY H & VICKI L	Jefferson
12	28-0410000.0000	FIERING STANLEY H & VICKI L	Jefferson
13	28-0410000.0000	FLUS CARMEN R & JULE	Jefferson
14	28-0410000.0000	GUILBERT HAROLD EDWARD & MARY E	Jefferson
15	42-0004000.0000	GRANDA DANIEL & ESTHER L TRUSTEES	Washington
16	28-0410000.0000	HIGHLEY ROBERT E & PATRICIA	Jefferson
17	42-0020000.0000	HIGHLEY ROBERT E & PATRICIA L	Washington
18	42-0020000.0000	HIGHLEY ROBERT E & PATRICIA L	Washington
19	28-0410000.0000	HINES JASON E & EMILY A	Jefferson
20	28-0410000.0000	JOHNSMAN DAVID W	Jefferson
21	28-0410000.0000	JOHNSMAN DAVID & JOSEPH TRUSTEES	Jefferson
22	28-0410000.0000	JOHNSMAN JOSEPH LEE A JOHNSMAN DAVID ANDREW	Jefferson
23	28-0410000.0000	JOHNSMAN JOSEPH LEE & JOHNSMAN DAVID ANDREW	Jefferson
24	28-0410000.0000	JOHNSMAN LEROY J & RUTH TRUST	Jefferson
25	28-0110000.0000	KARR JEAN A TRUSTEE & RANSBOTTOM WILLIAM J	Liberty
26	28-0110000.0000	KARR JEAN A TRUSTEE & RANSBOTTOM WILLIAM J	Liberty
27	28-0110000.0000	KAMPE DAVID M & AMERICA M	Liberty
28	28-0110000.0000	KAMPE DAVID M & AMERICA M	Liberty
29	28-0110000.0000	KAMPE MARK L TRUSTEE	Liberty
30	28-0410000.0000	KAMPE TIMOTHY ALAN	Jefferson
31	27-0410000.0000	KRICK THOMAS L & CHARLES J	Jefferson
32	27-0110000.0000	KRICK THOMAS L & CHARLES J	Jefferson
33	42-0020000.0000	KUHN DARRELL DEAN	Washington
34	42-0020000.0000	KUHN MARILYN	Washington
35	28-0110000.0000	KUHN MARVIN EARL	Liberty
36	28-0410000.0000	LINN LINDA B ETAL	Jefferson
37	28-0410000.0000	MCCORKHUSE DAVID J & DEBORAH A	Jefferson
38	28-0410000.0000	MCMILLAN DAVID J	Jefferson
39	28-0410000.0000	MCMILLAN DAVID J	Jefferson
40	28-0410000.0000	MCMILLAN DAVID J & LAURA B	Jefferson
41	28-0410000.0000	MCMILLAN LOIS J	Jefferson
42	28-0410000.0000	MEIER CHARLES J	Jefferson
43	28-0410000.0000	MEIER CHARLES J	Jefferson
44	28-0410000.0000	MEIER CHARLES J	Jefferson
45	42-0010000.0000	MEYER JEROME L & AMY L	Washington
46	42-0010000.0000	MEYER JEROME L & AMY L	Washington
47	42-0010000.0000	MEYER JEROME L & AMY L	Washington
48	28-0110000.0000	POST DANIEL	Liberty
49	28-0110000.0000	POST DANIEL L	Liberty
50	28-0110000.0000	POST DANIEL L	Liberty
51	28-0110000.0000	POWELL JERRY & BETTY	Liberty
52	42-0020000.0000	POWELL JERRY & BETTY TRUSTEES	Washington
53	42-0020000.0000	POWELL JERRY & BETTY TRUSTEES	Washington
54	43-0010000.0000	POWELL JERRY W & BRYAN L TRUSTEES	Washington
55	42-0020000.0000	POWELL MARY LEONE ETAL	Washington
56	42-0020000.0000	POWELL MARY LEONE ETAL	Washington
57	28-0110000.0000	POWELL THOMAS L & BRYAN B	Liberty
58	43-0010000.0000	POWELL THOMAS L & BRYAN B	Washington
59	42-0030000.0000	TOMANDER TIMOTHY ETAL (PREDECEASED)	Washington
60	42-0030000.0000	ROSE CARL W & LUCILLE	Washington
61	42-0020000.0000	SCHROYER DOROTHY A	Washington
62	28-0410000.0000	DEARBORN ROBERT E & DONITA E	Jefferson
63	28-0410000.0000	DEARBORN ROBERT E & BONNIE	Jefferson
64	28-0410000.0000	DEARBORN ROBERT E & BONNIE	Jefferson
65	28-0410000.0000	DEARBORN ROBERT E & BONNIE	Jefferson
66	28-0110000.0000	SHEETS DUANE R	Liberty
67	28-0110000.0000	SHEETS DUANE R	Liberty
68	28-0110000.0000	SHEETS RODNEY E	Liberty
69	28-0410000.0000	SHEETS RODNEY E & LINDA	Jefferson
70	28-0410000.0000	STEPHENS JEFF	Jefferson
71	28-0410000.0000	STEPHENS JEFF	Jefferson
72	28-0410000.0000	STEPHENS JEFF	Jefferson
73	42-0010000.0000	STEPHENS MARY	Washington
74	42-0020000.0000	STEPHENS MARY & RONALD	Washington
75	28-0410000.0000	SUNS DAVID J & RITA K	Jefferson
76	28-0410000.0000	SUNS DAVID J & RITA K	Jefferson
77	28-0410000.0000	SUNS RITA MAY	Jefferson
78	28-0410000.0000	SUNS RITA MAY	Jefferson
79	28-0110000.0000	SUTTER CARL A & JUDITH A	Liberty
80	28-0110000.0000	THOMAS DALE R & HELEN G	Liberty
81	42-0010000.0000	WIESMAN JOHN & VICKI	Washington
82	28-0410000.0000	2 FARMS INC	Jefferson
83	28-0410000.0000	2 FARMS INC	Jefferson
84	28-0410000.0000	ZUMBERGE CHARLES ETAL	Jefferson
85	28-0410000.0000	ZUMBERGE CHARLES ETAL	Jefferson
86	28-0410000.0000	ZUMBERGE CHARLES ETAL	Jefferson
87	28-0410000.0000	ZUMBERGE JOHNNY D	Jefferson
88	28-0110000.0000	MUHLENKAMP WILLIAM	Liberty
89	28-0110000.0000	MUHLENKAMP WILLIAM	Liberty

☆ POST, ET AL

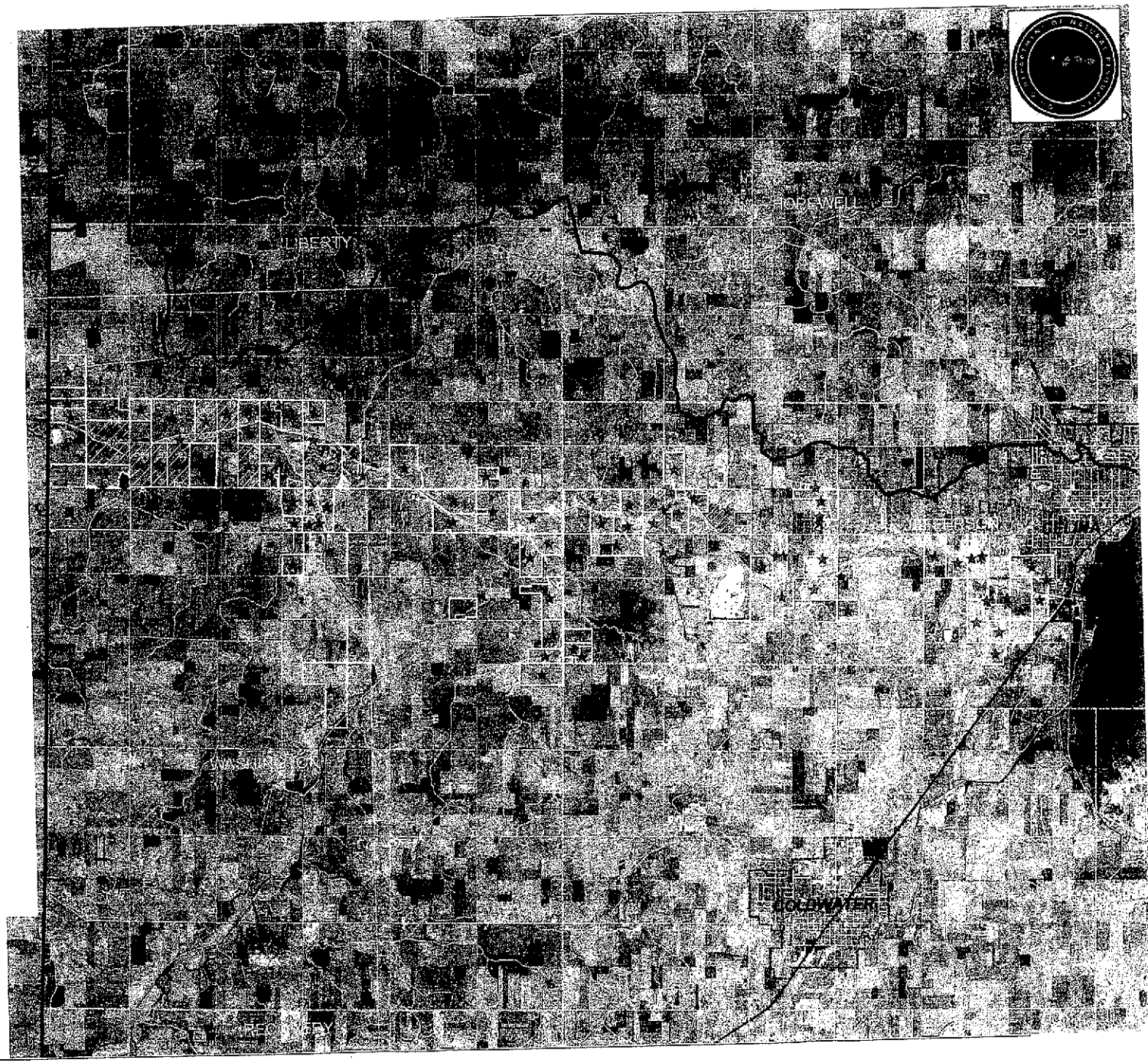
NUMBER	PARCEL	OWNER	TOWNSHIP
90	28-0410000.0000	BAUCHER RICHARD L & PATRICIA	Jefferson
91	28-0410000.0000	BAUCHER RICHARD L & PATRICIA	Jefferson
92	28-0110000.0000	LINN TERRY L & THERESA R	Liberty
93	28-0110000.0000	LINN TERRY	Liberty
94	28-0110000.0000	LINN TERRY L & THERESA R	Liberty
95	28-0110000.0000	LINN TERRY L & THERESA R	Liberty
96	28-0110000.0000	LINN TERRY L & THERESA R	Liberty
97	28-0110000.0000	MINICH EMILY W TRUSTEE	Liberty
98	28-0110000.0000	MINICH EMILY W TRUSTEE	Liberty
99	28-0110000.0000	POST FAMILY TRUST	Liberty
100	28-0110000.0000	POST FAMILY TRUST	Liberty
101	28-0110000.0000	POST FAMILY TRUST	Liberty
102	28-0110000.0000	POST FAMILY TRUST	Liberty
103	28-0410000.0000	ZUMBERGE STEPHEN J & VIRGINIA A TRUST	Jefferson
104	28-0410000.0000	ZUMBERGE STEPHEN J & VIRGINIA A TRUST	Jefferson
105	28-0410000.0000	ZUMBERGE STEPHEN J & VIRGINIA A TRUST	Jefferson
106	28-0410000.0000	ZUMBERGE STEPHEN J & VIRGINIA A TRUST	Jefferson
107	28-0410000.0000	ZUMBERGE STEPHEN J & VIRGINIA A TRUST	Jefferson

★ CASE LEASING

NUMBER	PARCEL	OWNER	TOWNSHIP
108	27-0110000.0000	CASE LEASING & RENTAL INC	Jefferson



Respondent 4

1 0.5 0 1 Miles

2009 Mercer County aerial imagery, Mercer County Auditor
2009 Mercer County Auditor parcel data
National Hydrography Dataset for Ohio, 2008, USGS
Watershed boundary, NRCS, 1999
Township / City boundary, ODOT, 2007
Map: GIS Services, ODNR, April 27, 2010