A: That's right. We made no changes on Conchas. Usually, the Waterways Experiment Station constructs the original model based on district office prototype design drawings. Then the tests are made see how the model operates. If the model shows a problem, then WES advises the district designers and suggests changes to correct the problem.

In the case of Conchas, the original design called for a stilling basin because the river was erodible. If instead the original design had called for a flip bucket, it would have been constructed in the model. Also, a model downstream river channel would have to be constructed so that the extent of its erosion could be determined.

If a large hole is eroded and progresses to the toe of the dam, that might endanger the dam. WES would show the model test results to the district's designers and say, "You shouldn't have a flip bucket. You should construct a stilling basin. " Fortunately, the district designers originally selected the stilling basin.

So the purpose of the model there was to have the design flood go over the spillway into the stilling basin and check out to see that the stilling basin dimensions were correct to form a good hydraulic jump and give maximum energy dissipation in the concrete-lined stilling basin before the water flowed down the erodible stream bed.

Q: That was the first of the models that you actually worked on and helped put together.

A: Yes.

Q: When you did your calculations, was it all done by hand or slide rule, or were early mechanical calculators involved?

A: We certainly didn't have computers.

Q: I know. [Laughter].

A: There were mechanical calculators, all right, but I always used the slide rule. I liked to use a slide rule. Figures could be carried out to the second or third decimal point with mechanical calculators. Models don't reproduce nature 100 percent, some only come within five to ten percent. I always found a slide rule to be satisfactory for making hydraulic model study calculations.

Q: You mentioned computers--how much did they enhance your ability to do these calculations when they came into use in significant numbers in the '50's and '60's?

A: I never used a calculator because I never had to make a detailed design where I had to do all the calculations myself. The district designers did that. When I went to the Chief's office, I never used mechanical calculators because I wasn't doing design. I was checking the design by slide rule. In a very short time, I could check something close enough and decide that's all right.

Q: The models that you made, like Conchas, came in from the districts. So they were funded by the districts to WES, right?

A: Yes. District projects are authorized by the Congress and money is made available to the Corps of Engineers for design and construction. Usually, it takes two or three years before districts get enough money, especially if they need to do a lot of geological field surveying, before they can complete the design sufficiently to send it to the Waterways Experiment Station for model testing.

Q: This was not done for all projects, was it? This was just done for certain projects that had questionable design aspects?

A: Small dams are not model tested, if they don't have questionable design aspects. All large dam projects that the Corps and the Bureau designed and built were tested with hydraulic models.

Q: When you were at WES, your friend Joe Tiffany was there. You've known him since then.

A: Yes. He called me up last night at 10:30. [Laughter]

Q: What was he like then, when you first met him in the '30's?

A: When I was at WES, he was the top engineer there. He wasn't outstanding intheoretical hydraulics or anything else, but he had good sense and was a good executive. Everyone respected him. Later, when I was in the Chief's office, I would go to meetings at WES several times a year. I'd always make a point of talking to Joe for an hour or so about things going on. Things that I had to look at and that affected the Waterways Experiment

Station, and we got along very well.

When the Committee on Tidal Hydraulics was established, he was appointed to that committee right from the beginning. Clarence Wicker of the Philadelphia District was elected chairman, but when Clarence retired, Joe was then elected chairman. He was chairman from '61 to '69, and he was a good chairman.

Q: Was there anything else you wanted to discuss concerning WES?

A: You asked me several times what did I think about WES. I have a letter that I wrote to WES after I was invited to their 50th Anniversary. The invitation is dated '79 and signed by Colonel Cannon, Commander and Director.

Twelve years ago. This was shortly after I retired from the Corps. I wrote, "Thank you for the invitation to attend the station's 50th anniversary. I regret that I shall not be able to attend. I arrived at the station fresh out of the university in July of 1935 when the station was barely five years old. It was small then, and the Engineers were just getting their feet wet in hydraulic models and soils testing. The station has grown tremendously with expansion of its research and engineering investigations in many engineering fields. It is now regarded perhaps as the world's leading research institution."

This is a great tribute to the many outstanding directors, staff and employees who have contributed so much to the development of the station's capability. I am proud to have had a small part in advancing the station's technical capability in hydraulic engineering in 32 years of service in the Office, Chief of Engineers. My association with the station's people have always been most cordial and rewarding. Sincerely ..."

Since you asked me what I thought about the station, I am pleased to have the above recorded.

Q: Now, I know that you weren't at WES when Herb Vogel was there.

A: That's right. Falkner was there. Vogel--I forget when he left--but I think it was a couple of years after Vogel left. First Lt. Falkner; Francis Falkner, was the director when I came there in 1935, July of 1935. He came from California, and hated Vicksburg. He always said, "Boy, anybody who comes to this God-forsaken place deserves a raise right now." That's when I went in to his office when I first arrived. He said he'd raise me $10.

Q: Did you ever work with Herb Vogel after that?

A: No, I never did. I met him a number of times. He was up here working for the World Bank, wasn't it, for awhile?

Q: Yes.

A: He was a consultant there, but I never worked with him, never was on any committees or anything.

Q: How about Gerard Matthes?

A: No, I never worked with him, either. I wasn't at the station in '36.

Q: Yes, he was there for years.

A: Not too many years, because Tiffany got his job. Tiffany's biography states that Matthes was there because the head of the Mississippi River Commission sent him over to be the Technical Director at the Waterways Experiment Station.

Q: Well, Tiffany was there until '69.

A: Yes, he was, but he was Director way before then. He was director in the early '50's. It says here when he was director. Here's what Tiffany says: "I served as WES Acting Director from Pearl Harbor Day in December 1941 when Captain Fields left for active duty until January 1, 1942. Max Tyler finally changed his mind about me continuing as Acting Director and instead appointed Gerard Matthes to the job. I did not talk to anyone about this, but Humfrey Moore told me that General Tyler had pulled a raw deal on me and Bill Turnbull told me he was perfectly satisfied with how I ran things when I was acting director for the preceding six months. These two voluntary statements made me feel pretty good. I figured out later why he did that."

General Tyler sent Matthes there. Tiffany figured out why he did it: "The MRC had two top engineers with exactly the rank and the general had to choose between them. One was Mr. Matthes, who was over 70 years old and a bit senile, the other was Harry Seymour, who was younger and more vigorous. The general sent Matthes to WES to put out to pasture, where he could not do anything harmful."

Q: What other studies did you do when you were at WES? Did you basically stay on dams?

A: Mostly, yes. I was there only one year, and after working two or three months up on the Mississippi River Basin model reading gauges, then I worked on dam models for nine months before I transferred to the Bureau of Reclamation in Denver, Colorado.

Bureau of Reclamation

I stayed [at WES] one year during which time I took a Federal junior engineer exam and passed it with a pretty good grade. I got three job offers, one from the Bureau of Reclamation, one from Brownsville District of the Corps of Engineers, and one from the Savannah District of the Corps of Engineers. The junior engineer grade paid $2,000.00 a year, and I thought, boy, that's a real big increase, from $120.00 to $167.00 a month. The Bureau of Reclamation paid $2 $00.00, but the districts only paid $1,620.00. Well, that didn't make it too hard to decide to go to the Bureau of Reclamation.

So I did, and went out to Denver, Colorado, where they assigned me to the Project Investigations Branch where they studied the feasibility of constructing projects to produce more power or irrigation water. The Bureau was not as flood control oriented as the Corps. I remember that after a feasibility study was authorized I had to take rainfall and runoff records and produce flow hydrographs to determine what large floods could occur and how much water supply could be obtained at specific locations where a dam might be constructed. The trouble was that three of us young engineers had to do all the boring work of looking up records, tabulating and adding them, do this and that, and then bring them into the boss. After about three months of that, I got tired of tabulating rainfall and runoff records, getting a hydrograph, and bringing it into the boss so he could use it and make the decision about what to do with it. He does all the studying, and would say, "Now, you do that and then add this, and let's try a bigger flood." He did all the interesting work and wrote the report on the feasibility of the project.

The Bureau of Reclamation had a little laboratory down in the basement in the old Customs House in Denver. So I wandered down there, and was interested in the models. I found that several Bureau dams were being model tested. I introduced myself to Jake Warnock, who was the director of the laboratory then. He asked if I were interested in working in the lab, and I said, "Yes, I'd just came from Vicksburg where I'd worked in the lab for a year, and I liked lab work." I told him I'd be interested in working in the laboratory whenever he had a vacancy. It wasn't very long, a month or so, when I started to work in the laboratory. He arranged for me to work in the Bureau's lab, and I worked there for about three years, mostly on hydraulic model studies of spillways and outlet works for dams being designed by the Bureau. I learned a lot about hydraulics and dams

there because we worked on model tests for about eight different kinds of dams with various kinds of spillways and outlet works.

Q: So this was a critical experience for you, then?

A: It certainly was.

Q: How much did you note the difference between the way the Corps worked and the way the Bureau worked at that time? Or had you spent just too little time with the Corps to understand that?

A: Yes. Well, the impression was in the engineering profession that the Bureau of Reclamation was the outstanding government engineering agency. They knew more about design and construction of dams than any other agency. That's not surprising because the Bureau started at least 20 years before the Corps on designing and constructing dams. When I was working for them, they were doing a lot of things that the Waterways Experiment Station wasn't doing. The Waterways Experiment Station was just doing model testing. I was in the Bureau's head office, where design, model testing, project investigations, concrete and earth dam engineers were all in one building.

Q: Did you discern any kind of institutional approaches on the Bureau's part at that time? Did they have a preference for a type of dam, earth versus concrete, or a specific design?

A: No, I don't think so. A lot of their dams were earth. Of course, the specific factors and conditions many times made it obvious whether an earth dam or a concrete darn should be constructed. In a narrow gorge with rocky abutments, a concrete dam will be the least costly. Construction of an earth dam is difficult in that kind of site. On the other hand, for a low dam in a valley, 500 or more feet wide, usually an earth dam was cheaper. The cost usually determines what kind of dam is constructed.

Q: The cost and the actual physical topography of the area that you're dealing with are also critical, aren't they?

A: Yes. That has something to do with it, too. Topography affects the cost, so, actually, topography, type dam, and cost are interrelated factors. Also, for a fairly high dam, if there is no good rock foundation, it's better to construct an earth dam because the base of the earth dam is much broader than a concrete dam. That's the most important factor to

consider in deciding whether an earth or concrete dam should be constructed.

Fort Peck Dam on the Missouri River is an earth dam constructed on a foundation with very little rock. The dam is relatively low and the river is unusually wide. Construction of a concrete dam was not even considered because the conditions strongly favored the earth dam. The spillway and 36-foot diameter outlet tunnels were constructed of concrete to carry the large, high-velocity flows. Concrete stilling basins were constructed at the downstream ends of the spillway ad outlet tunnels to still the water flows before entering the Missouri River's erodible channel.

Q: So, even in those big earth dams, you still have a lot of concrete work that you have to put in?

A: Oh, yes. There's a lot of concrete.

Q: And that's where your skills come in?

A: That's right, the hydraulic engineer is involved with both concrete and earth dams because in almost every case the spillway and outlet works need to be constructed of concrete. Only for low dams and very good rock conditions, can the spillway be excavated in a dam abutment.

Q: I may be jumping ahead here a little bit, but how much different is it in the hydraulics when you have to do a multipurpose dam, when you're going beyond just flood control, when you're starting to put in the penstocks and the hydro. Does that cause a lot more difficulty in the design? You have to look at a lot more things then, don't you?

A: In either case, there's no difference as far as the spillway is concerned. The difference is in the outlet works. For a large dam, like all those on the Missouri that produce a lot of power, one or more penstocks are needed. These are constructed of concrete underneath the dam at its base to the power house and turbines that generate the power. In addition, one or more conduits or tunnels are needed to serve as outlet works. During a large flood, some water can be released through the power penstock, but not nearly as much as through the same tunnel if it is not hooked up to a power turbine.

For example, Fort Peck Dam has, as I recall, about six big tunnels, of which four lead into a stilling basin and are used as outlet works. Maybe it's the other way around--four lead into the power houses, and two lead into a stilling basin. Normally, when water

stored in the reservoir was being released to produce power, no water was released through the outlet works tunnels.

But, if a large flood occurred and the reservoir water level increased so the spillway operated, then the outlet tunnels would be operated to control the reservoir level and spillway flow. The spillway and outlet tunnels are designed to be large enough so that their combined maximum discharge will control the probable maximum flood at the dam. This, also, determines how high the dam needs to be to prevent overtopping by the probable maximum flood.

Q: The Bureau, at that time, was involved in a lot of dams. It was working on Grand Coulee, then, in the late '30's, and had just finished Hoover, right?

A: Hoover was finished in about 1936, and Grand Coulee a few years later.

Q: Do you remember any of the dams that you were doing work on in your laboratory work?

A: I remember one especially, Lahontan Dam in Nevada. It had already been constructed with an unusual type of spillway, a step spillway. Instead of having a smooth concrete spillway invert down to the river channel, it had a series of steps. The water flowed about 100 feet on a level floor and then dropped vertically about 10 feet. There were about eight such steps before reaching the river channel.

The dam was operated a couple of times during large flows, which caused erosion at the bottom of those steps. A model study was not made of the stepped spillway during the design stage, so a model was designed and tested to determine what changes had to be made to improve the operation. I did those model tests and found that rounding the top of the steps improved the flow over them sufficiently to eliminate the erosion problem. Tests also showed that some of the steps could be eliminated, but at greater cost.

The prototype spillway was modified in accordance with the model test results. A few years later a large flood occurred, and the spillway operated satisfactorily without any erosion. I haven't heard anything about it since. It's probably still operating satisfactorily.

Q: When you were in Denver, did you do any additional work at either the University of Colorado or Colorado State, both of which apparently offered some advanced work in hydraulics?

A: Yes, they did. The Bureau had done some of their model testing up there at the University of Colorado. E[mory W.]. Lane was in charge of the model testing there.

Q: Was that at Colorado State at Fort Collins?

A: Fort Collins, right.

Q: Yes. That was Colorado State.

A: Colorado State. Oh, yes. University of Colorado is south of Fort Collins, isn't it?

Q: Right. It's in Boulder.

A: Right. Boulder. I didn't do any work in the Fort Collins laboratory.

Q: So you were in there in the Bureau's Denver Laboratory the whole time?

A: Yes. Oh, I did some work in the Denver laboratory on the Boulder Dam tunnel spillway. Joe Bradley was there then. Did you ever hear his name?

Q: No. Who was he?

A: Jake Warnock was head of the laboratory, and Joe Bradley was the assistant. He was in charge of the Boulder model, and I worked with Joe on that. The details of that escape me right now.

Q: Well, you had some fairly important engineers working there in Denver, didn't you?

A; Yes. I think they knew more about the hydraulics of dams than anyone in the Corps at that time.

Q: Well, besides Lane, didn't you have Edgar Houk there?

A: Houk? Yes, he was in the Denver office. He headed one of the design branches. I never

was very close to him.

Q: They did a lot of early work there at Denver on modeling and hydraulic modeling.

A: That's right. And design. They did all the design right there in the Denver office, too. They didn't have field offices that did design like the Corps' district offices. They had field offices that did the surveys and, when construction started, managed the construction. The Denver office did all of the design.

Q: We were talking about the Bureau's design work at the Denver office. They apparently were pretty good and pretty far advanced from what you say?

A: Yes, they were. They were known the world over as being the leading dam designers.

Q: So actually, your work in the Bureau was like a post-graduate course in dam design?

A: Right. That's right.

Q: Do you ascribe a lot of your later success to that experience?

A: Yes, I do. After I left the Bureau, in 1938, I went back to the Corps of Engineers, Los Angeles District Office. I remember many times when we discussed a design problem, I'd say, "The Bureau does it this way, and I think that's the way it ought to be. " The Corps people recognized that the Bureau knew what it was doing.

Q: How much interaction was there between the Bureau and civilian hydraulics professors, not consulting engineers?

A: I had significant contact with Professors Rouse, Straub, and Ippen, who headed the Iowa, Saint Anthony Falls, and MIT [Massachusetts Institute of Technology] hydraulic laboratories, respectively. They were on a number of Corps of Engineers' consulting boards. I took a course from a professor at Colorado State. It was a good course, closely related to model testing.

Q: So, it was more theoretical or practical?

A: More theoretical. That's right. Other than that, I had no contacts with professors.

Q: I was looking at Hunter Rouse's book on hydraulics in the United States...

A: I first met Hunter Rouse in 1936 when he worked for the Sedimentation Laboratory at the California Institute of Technology. Later, I attended annual conferences in hydraulics at the University of Iowa, which were organized by Rouse.

Q: Was that in the 1930's or later?

A: It was later, I think, in the late 1940's and early 1950's.

Q: Well, Hunter Rouse was already at work there by that time?

A: Yes. I think he became a professor at Iowa in 1939. I've got the proceedings of his hydraulic conferences in a box here, which I plan to donate to the Corps' Office of History. The Corps used hydraulics professors as consultants more than the Bureau did. Maybe it was because I was new at the Bureau, and didn't get involved as closely with professors as I did later when I was with the Corps.

Q: Did the Bureau have so much experience that it really didn't need many professors?

A: That would be the reason, because the Bureau developed its design procedures before the professors came aboard. Rouse was a young man when the Bureau was well into the design of dams. The Bureau engineers were practical designers, and didn't use the theoretical fluid mechanics that Rouse was teaching. I think that's probably the reason.

Q: So again, it's a conflict between theory and practice?

A: That's right.

Q: When you were dealing with Rouse, you were more in the applied area and he was more in the theoretical.

A: That's right. I was on a couple of boards with him. One was a large dam in British

Columbia, Mica Dam. He and I were on the same board for about five years. When a question arose about a hydraulics problem, I said, "Call on Hunter Rouse first, and let him give us the theoretical aspects of the problem, and then I'll speak on the practical aspects of the problem." Everybody laughed. Usually, the practical and the economic method was the one that was selected over a purely theoretical way of solving the problem.

Q: You also mentioned Lane, Emory Lane.

A: Yes.

Q: What kind of a person was he, and how much influence did he have on your subsequent career? Was there any?

A: He didn't have very much influence because I never was close to him. He was up in Fort Collins all the three years I was at the Bureau, and I didn't have very much contact with him.

Q: From your knowledge of his work?

A: He was a well-known man in his field of hydraulics.

Q: How about Warnock? He must have had some significant influence on you?

A: Yes, he did. He was a good producer, and he was extremely practical, but he was short on theory. He didn't like to write reports. Just wanted to get the laboratory work done as fast as possible.

Q: So he was an activist?

A: Yes. Unfortunately, he became ill, and died in his early 50's.

Q: Didn't the Bureau also have a small laboratory out in Montrose, Colorado?

A: Yes, it did. I don't think I ever went there. I don't know anything about it.

Q: Were they mainly working on irrigation?

A: That could be, yes. They did quite a bit of work on development of irrigation techniques. I didn't get into that, at all.

Q: I've got some other names here I'm going to ask you about, and see if you can remember any of them.

A: All right.

Q: Did you do anything with Mr. John L. Savage?

A: Yes. He was the Chief Engineer or Commissioner when I first went to the Bureau. I remember that he wasn't in Denver much of the time because he was already working as a consultant for the Chinese on their big projects. He consulted on a very large Chinese dam, one of the largest in the world. I've forgotten its name. I don't think it's constructed yet. Savage was the first American consultant on it.

About ten years ago, a team of Bureau and Corps engineers went to China to advise on the dam's design. After nearly a year, they produced a report. Now, Lloyd Duscha, who retired from the Corps of Engineers as Chief of the Engineering Division in the Chief's office about four years ago, goes to China as a consultant on their dam projects.

Q: I want to ask you about some other people who were working out there in Denver or at Fort Collins about the same time you were there. John Drisko?

A: Yes, he was there. He worked in the Bureau's hydraulics laboratory the first year I was there, and then he went to New York to work for Tibbetts, Abbott, & McCarthy, consulting engineers. I did a lot of consulting with Tibbetts, Abbott, & McCarthy, and Drisko was there for awhile. He retired about 15 years ago. I don't know anything about what he's doing now.

Q: How about Frank Campbell?

A: Frank Campbell. Yes. Did Frank work at the Bureau?

Q: He was at the laboratory there in the late '30's.

A: Oh, he must have been up at Fort Collins.

Q: He may have been at Fort Collins.

A: He went to work for the Corps in the Omaha District Office in the early 1940's. When I went to the Chief's office in 1946, I met Frank in the Omaha District Office shortly afterwards. He was in Hydraulics Design Branch there. One thing we talked about was the hydraulic design criteria that the Bureau had developed and was publishing in design criteria manuals.

I said that the Corps ought to be doing something like that, too. He agreed, but it was a couple of years before I was able to persuade the people in the Chief's office that we ought to develop our own design criteria. We got plenty of basic information, but we've got to get somebody somewhere to sit down and put it together.

Slichter was Chief of the Engineering Division, and he said, "You think about it, work something out, and come back." I had the idea that Frank Campbell was the type of engineer who liked to collect available information and develop design criteria. Slichter agreed that I should organize the work.

I called Frank and said, "I've got authority to organize the development of the Corps' design criteria. I think the way to do it is to have the work done at the Waterways Experiment Station. Are you interested in going to Vicksburg and working on this?" He said, "Yes, I am." He went there, and arranged for two other laboratory people to work with him. He finished his career working the last 15 years or so down in Vicksburg. He developed and published a lot of hydraulic design criteria. Frank retired nearly 20 years ago and is still living in Vicksburg.

Q: What about Donald Barnes?

A: Don Barnes was in the Bureau's Denver laboratory when I was there. He was Jake Warnock's assistant for a while. I worked with him on several model tests. He was an exceptional person and engineer.

Q: Did he stay in the Bureau then?

A: No. He left about 1945 and went to the Washington office of the Department of the Interior. He retired in the 1950's and came back to Denver. I haven't heard of him for many years. I think he is still in the Denver area.

Q: How about Haywood Dewey?

A: Oh, yes. Dewey and I were very close. In fact, we had desks right next to each other when we were working in the Bureau's Project Investigations Branch. We also worked together in the laboratory. Dewey was an Army reservist, and when World War II started, he served in the Army for about two years. After the war, he went to work for the Corps of Engineers. I don't know where, but in about two years he went to the San Francisco District as head of the hydraulic laboratory.

Q: Was he involved with the San Francisco Bay Model at all?

A: Yes. A very large model of the San Francisco Bay was the only model being tested at that time

Q: The Bay Model was quite intricate, wasn't it?

A: Yes, it was. I never worked there, but when I was in the Chief's office, I went to the laboratory several times to attend review meetings of the model tests results. It was a very good model.

Q: What about Victor Streeter?

A: Yes. Victor Streeter was also at the Bureau of Reclamation's Denver laboratory when I was there. He was very theoretical, and didn't seem to be happy about just running model tests in the basement. It wasn't very long before he left to become a professor at the University of Illinois. He wrote a book on fluid mechanics. As far as I know, he ended his career there.

Q: By the time you had worked with both Streeter and Barnes, they had both been to Germany on John Freeman Fellowships.

A: Yes. That's right.

Q: Did they talk about that experience? How critical was that? Did they pass a lot of information back to you folks?

A: Not very much. I don't remember that they ever gave us a lecture on what they learned in Germany. They had some reading material. I don't really know very much about the Freeman scholarship.

Q: Many experts consider this to have been very critical in the development of hydraulics as far as international technical and scientific transfer is concerned.

A: I think that is correct, probably more with respect to the theoretical aspects.

Q: But you didn't gain anything from them on that?

A: No, I didn't. I don't remember anything.

Q: Is there anybody else you can remember from your days in the Bureau that played a significant role in the development of hydraulic engineering or hydraulics?

A: James Ball. He worked with the Bureau a long time in its Denver and Fort Collins hydraulic laboratories. When he retired, he did consulting and taught part-time up at the university in Fort Collins. The Bureau's laboratory was turned over to the university, and he headed that for a while. They did contract model studies for various clients, and Ball was in charge of making the model studies for a year or two when Richardson took over his place. Ball stayed at the university and taught a course, and then he did some part-time consulting. He and I were together in Iran, just before the Ayatollah took over. [see pp. 79-81].

Q: Let's see. We've now talked about all those folks. You've said several times that this Bureau experience was formative. Then you went from the Bureau back to the Corps and to the Los Angeles Engineer District.

A: Yes.

Los Angeles Engineer District

After working at the Bureau for about three years, '36 to '39, I wanted to get back to California. I knew some fellows who were in the same class as I was at Berkeley who had gotten jobs with the Los Angeles District, so I wrote them a letter. They said, "Jimmy Jobes is Chief of the Hydraulics Branch here, and he runs the lab also, plus the hydraulic design work. Write him a letter. "

So I wrote him a letter, and in a short time he replied, "We've got a job in the Hydraulic Design Section paying $2,300.00." Well, that's $300.00 more than the Bureau was going to pay me.

It wasn't very long before the word got around that I was leaving the Bureau to work for the Corps, and Debler, Chief of the Project Investigations Branch, asked me to come and see him. He said, "I hear you're going back to the Corps of Engineers." "Yes, to the Los Angeles District office. I want to get back to California, and they're paying me 2,300. That's more than you folks pay here." He said, "I'm going to tell you one thing. The Corps of Engineers is not a good outfit to work for. They're just crummy. I've got a place for you to work up in Boise, Idaho, where we've got a field office, and I'll pay you 2,300 if you'll go up there."

I said, "Well, no, I appreciate all your kindness, but I want to go back to California. All my family's there." So I did. That's how I got back to California.

Wolf Creek Dam, Nashville Engineer District

Q: I've got some information here that says you went to Nashville District first, in 1939.

A: Well, I went to Los Angeles District, but I was there only a short time when I was sent to the Nashville District. TVA was trying to get money to design and construct the Wolf Creek Dam in Tennessee. The Corps of Engineers thought that its Nashville District should do it.

It got to be quite a hot political item. Roosevelt was president then, and it was all laid out before him. He said, "The Corps of Engineers should do it. " It was known that there was something he didn't like about the TVA. The TVA said, "The Nashville District doesn't have any experience designing dams. We do."

Roosevelt asked the Corps representative, probably the Chief of Engineers, what he could

do about that. He answered, "We've got a lot of good dam designers in the Corps. What we'll do is get a group together from our districts, our most talented people, and we'll send them to Nashville for however long it takes to design the dam, probably about a year." So Roosevelt said, "Fine. Do it that way."

It wasn't very long before Åke Alin, Chief of the Engineering Division, Omaha District, was assigned the job of heading up the team. He decided the kind of engineers that were needed: hydraulic, structural, concrete, and electrical engineers. He contacted several divisions and districts, including the Los Angeles District, asking for volunteers to fill the positions on the team. I applied for the hydraulic engineer job and got it.

I was on loan to the Nashville District and was paid per diem by the Los Angeles District. I remember the per diem was $5.00 a day. [Laughter] Holy Moses! $5.00 a day! I was there for about three months. My wife and I were married about a year, and she enjoyed going there. We had a room in a boarding house, which didn't cost us very much. We saved enough money to buy a new car. First car we owned.

Q: Were there any peculiarities about Wolf Creek that you remember?

A: It's design was quite simple, much like Conchas Dam. It was a concrete dam, with a center overflow spillway, small sluice outlets, and a stilling basin, which did not require model testing.

Q: Just went in and designed it?

A: My experience with the Conchas Dam and several others made it easy to design Wolf Creek Dam.

Q: You were out there for several months then?

A: I was there about three months. My wife's sister and brother were still living in Washington, D.C., where she lived for a number of years. We went to Washington and visited there awhile, and it was about four months before we got back to Los Angeles. I went back to work on my previous job in the Los Angeles District.

Hydraulic Engineer

Q: Let's go back to the Los Angeles District now. You went to Los Angeles District in 1939 as a hydraulic engineer. Were you hired to do general hydraulic design work in the district or were you specifically hired for some of that flood control work in Los Angeles?

A: Jimmy Jobes was Chief of the Hydraulics Branch, which had hydrology and hydraulic design sections. There was a small laboratory along the river in the park, about six miles from the office, which also was under the Hydraulics Branch.

Bill Cassidy was in charge of the hydraulic design section, and I worked under Bill. We designed flood control channels for the Los Angeles River, San Gabriel, and other rivers. These channels were mostly concrete-lined, but some were lined with rock riprap. We also did the hydraulic design and model studies for Santa Fe, Hansen, Sepulveda, and several other dams and debris basins.

After a year or so, Bill Cassidy was promoted up to the Division office, ... and Jimmy Jobes got promoted to Assistant Chief of the Engineering Division. I got promoted and I got Bill's job. I was chief of the hydraulic design section, and had the hydraulics laboratory under me. Al Gildea was in charge of conducting the model tests, which were mostly on river channels then.

Flood Control Dams and Channels

Q: These flood control dams were a little different for you, weren't they?

A: They were a little different dams; they weren't as high and were designed to store debris as well as water. Dams which were designed mainly to store debris were called debris basins. The mountain streams carried large volumes of gravel, which, if not kept from passing through the concrete outlet works, would cause severe erosion damage to the outlet.

Another problem had to do with trash racks in front of the outlet works. Normally, large quantities of floating trash would be carried by flood flows to the trash racks. At Sepulveda Dam, during one big flood, there was so much trash blocking the trash racks that only about 20 percent of the design flow was passing through the outlet works. When I went out to study the problem, the reservoir water level was about 30 to 40 feet higher upstream from the trash rack than the water level on the downstream side of the trash rack. This was caused by the large amount of trash blocking the rack.

Q: What was required? Make wider spillways or something that would take that junk out?

A: We had to enlarge the openings in the trash rack so the debris would go on through.

Q: When you do something like line the Los Angeles River with concrete, those floods are very large flows, aren't they?

A: Yes, they are.

Q: Your design has to be specifically gauged to those large flows, doesn't it?

A: Yes. We had what was called a design flood, and we designed the channel to carry the peak flood discharge of that. The channel was constructed wide enough and deep enough throughout its length to carry the design flood.

The Los Angeles River channel is concrete-lined, except for the lower six or eight miles where the slopes were flatter and the velocity is not so high. Here, it was found that a less costly method of rock lining the levees and constructing rock drop structures across the channel every 1,000 or 1,200 feet was a lot cheaper than concrete-lined channels.

Q: What were the problems that you might have had working on those flood control channels? We talked about the debris problem.

A: The drop structures had to be designed so that the water would drop about 10 feet, and they had to be designed as part of a small downstream stilling basin. Even though the velocity was fairly low, the river bed is nothing but sand, which might scour sufficiently to undermine the downstream levees. Model tests were made of the drop structures to be certain there was adequate protection. Downstream of the drop structure, some rock protection was required to prevent excessive erosion of the sand beds.

Q: There was a lot of work going on in the late 1930's.

A: Yes. There was a lot of work going on then. During the time I was there, we designed San Gabriel River channel from the mountains all the way down to the Bay. The Los Angeles River channel construction was already completed. The San Gabriel River channel, which was about three or four miles to the east and ran almost parallel to the Los

Angeles River channel for the last 10 or 15 miles, was not concrete-lined; it was rock-lined all the way, with drop structures. At the same time, we were designing Santa Fe and Whittier Narrows Dams.

Q: So the one we see--mostly on TV--is the Los Angeles River?

A: Yes. That's right. One time someone got the idea that, since the river was dry most of the time, a traffic freeway should be constructed through the City of Los Angeles on the bottom of the river channel. [Laughter]

I pointed out that at least small flows occurred at all times along the center of the channel, so the freeway would need to be placed part way up on the channel banks, with one side going south and the other side north. The problem was how high up on the banks would it need to be to remain in service most of the time and not be flooded by river flows resulting from every rain storm.

Q: Did you get involved in the Santa Ana River work at all?

A: Yes, I did.

Q: That's still ongoing, isn't it?

A: Yes, it is. Prado Dam was built while I was there. I worked on its design. The hydrology of the whole Santa Ana River system was reviewed several years ago. It was concluded that the Prado Dam isn't large enough to take a probable maximum flood. Now the Corps is thinking about constructing another dam at the upper end of the Santa Ana River at the base of the mountains.

After Prado Dam was constructed, the Santa Ana River levees downstream of the dam were raised so the river channel would carry the Prado Dam spillway design discharge. However, those levees are not high enough to carry the probable maximum flood discharge. The levees are so low that if the spillway had gone into its maximum flow, it would have flooded that development downstream from Prado Dam to the ocean. When Prado Dam was built there, much of that was just farmland and so on. But now, it's all houses. The quickest thing they could do was raise the levee all the way down. That hasn't been completed. The design of the second dam and for additional raising of the Santa Ana River levees has been completed, but construction has been delayed because of budget problems.

Q: Were you involved in the San Antonio project?

A: Not in its design. It was already constructed when I was there.

Q: Well, none of those were particularly different, were they? I mean, these are all flood control and debris basins basically.

A: That's right. All the dams in the Los Angeles area were for flood control and debris storage. It was not economically feasible to develop water supply or hydropower in the Los Angeles area because rainfall occurred about three months of the year, so the reservoirs were usually dry.

Q: So mainly there's just flood control there?

A: Yes.

Q: So you spent the time from 1939 to 1946 primarily working on these flood control structures?

A: Yes.

Los Angeles District During World War II

Q: You weren't switched to any of the military construction when the war started?

A: No, no military construction, except that when the war started, a more concerted effort was made to protect airfields from flooding. Moffett Field was one. When it was constructed before the war, nothing was done to protect it from flood drainage. But after the war started, the military decided that flood protection was needed so that the field would be operational at all times. I assisted in the design of drainage ditches to prevent water flows during large rainstorms from flooding the runway.

Q: Do you remember anything else about working in Los Angeles District there during those years? People you worked with?

A: In 1939, Dick Eaton was Chief of the Navigation Section, Los Angeles District. The lower ends of the rivers that ran into the Pacific Ocean or a bay were navigable. Also, many of the bays had navigable harbors. Many of the navigation channels and harbors had to be deepened and maintained by dredging. In about 1941, Dick got promoted to the division office. He was put in charge of harbor design and maintenance for the entire South Pacific Division, all up and down the Pacific Coast. Several years later he came to Washington, and he was technical director of the Beach Erosion Board [BEB], and later, the Coastal Engineering Research Center **[CERC].**

Q: So he was one of the coastal engineers that you later dealt with. During the war, then, you just kept on working on those flood control projects?

A: Yes. We kept on designing them, but we didn't get money to do any construction. We were told by higher authority that the flood control projects had to be designed and put on the shelf because when the war ends there will be a lot of people, including soldiers, looking for work, and there will be plenty of money to construct these projects. For two or three years, that's all we did. Then after the war ended, it was about another year before construction started again.

Q: What was the Los Angeles District like during the war years?

A: There was a military division in the district. Jack Tyler was in charge of the military work. They designed and managed the military construction of several military airfields and camps. I wasn't involved in that.

Q: That must have been a pretty large district?

A: Yes, it was one of the largest, if not the largest, Corps district. I remember the District Engineer when I first came there. He went to Honolulu and became District Engineer there. After the war started, he came back to the Los Angeles District to recruit engineers to go over to England to help prepare for the invasion of Europe. He spent several days in the Los Angeles District, and then went to other districts for the same purpose. Somehow or another, he got my name, and I was called to go and talk with him. This was in 1942.

He explained that he was enlisting Corps engineering employees, on a voluntary basis, to join him, and form a battalion of engineers in London to help in the crossing of the

English Channel when the invasion took place.

He wanted to know if I'd be interested. I said, "What would I be?" He said, "I can give you a Captaincy." I said, "That sounds pretty good to me." I thought a little while, and said, "You know, I would certainly like to do that, but my wife is in the hospital. Our first son was born yesterday [April 23, 1942], and I don't think I want to leave her right now." He said, "I understand," so that was the end of that.

Q: Was that Ted Wyman?

A: Ted Wyman. You're right. Your memory is better than mine.

Q: Well, I've got some aids here, you know. [Laughter] He was the District Engineer in Honolulu.

A: Yes. He was there, after he left Los Angeles.

Q: I don't think he ended up going to England. I think he ended up in Alaska.

A: That's right. He went to Alaska. I think he just had this one job, to get these people organized, and then his next assignment was up in Alaska. He worked on the All-American highway down to South America.

Q: He had the Alaska Highway, and he had that CANOL [Canadian Oil] Project.

A: Right.

Q: CANOL would have been enough to drive anybody crazy. [Laughter] What was wartime Los Angeles like?

A: Wartime Los Angeles?

Q: Just so I can get a taste for the social aspect of the war era.

A: It didn't seem much different than before the war. Of course, there wasn't much war

going on in Los Angeles, those who were involved in the war went across overseas.

Q: So they weren't staying around very long?

A: No. When Wyman came, he talked to another engineer who was in the district, who was in charge of hydrology. I forget his name also. He accepted and went to London. I got word later on that everything worked out all right, and he was promoted to major. But his wife stayed in the Los Angeles area, and we'd see her now and then. Finally, word got around that the two had separated, and that he wasn't going to come back. Later, he married a German woman.

Q: So he stayed in Europe after the war?

A: That's the last I heard.

Los Angeles District Personnel

Q: Is there anything else about the people you worked with in Los Angeles District that you'd like to mention--you have mentioned Jobes.

A: Yes.

Q: You mentioned Dick Eaton and Jack Tyler. Any other people with whom you worked who went on to have significant careers in the Corps of Engineers?

A: Let me see. Jack Tyler was a reserve officer. Dick Eaton was recruited as a civilian engineer, and Jimmy Jobes was a reserve officer who was recruited. He served a couple of years in the Army, and then he came back to the Los Angeles District as a civilian employee.

Q: I've got some names here. Let me run them by you, and see if you can remember them.

A: All right.

Q: You have already mentioned Harry Thompson.

A: Yes, Harry Thompson. He was Chief of the Engineering Division when I left the district in 1946. He was an excellent man to work for. He wasn't all that strong technically, but he really had excellent judgment and was a very practical engineer.

Q: Did he stay there after the war? I mean, after you left?

A: Yes, I think so. I think he still was there for awhile, and then he retired. Ed Kane took his job as Chief of the Engineering Division.

Q: How about Guy Bebout? Was he there?

A: Yes. Guy Bebout was there when I first came in 1939. He was the top civilian.

Q: Chief of the Engineering Division?

A: Engineering Division, right. Larue was his assistant. Jimmy Jobes was under those two guys as Chief of Hydraulics Branch.

Q: How about an Archibald?

A: Archibald. The name's familiar, was he an officer?

Q: Not according to this. He was Assistant Chief.

A: Under Bebout, I guess.

Q: Yes.

A: Well, I didn't have too much to do with them.

Q: This is for the late '30's, so it might not be when you were there--how about Mr. Evans? L.T. Evans?

A: Yes. L.T. Evans. He was the structural man, Chief of the Structural Branch.

Q: Right.

A: Sometime he was kind of hard to get along with. He knew structural engineering all right, but frequently had difficulty in accepting my hydraulic engineering viewpoint.

Q: There are some military folks who were there after Wyman, who may have been there when you were there. Herb Milwit?

A: I don't remember him.

Q: How about George Withers?

A: Yes. His name is vaguely familiar. I don't remember.

Q: Is there anyone else you can remember from those years that left any impression?

A: Oh, that's a long time ago.

Q: Oh, I realize that.

A: I remember the ones that I was closest to.

Q: Well, I realize that. Sometimes I like to give you a few names to see if they strike a bell. Frank Carlson.

A: Oh, yes. Jimmy Jobes and Harry Thompson, and all those. Frank Carlson was structural dam designer.

Q: How do you rate those folks that you knew against today's engineers? I realize that's not a fair question, given the difficulty of doing that kind of thing.

A: I'd rate them as very capable engineers, even though they lacked many of our modern

techniques and design criteria. Of course, Harry Thompson didn't have the experience that some of the engineers have today in the Corps' larger districts, where they have been involved with more large projects.

Q: Is there anything else you can remember from your time in LA District that you want to discuss?

A: No, I don't think so.

Involvement in Professional Engineering Organizations

Q: Let me go back and ask you a question about your time in the Bureau, and it applies to LA District, too. Were you encouraged to participate in the professional associations, the American Society of Civil Engineers (ASCE), and other professional engineering organizations? Not only to join as a member, but to prepare papers and go to meetings. Was there a lot of interchange, interaction, espoused by your superiors?

A: Most of my superiors participated in professional engineering organizations and encouraged the younger engineers to do likewise. They never pressured anyone to present papers or attend meetings.

Q: Did you do any writing and publishing at that time?

A: Yes, I did. I spent the last couple of days assembling all the papers that I wrote for publication. I have a total of 34 technical hydraulic engineering publications, of which 32 are papers, and the other two are contributions to the ***Handbook of Applied Hydraulics*** and a book, *Safety of Existing Dams.* The first paper I had published was on Green Mountain Dam, which I model tested during my first year at the Bureau of Reclamation. It was published in the *Civil Engineering* journal, dated March 1940.

While with the Los Angeles District, I wrote several papers on flood control channels and debris basins. When in the Chief's office, I wrote about a dozen papers, of which most were published in the ASCE's *Journal of the Hydraulics Division Journal.* When I joined international associations, like the Commission on Large Dams, Association for Hydraulic Research, PIANC [Permanent International Association of Navigation Congresses], and Irrigation Drainage Congresses, I presented papers at the meetings which were published in the proceedings of the meetings. Luckily, I have copies of those papers. I'm going to have them retyped in the same format and published in a book called my *Career Book.*

Q: You'll have all of your professional papers together in one place.

A: That is the main idea.

Tujunga Wash Rood Channel

Q: You wanted to discuss another project from your time in the Los Angeles District?

A: Yes. I think we covered all the Los Angeles District, but I didn't mention one thing that was developed there, which I think is very, very important to mention. It's brought out in some of the technical papers that I have written and will send to the Office of History. It concerns the design of the Tujunga Wash flood channel. The channel begins at Hansen Dam, where the outlets works discharged into the channel, which was an unimproved, natural channel. Every time large flows had to be released from Hansen Dam, it caused flooding along the Tujunga Wash channel, about 12 miles from the dam to the Los Angeles River. The water eventually got into the Los Angeles River, but flooded many highways and much valuable property along the unimproved Tujunga Wash channel.

In designing the channel improvement, it didn't take long for us to decide that the high velocities required the channel to be concrete-lined. We also made enough preliminary studies to determine that a rectangular concrete-lined channel would be the most efficient, and less costly than a trapezoidal concrete-lined or a trapezoidal rock-lined channel. So we proceeded immediately to design a concrete-lined, rectangular high-velocity channel. We did the preliminary hydraulic studies and then decided we had to model study this channel because of the many sharp curves and the high velocities. We wanted to check to see that the channel was designed properly with sufficiently high walls, especially around the curves.

A 1:40 scale model of the rectangular channel was constructed and tested at the primary hydraulics laboratory in Griffith Park along the Los Angeles River channel. The tests showed that the velocities caused water depths to be significantly greater on the outside walls of sharp curves. The average depth of flow for the design discharge in the straight channel sections was about 12 feet. But going around the sharpest curves the water depth would be four feet higher on the outside wall and four feet lower on the inside wall. That would require the outside wall to be eight feet higher than the inside wall. This wall would gradually taper from the normal height on a tangent to the higher height through the curve and then back down to the normal height on the other side of the curve. On the inside of the curve, the height of the wall could be reduced the same way.

This would add a lot to the cost because a higher wall costs more, and the variable wall height makes construction much more difficult. So we got the idea of designing the channel like a high-speed highway with spiral transitions between straight sections and curves. The spiral transitions gradually change the direction from a straight line to a curve. After passing through the curve, a reverse spiral is used to gradually change back to a straight line. In addition, highway pavements are super-elevated around sharp curves to provide a gravity force component which improves the passage of high-speed traffic around a curve.

We reasoned that flow in a high-velocity channel would be similar to traffic on a high-speed highway. The 1:40 scale model was reconstructed with super-elevated curves and spiral transitions. It was remarkable how much better the water went around the curves. Flow depths were essentially equal in the curves along the inside and outside walls, which made it possible for those walls to be equal in height. Also, the super-elevated transitions reduced wave disturbances which otherwise occurred because of sudden changes in flow direction of the water.

We measured five feet high waves on the outer side of the curve. The waves progressed quite a distance downstream from the curve. Higher walls would be required to take care of those waves. By super-elevating and using spiral transitions in the curves, these waves were greatly reduced in the 1:40 scale model. We decided that this was a very significant improvement that should be tested in a large-scale model.

Fortunately, the outlet works and spillway were already constructed at Hansen Dam. The outlet works discharged on the spillway chute, which was quite flat. A flume was constructed at the end of one of those outlets, in which a 1: 10 scale model of the rectangular Tujunga Wash channel was tested. This model was tested with and without spiral transition curves and super-elevated inverts to compare it with the 1:40 scale model. The 1: 10 scale model generally confirmed the previous 1:40 scale model test results. Only small height waves formed in the spiral transitions and super-elevated curves. Also, the depths of flow were essentially the same through curves as in adjacent straight channel sections. That reduced wall heights and construction costs appreciably. The channel was designed and constructed that way.

We made a great point of spreading this information throughout the Corps. We said, "This is the way high- velocity channels should be designed." That's the way they've been designed ever since by the Corps and others who have designed high-velocity channels. I don't know how much it has saved over the years, but certainly it saved a great deal of money.

Q: So that was a matter of just applying some highway engineering techniques to the hydraulics?

A: Yes. To the hydraulics.

Q: Was that normally done? Had that been done before or was this sort of a pioneering effort?

A: Oh, this was pioneering, as far as I know. It was never done with high-velocity channels. It might have been done with some other problems, but I don't know of any.

Visit of Lt. Gen. Wheeler and Gail Hathaway

Late in 1946, General Wheeler [Lt. General Raymond Wheeler], the Chief of Engineers then, came out with Gail Hathaway, who was then a Special Assistant to the Chief of Engineers [former Chief of the Reservoir Regulation and Hydrology Section in Civil 'Works from 1937-45], for a Board [Board of Engineers for Rivers and Harbors, BERH] meeting to review the Los Angeles projects. General Wheeler wanted someone to brief him on the projects that were in Los Angeles before the Board meeting. The District Engineer sent word down to Harry Thompson, who was Chief of the Engineering Division then, and Harry Thompson picked me out to make the talk, covering what projects we were working on. Most of it was flood channel improvements because there was a lot of channel work there then, in addition to design of several small flood control dams.

I spent half-an-hour talking to him, and I guess I did a pretty good job of explaining the whole thing, at least General Wheeler thanked me. After General Wheeler left, I went down with Harry Thompson to his office, and Hathaway came down there. He said to Harry: "Harry, we need somebody like Jake in the Chief's Office. I need someone in hydraulics. I'm weak in hydraulic design."

So Harry said, "Well, that's up to Jake." So I said, "Give me one day. I'll have to talk to my wife." So when I got home, and I mentioned this, she said, "We're. off to Washington," because she lived in Washington for a good many years. She graduated from high school in the District of Columbia. She didn't like Los Angeles at all. So there was no doubt about it, we were going to Washington. The next day I told Hathaway that I would take the job. I reported to the Chief's Office on December 6, 1946.