ORAL HISTORY INTERVIEWS

VERNON POWELL

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STATUS OF INTERVIEWS:

OPEN FOR RESEARCH

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Interviews Conducted and Edited by:
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Bureau of Reclamation

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STATEMENT OF DONATION
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VERNON POWELL

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INTERVIEWER:________________________
Brit Allan Storey

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Editorial Convention

A note on editorial conventions. In the text of these interviews, information in parentheses, ( ), is actually on the tape. Information in brackets, [ ], has been added to the tape either by the editor to clarify meaning or at the request of the interviewee in order to correct, enlarge, or clarify the interview as it was originally spoken. Words have sometimes been struck out by editor or interviewee in order to clarify meaning or eliminate repetition. In the case of strikeouts, that material has been printed at 50% density to aid in reading the interviews but assuring that the struckout material is readable.

The transcriber and editor also have removed some extraneous words such as false starts and repetitions without indicating their removal. The meaning of the interview has not been changed by this editing.

While we attempt to conform to most standard academic rules of usage (see *The Chicago Manual of Style*), we do not conform to those standards for individual's titles which then would only be capitalized in the text when they are specifically used as a title connected to a name, e.g., "Secretary of the Interior Gale Norton" as opposed to "Gale Norton, the secretary of the interior;" or "Commissioner John Keys" as opposed to "the commissioner, who was John Keys at the time." The convention in the Federal government is to capitalize titles always. Likewise formal titles of acts and offices are capitalized but abbreviated usages are not, e.g., Division of Planning as opposed to "planning;" the Reclamation Projects Authorization and Adjustment Act of 1992, as opposed to "the 1992 act."

The convention with acronyms is that if they are pronounced as a word then they are treated as if they are a word. If they are spelled out by the speaker then they have a hyphen between each letter. An example is the Agency for International Development's acronym: said as a word, it appears as AID but spelled out it appears as A-I-D; another example is the acronym for State Historic Preservation Officer: SHPO when said as a word, but S-H-P-O when spelled out.

Introduction

In 1988, Reclamation began to create a history program. While headquartered in Denver, the history program was developed as a bureau-wide program.

One component of Reclamation's history program is its oral history activity. The primary objectives of Reclamation's oral history activities are: preservation of historical data not normally available through Reclamation records (supplementing already available data on the whole range of Reclamation's history); making the preserved data available to researchers inside and outside Reclamation.

The senior historian of the Bureau of Reclamation developed and directs the oral history program. Questions, comments, and suggestions may be addressed to the senior historian.

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For additional information about Reclamation's history program see:
www.usbr.gov/history

Oral History Interview
Vernon Powell

Background

Storey: This is Brit Allan Storey, senior historian of the Bureau of Reclamation, interviewing Vernon Powell, a former employee of the Bureau of Reclamation, at his home at 17634 Calico Street in Sun City, Arizona, on April 23, 1996, at about ten o'clock in the morning. This is tape one.

Mr. Powell, I'd like to ask you where you were born and raised and educated and how you ended up at the Bureau of Reclamation.

Powell: Well, I was born in a small town in Nebraska called Ravenna, 1926, and lived there, of course, until I graduated from high school, and then I kind of progressed my way through the school of hard knocks.

Storey: When was that?

Powell: That was in 1945.

Storey: You were born?

Powell: No, 1926 I was born, 1945 when I left my hometown and graduated from high school. Then while working on a couple of projects, I was in construction even then. I ran across some fellows from Grand Island, Nebraska, that worked for the Bureau of Reclamation, and they were looking for young people to help them start out as surveyors. Since I was always interested in outside work and liked the activity, I applied for a job with the Bureau of Reclamation. I had previously worked for the Army Engineers in Garrison, North Dakota, on Garrison Dam for a little over one year.[1] I started there in 1947, and then I came down to Nebraska in 1948, and went to work for the Bureau of Reclamation.

Storey: At Grand Island?

Working for Reclamation

Powell: At Grand Island, Nebraska, yes. At that time we had a project that was called the Midstate, was on the Platte River. I thought that that would be a good place for me to be able to start a long-term Bureau career. As most people know, the Midstate Project never did develop.

So after that, I moved around with the Bureau of Reclamation a little bit. I worked on a project at Loup City, Nebraska, and that was up until 1952. While there, where we were doing a lot of investigative and preconstruction work, a lot of topography and land surveying, trying to determine if the projects were feasible or not. And then when we'd compile the information and hand it into our office, then they would look at it and try to see if they could design what they had thought would be feasible.

So after that, then I traveled with the Bureau of Reclamation and went on down to Beloit, Kansas. We moved around quite a bit then. We were doing the same thing. We were on the investigating surveying, which means we'd come into an area, look at a valley, maybe do some topography on a fifteen-, twenty-mile-long valley to see if it was conducive to irrigation, and if the farmers in the area wanted to see something develop along those lines.

1. The U.S. Army Corps of Engineers completed Garrison Dam in 1956 as part of the Pick-Sloan Missouri Basin Program, see United States Department of the Interior, Water and Power Resources Service, *Project Data* (Washington, D.C.: U.S. Government Printing Office, 1981), 872.

Then I moved on to Red Cloud, Nebraska, for a short six-month stay, finishing up a small job that they had there. Then in 1952, in December, I moved to Phillisburg, Kansas, and worked on a couple of projects there that we had. One of them was called Kirwin Dam, and it was eventually built. That was near Phillisburg, close to a little town called Kirwin. Then we also worked on Webster Dam, which was south of there forty or fifty miles in a little town called Stockton, Kansas. Both of them were small dams for some irrigation and flood control.[2]

On the Kirwin Dam, we did that first. We had about a thirty-mile-long valley that was necessary to put in control for mapping, so that then they could develop the canal that was later completed on that project. It involved working with several crews of men. At that particular time I had moved up from rodman to an instrument man, to a party chief. So that was naturally my goal since I had decided that I would try to make a career out of surveying. I naturally wanted to advance up the ladder as far as I could.

1959, I had a job offer before the other job was completed, to go to a little town in Colorado called Paonia, P-A-O-N-I-A. They were about ready to start construction on a small dam on the Anthracite River, or I suppose they would call it creek. It was a small river. Actually, it was where the Muddy and the Anthracite came together, so it was kind of on the confluence. So I worked on that particular job as a party chief. Then when we were completing that job, we also constructed a small dam called Crawford Dam on Iron Creek, near Crawford, Colorado.[3] That was approximately fifteen miles south of Paonia, where the other dam was

2. Kirwin and Webster dams are units of the Pick-Sloan Missouri Basin Program on the Solomon River in Kansas, see USDOI, Water and Power Resources Service, *Project Data*, 923-7, 1007-8; see also Wyndham E. Whynot, "Kirwin & Webster Projects: Solomon Division Pick-Sloan Missouri Basin Program" (Denver: Bureau of Reclamation History Program, 1996).

3. A unit of the Smith Fork Project, Crawford Dam is located in Delta and Montrose counties, Colorado, see USDOI, Water and Power Resources Service, *Project Data*, 1163-6; see also Thomas A. Latousek, "Smith Fork Project" (Denver: Bureau of Reclamation History Program, 1995).

approximately fifteen miles north of Paonia. They were on two different watersheds.

So we had some pretty heavy construction tunnel work, spillway work, working with the contractor. At that particular time, the Bureau of Reclamation had the surveyors do all the preconstruction and construction surveying. The contractor did a little surveying on his own, but we controlled all the surveying during construction. That included setting and checking and completing all the structures on the total projects.

Then in about 1962, early part of 1962, I received a promotion and transferred to Durango, Colorado, to work on the dam to be constructed called Lemon Dam. It was on the Florida River.[4] So I was kind of in charge of–we had three survey crews. We were working with the contractor to get this job completed in about three years. It involved heavy construction of a half-mile-long tunnel, a large spillway, and the reconstruction of some canal work and laterals below the dam that would service a lot of fruit trees. That's a great fruit-growing valley with all sorts of deciduous fruit. They needed the additional water to make sure that they had water during the bad times. That turned out to be a real pretty job.

The Durango job we thought that maybe we would eventually get to after we completed that job to work on the Animus-LaPlata. This was in 1963 and 1964. It was in the development stage. It was part of the Upper Colorado Project that was to be agreed to be completed, but in its way it is still waiting to be started and completed. They've made many changes on that project at Durango, and, in fact, it almost got started in 1993 and '94, but they had to drop it in '95 again. Hopefully, that still will come to fruition. I'm not sure about that. That's up to the politicians,

4. Lemon Dam, on the Florida River, is the principle feature of the Florida Project in La Plata County, Colorado, see USDOI, Water and Power Resources Service, *Project Data*, 461-4; see also Robert Autobee, "Florida Project" (Denver: Bureau of Reclamation History Program, 1995).

of course.

After that job was completed–I guess is this kind of along the flow of the lines you want to go, or you want to spend a little more time on this one?

Storey: Keep going. Keep going. We'll go back and go over it all.

Powell: All right. Then in June of 1964, the Fryingpan-Arkansas, which was a huge diversion project to bring water from the west slope to the east slope, had a job for me, because the Durango job was getting to the point where we were just completing it. So I transferred to Durango and worked on the Fryingpan-Arkansas, that was headquartered out of Salida, Colorado, the main office.[5]

Storey: You said you transferred to Durango.

Powell: Well, excuse me, to Buena Vista, Colorado. Slight error.

Storey: That's very common. That's very common. Don't worry about it.

Powell: Then we lived in Buena Vista. We did a lot of preconstruction work to work on Sugar Loaf Dam. That was the first site that we built, which was near Leadville, Colorado. I worked on that then from '64 to 1968. Also at the same time they opened a small construction office at Glenwood Springs, Colorado, for the purpose of starting and completing construction on Ruedi Dam, which was on the west slope of the Rockies.

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5. The Fryingpan-Arkansas Project is a transmountain diversion project from the western slope of the Rocky Mountains to Arkansas River on the eastern slope, see USDOI, Water and Power Resources Service, *Project Data*, 485-7; see also Jedediah S. Rogers, "Fryingpan-Arkansas Project" (Denver: Bureau of Reclamation History Program, 2006).

Storey: You were responsible for the survey of that?

Powell: I went over and started the survey work for the tunnel and got them started on the alignment of the tunnel, and then I was only there on detail. Then I went back to Buena Vista, because we were in heavy construction on Sugar Loaf Dam. Then they transferred in some people to Ruedi. This was preparatory for getting the job, and they hadn't had people there yet. So I did go over on a short-term detail to help them get started on that. Then I went back to Sugar Loaf and we completed Sugar Loaf Dam and some of the preconstruction work on Twin Lakes. There was to be a small dam constructed there, but that was to come years later.

Coming to the Central Arizona Project

In the meantime, in June of 1968, I received a promotion to chief of surveys on the Central Arizona Project at Phoenix, Arizona. That was in anticipation of the authorization of the Central Arizona Project, which indeed then was authorized on, I think, September 30, 1968. Therefore, we had a lot of preparatory work, preconstruction work, and we had to do the design work on the canals and the pumping plant that started at Havasu Pumping Plant, which was near Parker, Arizona. In the meantime, while we were waiting to get funds to start that project, we also worked on some of the other project that at one time thought were going to be completed, like Buttes Dam, Charleston Dam, Orme Dam, and that later turned into a lot of work when they come up with another plan called Plan Six, then those were eliminated, because we had some alternative suggestions that were accepted, such as increased spillway at Stuart Dam on the Salt River, increased height and spillway of the Horseshoe Dam. In the meantime, then our survey crews grew from about five to ten or eleven survey crews, trying to keep up with the construction that had started in 1973 at Lake Havasu. That was to build the dike that we had there, to protect the spillway of the Havasu Pumping Plant, and to keep the ravages of the storms away from that, and to direct the water into the pumping plant.

Then the pumping plant involves lifting the water eight hundred feet up through twin pipes into the beginning of the Buckskin Mountain Tunnel, which was a 6.8-mile-long tunnel with one curve, one mile in from the inlet, or P-I, we call them, point of intersection. That took a lot of extensive surveying, because we couldn't access between the beginning of the tunnel and the end because it was rugged terrain, so we had to walk in to most of it. Occasionally we'd use a helicopter. But during that interim of time, we were able to purchase a significant upgrade in the technology of our survey work. We had the laser beam really begin to come into its being. This was an instrument we purchased that we could measure a distance to within a tenth of a foot thirty miles away. Up until that point, we could only measure possibly a couple of miles, and that was at night. We'd have to go out at night to survey, because the equipment prior to that that we had of a laser wouldn't measure through the daylight to any extent, although it was extremely accurate. So that really opened up the doors for us just at the right time, because we knew we had three-hundred-and-some miles of canal to build, and it had to fit from the beginning to the end, and the elevations of the canal had to be precise that total distance.

So at that same particular time, they did develop a, Wild Instrument, did develop a real accurate and reliable automatic level, as we called them. Well, since we had so many, many miles of levels to run, we needed to have this precise equipment. We could have done precise work without that equipment. It would have taken a lot longer and it would have been questionable, but it could have been as accurate. It was really our lucky day, I guess you could say, development of the laser beam come along at that precise time.

Further on in this discussion I can get into about the time other developments come along that were remarkable, but that's a little further towards the other end of the story.

Storey: Good.

Powell: The laser helped us measure precisely the distance in the tunnel, which would measure inside a tunnel. Since this was 6.8 miles, we had to start, because the mole would go from the outland of the tunnel, because the grade can increase that way. So the tunnel was built from the outlet. So we had to go into the tunnel 5.8 miles until we got to the P-I [point of intersection], and at this particular change of direction, then you had to go another mile. Well, its extremely difficult to survey underground six miles, and then go around a short curve where you have to set up four times, and then go another mile and hit precisely at the other end.

We were fortunate that we have some real good surveyors who were really good and with their patience in surveying this tunnel. When we holed out the other end after it was constructed and the mole was right behind it, they were building the concrete as the mole progressed, so you knew the tunnel had to be right. You couldn't say, "Oops, I missed it a hundred foot, when I come out the other end." So we missed it two inches. That's sixteen-hundredths of a foot. In the elevation we missed approximately one-tenth–that's an inch and a quarter–of being perfect. That's probably the best tunnel job the Bureau of Reclamation ever did. We were quite proud of that particular job, because it was an awful lot of hard work under trying circumstances.

Surveying Units of CAP

So after the tunnel, of course, we progressed on down through the canal with the surveys, and then the drillers would come along right with us, we had to go all the way in the desert to the three pumping plants between Lake Havasu and Phoenix. We had to make our own roads. There weren't too many roads, so we'd have to traverse through the desert and terrain, and then we worked with the planner and the designers, with an elevation that they knew they would need to provide information for where they exactly wanted to build the canal.

So our course was pretty well directed by elevation, and as that, we had to precisely survey that on down through all the way into Phoenix, across a lot of the big washes, Centennial Wash, the Hassayampa Wash, a lot of the main big washes, the Agua Fria, where they were going to build siphons. So we surveyed that all the way.

As we were getting the information, when we'd get the control set for the aerial mapping, then the designers would want us to shoot a strip of topography maybe 3,600 feet wide by whatever the length was, at a scale of 200 foot to the inch. That scale was adequate for the designers to pretty well locate that canal as to the elevations that they would need to construct the canal to their specifications.

That involved a lot of back and forth through the desert, and surveyors turned out to be a pretty tough breed of people, because they had to work in 115-degree temperatures and extreme heat all through the summer, yet we had to continue with the work. The heat does affect some of your survey instruments to a certain degree, because you cannot deflect that heat. Its coming from the ground and the air and everywhere else, off the rocks. But they did progress at a real good rate and we were able to push our way on down into Phoenix.

Then as the designers received the information from the aerial photography, then they would go ahead and pin down the alignment of the canal as accurately as they could. Then we would go back into the field, put out some rough staking, preconstruction staking, and run another line of elevations on those stakes with coordinates so that they could take the information we had, take it back into the office, plot it onto that aerial mapping, and determine if that was precisely the location they wanted to achieve, as an example, from Havasu to the first pumping plant, which was Bouse Hills Pumping Plant. Then you lift the water up somewhere between 80 and 110 feet, depending on the pumping plant, progress on the new alignments and elevation. They had, of course, down to Harquahala

Pumping Plant, same thing, then a tunnel, then another little tunnel about six-tenths of a mile long, then into the Hassayampa Pumping Plant. All at the same time they had to go through, I think it was four large siphons, which meant that these washes were of such large capacity of water during heavy rain, they had to go underneath the large washes and put in our twenty-one-foot pipe siphons to carry the water under. We would have had too much problem with water if there would have been an above-ground canal, so they had to siphon underneath.

So during this time, then we progressed through that all the way into Phoenix. Well, after we got to Phoenix, then they started looking at the Salt-Gila Canal, which was one leg on the way from the eastern part of Phoenix, and above Mesa, to Tucson. Well, then, from there to Tucson was eleven more pumping plants. Even though the distance wasn't as great, they had more pumping plants. So we progressed through the same-type surveying all the way into the Tucson office, and locating the pumping plants, completing more surveys for siphons.

During that particular time, we were also doing work on some of the other projects that we had, or helping other offices. We did help the Army Engineers a little bit, because we had developed some technology they didn't have, but maybe I need to talk about that just a little bit further down the road.

Storey: That's fine. Whenever.

Changes in Surveying Techniques

Powell: We were fortunate that on the Central Arizona Project, since it was the largest project the Bureau of Reclamation ever built, and it had so many demands on preciseness–I'm not even going to talk about all the checks that they had on the project to make sure the water deliveries were available where needed–we continued to look at the development of the surveying equipment.

The Bureau of Reclamation did change. They had another commissioner that came to work with the Bureau of Reclamation. I think his name was [Ellis] Armstrong at one time back in the early seventies, and it changed how the Bureau of Reclamation survey was conducted on construction surveys. It ended up so that the contractor had more responsibility for the surveys on the construction of the pumping plants and the canal itself all the way to Tucson. We would set the initial control. In other words, we would tell the contractor, "This is exactly where this plant is to be built," or this canal. "Here's the specs that show you the grades, the elevations, the measurements that you need, everything you need to complete this project. We'll set the initial control, get you started, then its your responsibility, then we'll come along and we'll do periodic checks."

In my opinion, that was a mistake. It cost the Bureau of Reclamation on this project, in my opinion, an awful lot of money–millions of dollars, because we had duplication of surveys. The contractor works and beats to a different drummer than the Bureau of Reclamation. We're directly responsible for the public's investment in their money, and we wanted to be a precise as we could. The contractor had a job to complete, and he wanted to get it done, of course, as accurate as he could, as quick as he could. So there was always a little bit of a conflict. But as we progressed down, we managed to get a good job on the Central Arizona Project, even with that little bit of a problem. Not all people share my views, but I was close enough to it to understand it probably more than anybody else.

Advances in Survey Technology

Then during the Bureau of Reclamation's time towards the completion of some of the projects, and on our way to Tucson, it come out in about 1984 that we come up with Bureau of Land Management and some other offices had what was called the G-P-S system. In other words, it was a Global Positioning System, wherein as we could take information from the satellites that were beginning to be put into the skies and use information from them, convert it into coordinates and elevation on the face of the Earth. Now, the whole time we built the Central Arizona Canal, since we went some 325 miles or whatever it ended up to be from Havasu to Tucson, that involved the curvature of the Earth, which is a significant difference. It doesn't matter that we're on a flat plain where we can measure everything flat. We had to take into consideration the curvature for every mile that we went so that it would fit down there with what we started with.

With the Global Positioning System that's come out, we were able to set up receivers and place coordinates and elevations on the face of the Earth to a tenth of a foot, or as is even today, even more accurate than that, to within an eighth of an inch, quarter of an inch. Fantastic accuracies, and of course, we had cooperation from the Coast Guard, the Air Force, and the people that we had to call to get information as to exactly where the satellites were, because they do move them periodically for security reasons. They would give us the new information so that we could use what they had, and we had people that we had trained involved in this precise computing of this information they give into coordinates and elevations on the Earth. It's quite an extensive process, but we were one of the first to use that, and we felt that it really come in handy on this project.

We did then get involved. We had done some photogrammetry, where we had purchased a camera that we could use in a helicopter to fly, take pictures on the Colorado River to see what was developing in some of the sand bars and that involved. The guys developed a particular mount that would fit in a helicopter that would fit under the camera that we purchased. Then we started to–

END SIDE 1, TAPE 1. APRIL 23, 1996.
BEGIN SIDE 2, TAPE 1. APRIL 23, 1996.

Storey: You had just started talking about our use of photogrammetry, I believe.

Powell: Yes, Brit. We were fortunate that we had some great personalities that had innovative minds, and they started talking about and thinking, "Why can't we compute quantities from photogrammetry."[6] In other words, we have great cameras that can take pictures of walls, structures, faces of dams, sheer rock walls. This created real problems for personnel. In other words, we had to be specially trained so that we could hang off the face of a dam, place targets on a wall, survey a sheer wall or cliffs, which was always dangerous work, because we had to hang from ropes, and there was many dangers and safety concerns involved with this. We were able to do this.

Kevin Black, who I think you know, had been with the Bureau of Reclamation, worked with us for some time, went into private industry for some time and learned considerable about photogrammetry. So what happened is through a lucky timing event, I had talked to Kevin some, and Bob Johnson, the construction engineer, agreed with me that we needed to update our photogrammetry if we wanted to do some of the things we were dreaming about doing. So we were able to entice Kevin to come back to work for us. So Kevin and the crew that he had worked with previously set their minds to doing a little experimenting. We had to learn how to do this, but we could go out to a face of a wall or a dam, and photograph it by setting precise coordinate locations and elevations, doing this structure, along the base, up on the top, on key points, then take a series of photographs of this particular face. I can use Roosevelt Dam as an example. We had previously done some surveying where we had run some lines from the top of the dam down to the bottom of the dam by hanging on ropes and precisely surveyed those lines in to see exactly what we had. As you know, the face of Roosevelt was in block construction, so it was a lot of in and out, in and out, all the way from the top to the bottom.

6. Photogrammetry is the science of making measurements from photographs typically used in mapmaking, see "What is Photogrammetry?" www.photogrammetry.com (Accessed December 2012).

Storey: Sort of stair steps.

Powell: Stair-stepped all the way. So as we developed this technology, we wanted to check out what this could do as against what that old survey had done, because it was very precise, but it involved a lot of safety concerns. Well, then, in the nineties then, we went ahead and did some survey with this photogrammetry, and we found that we were every bit as precise with the photogrammetry as we were with the lines as surveyed, if not even more so, and eliminated the risks of somebody falling and getting severely injured, having to crawl up on rocks on the face of a dam.

Storey: Why would we need to survey the face of the dam?

Powell: We needed to survey the face of the dam, for example, we would put glass, embedded prisms, in the face of the dam so that we could measure from the ground then to see if the dam was having any movement, if anything was happening to that dam subsidence-wise or reflective-wise. In other words, is that dam moving? We know that dams move, but we want to know how does the weather affect it, how it is affected when so much water is behind the dam itself, what's happening? So in order for us to be up on the technology and know what's happening to all the dams we have, we've done this on some of the other dams we've had now, where we place a glass prism, drill a hole, place a glass prism, and then put a precise coordinate on it, and we know whether it's moving up or down, in or out, precisely to a hundredth of a foot.

We were able to purchase another laser instrument that measures a distance like a thousand foot or so to a millimeter or two. I mean, that's fantastic. When I started out as survey, I used to dream about how in the world can we get across this canyon? Can I stretch a wire across there? How am I going to do this? Now, with the laser equipment that we have, and we do have automatic levels now, so all you do is line up your equipment and get your precise rods, aim the instrument, when its on the target, punch a button, and it records it on a tape that we can bring into the office, and reduce the notes we have. Its extremely accurate.

But with this photogrammetry, we were able to then take this ability that we developed and take it in work for the Army Engineers, [who] wanted us to go down and help them. They had some extremely high dam sites that they wanted our technology. They didn't have it and they didn't have the people. We've been able to go to other offices and show them this technology. Since this involves a lot of technical expertise, they were not able to do this, so we were able to do it for them. But between the Global Positioning System and the photogrammetric abilities that our Survey Section developed, either out of a helicopter, we can fly over a dam and take a picture of the dam from a helicopter without having to be on the ground, but we prefer to go on the ground. It's a little more or less expensive, and we can do it to a better advantage of the people. But that's something that the Bureau is going to continue to develop. We can develop any amount of quantities from the ground anywhere we want to. We can just get quantities precisely anywhere from photogrammetry now. You have to really understand what surveys have gone through over the years to understand this tremendous technology that's available to us today, in credit to some of the people that we were lucky enough to have working for us that really had that innovative-type mind.

I guess that kind of covers a lot of the things we did, in a nutshell. Of course, we also started, and now completed, Waddell Dam. That was a 17-million-cubic-yard project, some diversion tunnels, and water storage in the wintertime. But we did a lot of the surveying with the contractor on that particular job. I guess you know enough about Waddell Dam, or have heard from Larry, or some of the others. But we were involved in all of those projects from the very start, getting them their preconstruction data and setting every up for the contractor. That turned out to be a real good project.

Its kind of hard to just ramble on and on about the total project.

Storey: Talk about the technology that you started with, what the equipment was like, how it changed over the years, and what you ended up with, and how that changed the way surveying was done. You've already hit on some of this, but let's just sort of talk about that part of it for a little while.

Evolutions in Surveying Because of Technical Advances

Powell: Okay. I guess you could say pretty much when I started surveying in 1947 and '48, the technology to that state had not changed much. In other words, we had like what we call a thirty-second transit. We had the old dumpy levels where you would have to physically level the instrument two or three different directions by yourself with some thumbscrews, and that was the old method. You could run good levels, but it took an extremely amount of talent and time to do this. That's what survey was previous to that time and up until we started on this particular project.

Then in about the late fifties and the early sixties, they started coming out with an automatic level that had a compensator in it where you didn't have to worry about leveling the bubble yourself. If you got it close to a certain area, then the instrument automatically leveled itself. Wild happened to come out with the best ones and we worked with Coast Geodetic Survey on several projects with the same equipment, they did, and we did help them on a few occasions, also.[7]

We had the old allodade and the old topography method where we had the plane table, and the board, and we would do the plane table mapping back in 1948–I'm clear back into there again. That stayed that way for a long time until they started getting aerial mapping. They had aerial mapping back in the late fifties and early

7. Wild Instruments manufactures surveying levels and other surveying instruments.

sixties. They started getting good results with aerial photography from airplanes, and we would contract with certain outfits to get us a map of an area, 400 foot to the inch, 200 foot to the inch, whatever we used.

The instruments slowly developed into that NA2 automatic level, as we called it. We started getting better theodolyte. Theodolyte is an instrument that–in those days when we started, we had an instrument that maybe would read to ten seconds. Then it developed into an instrument up into the fifties, late fifties and sixties, the early sixties, they had an instrument that would measure to a tenth of a second, which was a great achievement, because your angles and that were just that more precise.

Storey: What is an allodade measure?

Powell: An allodade, all it does is measure the direction. You can get an elevation from it, but we usually used a transit in conjunction with the allodade. The allodade set on top of the plane table, and then you would measure the direction that the rodman had his rod up, and you'd measure how far out he is and the elevation. That way you'd measure the hills and the valley and plot them on the map. That was a fairly simple instrument compared to what they eventually evolved into.

Now, as we got into aerial mapping and that, we did not do much plane-table mapping. After the late fifties we got away from that. Only on small local projects, we might want to jump in and do something that we could do in a half a day or something like that, or a day.

The instruments continued to get better. We come out with Wild again, and some of the other instruments come out with an instrument that would measure a distance at the same time that it would turn an angle precisely. At that time, in the sixties, started to come out the glass prisms. In other words, a laser beam or an infrared beam would hit this glass prism, reflect back, and the instrument would measure the time over and back. Knowing the speed of the light, it would know what that instrument was precisely.

They also had at that time instruments that were called electrotapes. We used those some in the Bureau of Reclamation. In fact, I used them over on Ruedi Dam and on the Fryingpan-Arkansas Project. But they measured by a radio beam. That was altogether different than a laser. Turned out the laser ended up being better and more precise and a quicker instrument.

Storey: What about this nighttime measurement that you were talking about earlier?

Utilizing Laser Technology

Powell: All right. We had a light-beam instrument that would only measure–maybe on a bright day it would only measure maybe a mile. In a lot of our cases, for triangulation and that, we had to measure more than a mile. We did some work for the city of Flagstaff, where we were up in the top of the mountains doing some topography for the city to see about their water project in conjunction of a project we were working on at Lake Mary for their water needs. We needed to measure several miles away to get precise control into this area, so we made sure that it would fit with anything that they were going to do down the road–elevation and coordinate-wise. So we'd have to go out at night, and we could measure four or five miles then with this light beam, because it wasn't diffused from the light.

We did some work over at Tombstone, Arizona, on the Charleston Dam site area that we were investigating, and we would do some night survey back and forth across the San Pedro River, but I never liked that too well, because that's the time the rattlesnakes come out to look for something to eat, and they were quite numerous in that area. So that was a little bit something that we were quite careful about. All the years that we were here on this project, we only had one surveyor bitten by a rattlesnake, and we were involved with them all the time. There were a lot of rattlesnakes in the raw desert that we came across, because there weren't too many people out there bothering them. A good surveyor becomes aware of his environment. He has to if he's going to survive. So we really didn't have too much of a problem with them.

So that instrument, then, as I had mentioned, as we got the laser, then that light instrument, we done away with that.

Storey: When did it appear? When did it come out, do you recall?

Powell: It must have been about 1970 or '71 when we got that laser. That was developed in Sweden. We purchased that instrument at that time.

Storey: And the light method?

Powell: Well, the light was years before that. That was probably in the–I'm not sure about the time, but in the last forties or early fifties when that light beam had come about.

Surveying Methodology

Then we were fortunate enough that, as I mentioned a couple of times, a laser beam coming into being, and that really helped us because of the length of this project. As we progressed all the way along this project, we made ties to the Coast and Geodetic Surveys have placed all over the state a lot of horizontal and vertical control points, the city and state and federal and local people use to obtain elevations as well. So we would check into their stations every once in a while to make sure that we were not making any errors. That's a correct procedure for anybody is to check your work as you go, because you're not going to build a canal and have it running uphill or have any severe problems with the location.[8]

On this project, since land become quite valuable, you had to establish your right-of-way all the way along the canals, and from that right-of-way then the Right-of-Way Section had to develop coordinates and purchase land from landowners, and that had to, of course, be accurate and fit within 200 feet left or right of the canal or whatever the right-of-way boundary happened to be. But then, again, we worked hand and foot with the Right-of-Way Section to make sure that all of our legal descriptions and coordinates and track maps were all precisely measured so that we eliminated as many problems as we could. So it wasn't just the location of the canal, it was also the purchase of the land all the way along the canal. That had to be done, of course, in a very high-order survey also.

Then, as I had previously mentioned, then about that time, we started to leapfrog into the G-P-S, which came about in the eighties for us. Of course, we had to develop it. It isn't something that you get one day and tomorrow you're an expert at it, the same way as photogrammetry. We had to develop a system and work hard and make mistakes on our own until we finally proved that it was something dependable and accurate that we could use. Took quite some time to do that.

Storey: Were you cross-checking it using traditional methods all the time?

Powell: Absolutely. Yeah, we had to, because when you're learning a new process, you're not sure that its that reliable, and the first time we did it, it didn't prove out to be as good as, of course, when we got trained and learned how to operate this new thing, as we call it. It really turned out to be a blessing for us in the field. Then, of course, that related to all the office work. It helped a lot, too.

8. For more information on Coast and Geodedic Survey markers see George E. Leigh, NOAA Corps (Ret'd), "Bottles, Pots & Pans–Markings of the U.S. Coast & Geodedic Survey and NOAA," no date, www.ngs.noaa.gov/web/about_ngs/history/indexUSCGS.shtml (Accessed November 2012).

That's about it for instruments without getting tedious about it and involving too much of that. I guess I could say that I was pretty proud of the fact of this particular project that the Bureau of Reclamation was developing. I believed in it, I believed in some of the projects and saw some of the small dams I've worked on for water, additional water that was needed in certain areas. I believe that this particular project, although it has had its complaints, I think as the years go by, it will become even more of a blessing and a need to the different communities and the cities. I myself know that you can't rely on groundwater as being always there and not being contaminated, or an inexhaustible supply. I think that we should use all the surface water we can use while its available, before we have to rely any on the groundwater. I think it should be emergency. That's just my thoughts. I'm not stepping on anybody's toes, but I believe in what the Bureau of Reclamation has always accomplished.

Storey: How did you get started into surveying?

Becoming a Surveyor

Powell: Well, as I mentioned originally, I had graduated from high school, did a couple of different jobs, and moved to Carroll, Iowa, to do some work there, and then applied for a job with the Army Engineers, because I thought I wanted to be a surveyor. Then they accepted me and I transferred to Garrison, North Dakota, to work on what was called the Garrison Dam on the Missouri River, a hugh water-storage project. Then I worked there for maybe a year and a half, and then I went down to Nebraska and contacted the Bureau there, because I wanted to move back to Nebraska, because, frankly, the winters in North Dakota are not conducive to a surveyor. Forty-one below, the first winter I was there. That was a tough job.

Storey: Why did you think you wanted to be a surveyor, do you recall?

Powell: Well, I think because I had seen some people looking through instruments and were doing outdoor work. I didn't think I wanted to be an office type at that time. I thought, "Well, here's something that looks interesting. Maybe I can become a surveyor." I liked math to a certain degree, trigonometry, not calculus. But that's just a basic reason. As you're a young man just out of high school, you're looking for a job anyway, so you're trying to get something that piques your interest, of course.

Storey: So what were you doing at Garrison Dam?

Powell: Well, I was a surveyor at Garrison Dam.

Storey: What did that involve you doing?

Powell: Well, at that particular time they had just started the construction of this huge dam on the Missouri River. So that involved learning to slope-stake so that we could control the quantities of earth and tell the contractor where to begin the fill for the dam. They had some diversion tunnels I worked on. We were building a town for the people to live in called Riverdale. It all had to be surveyed and I had to help them get started to get the homes constructed first so the people had someplace to live. That came as they were thinking about getting starting on the dam. That's where I learned to do slope-staking and the basic parts of surveying.

In those days, we were lucky that they had so much Army, Air Force surplus, we could buy the parkas and the felt pack boots, because it was extremely cold. So you had to make hay while you could in the summer up there as far as construction of the dam itself.

But some good things did come from that. I learned quite a bit. I met my wife in Garrison, my future wife in Garrison, North Dakota. We got married. I talked her into moving down to Nebraska with me, and she's still with me, so didn't turn out too bad. But I've never been sorry that my career was in survey. I had a chance to go to college and I ruefully kind of wonder if I shouldn't had [done] that. I had a football scholarship, but I turned that down and decided I'd do it on my own. Today, if I was a young man again, I wouldn't work as a surveyor. The atmospheric conditions, I think, are more severe today than they were then. I think its tougher on your skin. I think skin cancer and some of the problems with sun are a real problem for a surveyor. I was very fortunate, but I wouldn't do it again. I would get into something altogether different.

Storey: What precisely were you doing at Garrison Dam? Were you carrying around stakes and pounding them in the ground?

Powell: Yes.

Storey: Were you working on the transit? Were you carrying the rod? Were you carrying the–what do they call it, the tape, was it?

Surveying at Garrison Dam

Powell: Well, you have a rod and then you have a tape, also, but you use a rod to set on the ground so that the instrument can read that information and determine where the stake would be pounded in the ground so that the contractor could begin to cut into the ground to clear out the prism of where the dam was to be located. Then after they got the ground cleared and cut, then they would start clear on the outside to fill the dam from the bottom up. Of course, it's a wider one for starts, so we'd put stakes clear right and left of centerline for the contractor to start his construction of the fill material. And the same thing with the rod that I carried, we would put points in the ground for the contractor to start construction of this diversion tunnel. In other words, the Missouri River had to be diverted around to the west side before they could start anything on the dam itself during that particular construction.

Also, in those days, instrument men were very protective. They didn't want you looking through their instrument. But I did have a little learner capacity, but only being there about a year and a half, I had to learn my job first before they'd start allowing me to move up into being an instrument man.

Storey: You job was–

Powell: Strictly as a rodman and chainman, to measure distances, to punch stakes in the ground. And I might remind you that in North Dakota in the wintertime, you have to use a frost pin to get a stake in the ground. In other words, you have to punch a hole about a foot deep in the ground with the steel pin and sledgehammer before you can stick a stake in the ground. We worked all winter, too, even though we had some problems with the winter. As you can imagine, and wind in North Dakota was always a problem–always a problem. The theodolyte with the optical plummet, you had to hang a plumb bob down, which means you have a sixteen-ounce weight hanging on a spring underneath the instrument, and the wind blows it all the time, and you're trying to precisely set that up over a little mark or a tack in a hub or something like that. Wind was always a problem in North Dakota.

Storey: How do you get around that?

Powell: Well, you have to be innovative. You have to learn to place your leg against the wind, or you have to put up some type of a barrier to get that located as precisely as you can. Of course, then when the theodolyte come out with the optical plummet, you just looked in a little bubble and see a little prism straight down to where you want to sit, and you move the instrument around, and it's a snap compared to what we used to have to do.

When you surveyed back then, you had to be a better surveyor in some respect to be able to chain a half a mile accurately, or to run an instrument under those conditions was a lot harder than it is today. But today the surveyor has advanced to the point where he has to be a computer expert, also along with this. His instrument, he has to be able to input the instrument precisely, he has to be very good at turning these angles. He has to really be an altogether different type of surveyor.

There were two different times–two different eras. Same thing with building dams. Of course, we know that the Bureau of Reclamation is just about out of the dam-building business, but we have built what I consider some great projects.

Storey: So you were on a survey crew at Garrison Dam working with the Corps.

Powell: Corps of Engineers.

Storey: How many folks on a survey crew?

Powell: In those days it was about four.

Storey: What did each person do?

Powell: Well, there would usually be two rodmen, a party chief, and an instrument man. The party chief would usually keep his own notes and the instrument man would turn the angles and do that part of it, and then two rodmen punching stakes and driving pins into the ground. So it was a heavy-duty work effort, you might say.

Storey: So why two rodmen?

Powell: Well, because by the time one rodman was driving in a stake or marking up the stake that said how much you needed to cut the ground or fill the ground on what percentage of slope, the instrument man was talking and working with another rodman. So you didn't just wait for each other. We tried to work pretty hard, and keep going, and get a quantity of work done, especially when you're in construction.

Storey: Did you work with the same crew throughout your time at Garrison Dam?

Powell: Yes. A year and a half is usually is not too long a period to work with one crew. Now you might alternate a little more because you have many more different things that you do, like G-P-S, and we have our experts on the Central Arizona Project in the G-P-S, the experts from the photogrammetry, the experts in the office, people that can do wondrous things with the computers today.

Storey: Do you remember the name of your crew chief?

Powell: I know that the guy in head of surveys, his name was Ernest Borsherdine [phonetic]. He was the head of it, but the name of the party chief, I think, was Swede Olson [phonetic]. Now, whether that was Harold or what, we called him Swede–Swede Olson. I know one of the rodman's name was Joey Krebsbach [phonetic]. He worked with me. Another guy from Washburn named Mike. I can't think of his last name. That's fifty years ago. I don't recall that too well.

Storey: Where were you living?

Powell: I lived in Garrison, North Dakota, at that time. That was seventeen miles away up the Missouri River. For a time I also lived right there at Riverdale in some single apartments they had for some of us that weren't married.

END SIDE 2, TAPE 1. APRIL 23, 1996.
BEGIN SIDE 1, TAPE 2. APRIL 23, 1996.

Storey: This is tape two of an interview by Brit Storey, with Vernon Powell, on April 23, 1996.

Powell: Let me ask you, is the way we're going kind of what you want?

Storey: We're doing wonderfully, yes.

Powell: I didn't want to get too boring.

Storey: No, no. You don't need to worry. I'll guide us to something else if that should ever happen. It hasn't so far.

Powell: Were we still with the [Corps of] Engineers?

Storey: Yes. We were talking about where you lived.

Powell: I guess that's right, yes.

Storey: What were your quarters like out at the dam?

Powell: Well, they kind of had some two-story buildings, and it was an apartment house that had everything you needed. They had steam-heated rooms. In fact, the steam would get so hot, everybody would have their windows open even in the wintertime.

Storey: At 41 below. (laughter)

Powell: At 41 below. They had a big place that the contractors set up so that we could all get our meals, and cost us like fifty cents for an all-you-could-eat lunch. Of course, you've got to realize this is back in '47 and '48. But the contractor and the engineers seemed to get along real good, and we seemed to have a real good working relationship with the contractor.

Then, of course, then I moved into Garrison, North Dakota, which was a little town north of the dam site, three or four miles to the Missouri, a farming community, mostly wheat and that's about it. Not much corn, some sorghum. In those days, they used to raise flax, but that's because flax went up to eight, ten dollars a bushel.

Then I met my wife, Mary Ann, whose parents were on a farm, and we got acquainted. She was working for what they called Triple-A in those days, kind of like Soil Conservation.[9]

Storey: Agricultural Adjustment Administration, maybe.

Powell: Yes. Well, anyway, so then a year and a half later, we moved down to Nebraska, and that's when I went to work for the Bureau of Reclamation.

Storey: How did you get your job with Reclamation?

Starting Out with Reclamation

Powell: I think I mentioned that I had met some Bureau of Reclamation people who were coming through town to eat lunch. On a station wagon I saw the insignia, and since I had some knowledge of the Bureau of Reclamation, I asked them how–this was in my home town of Ravanna–how I could get in contact with their main office if they were interested in any additional surveyors. He said, yes, they thought they needed one; in fact, he did.

9. The Agricultural Adjustment Administration was part of FDR's New Deal; renamed the Agricultural Adjustment Agency in 1942.

So I went down to Grand Island, Nebraska, talked to Bill Bombeck, I think was his name, who was a personnel man. He helped me fill out an application, and they hired me and I went to work for a guy named "Shorty" Lewis, I think, we used to call him. Worked out of the Grand Island office, and then they sent me up to Loup City, Nebraska. I think we mentioned that. I started serious with the Bureau of Reclamation about that time.

Storey: So, were you a rodman throughout your career at the Corps?

Powell: At the Corps, yes. I was a rodman that whole particular time. I hadn't received a promotion, but you still are a rodman for the first couple of grades.

Storey: Tell me what your first grade was.

Powell: I think the first grade was SP-2, and then I went to an SP-3, and later on the government changed SPs to GS, but that was some time down the road.

Storey: And when you went to Reclamation, was it for a promotion?

Powell: I think I started with that same grade, SP-3, that I'd been promoted to.

Storey: So, in effect, you'd lateraled into Reclamation.

Powell: Yes. And then at a later date, after I finally got up to what they called an SP-5, which was an instrument man, if you got to be an SP-5 man, you got to run the instrument. Then right away the government changed and put it down to a GS. I went from an SP-5 to a GS-4. They lowered the grade one notch. From an SP-5, everybody went to a GS-4. SP-8 went to a GS-7, or whatever, you know. But that's basically what it took to get me involved with surveying.

Storey: When they went from an SP to the GS system, did that affect your pay, or just the grade level?

Powell: I don't think it affected our pay. I think it only affected the grade.

Storey: They were adjusting the grade-level system.

Powell: Yes, but not the pay. I think our pay stayed the same. But this was in the early fifties, but I'm sure that was the case, yes.

Storey: How long were you with Reclamation before you became an instrument man?

Powell: Well, let me think here. I'm really not sure. I did run the instruments some before I left Loup City. It must have been a couple more years, probably, before I got to be an instrument man. First you learn how to run the level. We had the old dumpy levels. You did that before you'd run a transit, generally speaking.

Storey: And the level does what?

Powell: The level you use to establish elevations for your height, up or down, where you want to go. If you're going to make a map, you have to know the elevations of the highest points down to the lowest points. Then you contour the map. You have to learn how to contour. In those days, we did everything long hand, the hard way.

Storey: How did you learn it? If you were out on the rod hundreds of yards, dozens of yards away from the plain table, how did you ever learn to do that end of it?

Learning the Surveyor Trade

Powell: Usually you could start out by learning maybe on an extended lunch hour, maybe the party chief would show you. Maybe he'd take a little time maybe when you were riding to town. They had the map on a board. You could look at that, and he'd show you how to do the contouring, how to draw in the drains, and how to pull your contours up your ridges and back. It was just through the benevolence of the party chief. They were pretty much willing to help young people that wanted to learn. If you asked them, they would usually try to find time. And that was another way you got promoted. If you showed interest in learning the next position or two, then the party chief was always willing–most of them–to help you get along.

Storey: What would the party chief be doing?

Powell: The party chief usually was the man, of course, that was in charge of where you were going that day, what job you were going to do. If you were going to do topography, as an example, where you were going to go, how you set up, and who was to do what. He might let me run the instrument that day in a learner capacity if it was a small area. If it was a big job we needed in a hurry, everybody resorted to the job they knew best.

But the party chief was the one that kept notes, kept the work efforts of the day, made the contours on the map that was to be handed into the office. He was in charge of the total production of that crew and responsible for the accuracy and the quality of the work.

Storey: So he would be with the survey crew all the time?

Powell: All the time, generally speaking, yes.

Storey: And standing with the instrument person?

Powell: Sometimes, or if we were doing topography, he might be sitting in the vehicle with the plain table on his lap, because before we used the allodade, we had another method of turning angles to the closest five minutes, and he'd just plot that up with a protractor. Depending on the type of topography, where we're at, what instrument we use, and that was up to him to decide.

Storey: Any women?

Powell: In those days, no. In those days, there weren't. I don't really know exactly why. I think women at that time thought that that was just a job for a man, you know. They were not really seeking that type of work to any degree that I can recall, until much later. Out here on the Central Arizona Project, I think we–in fact, I hired the first lady surveyor we had here. And you had to ask them questions such as, "Hey, this is hard, tough work. Can you pack fifty pounds up this mountain? Can you cross this river? Are you afraid of snakes? Its 110, 115 degrees out, even 120, can you hack that? Can you find a way to go to the bathroom out in the desert with the guys around?" You know, that's a question you have to ask. But we had some–then more women wanted to come to work, and it turned out we had some real good ones, and they were just like the men. Some of them were good, some of them weren't. [Telephone rings. Tape recorder turned off.]

Storey: We were talking about the people on the crew, on a typical survey crew, back when you first started. There would be four folk.

Powell: Right.

Storey: The party chief was sort of in charge of the paperwork, is that what I'm hearing?

Powell: The paperwork and the organization and the quality of the survey you were to do that day. He was the guy that made all the basic decisions.

Storey: Then the instrument man was taking care of the instruments?

Powell: The instrument man did his work, which was to turn angles and measure distances or record the data that the rodmen were flashing to him, but pretty much under the direction of the party chief. It was pretty much an everyday task on a set crew.

Storey: Then a couple of rodmen.

Powell: Couple of rodmen.

Storey: Holding the rods, chaining distances?

Powell: Yes.

Storey: And driving stakes and marking the stakes.

Powell: Correct.

Storey: When you moved to Reclamation, did that change at all?

Powell: No, same basic type of survey.

Storey: Four folks?

Powell: Four folks. You could operate with three. You might even, on a specific type of work, if you had, for example, on planning work, if you had 1,000-foot-to-inch topography up a big valley, you might want three rodmen. You might want five people if they're available. Basically you tried to take the amount of people it took to do the job the best for the least amount of money. You don't want too many people where somebody's standing around. You don't want too few where it affects your accuracy because you don't have enough people or it affects your time because you have to retrace your footsteps too much.

Storey: How did you get to where you were going to work?

Conducting a Survey

Powell: Pretty much we would all report to a base station. That's where the government would have an office set up, where the man in charge of the office and the office people, if there were some, and then we had all of our suburban vehicles, usually with racks on top to carry the rods and some of the tripods and boxes on top. Then inside we would carry the instruments, put them on a seat so that they would not get out of adjustment. You had to treat an instrument pretty good or it wasn't any good to you. If it bounced around on the floor, it would be out of adjustment and wouldn't operate correctly without spending more time adjusting it. So pretty much all two- and four-wheel-drive suburban vehicles.

Storey: When did you start on government time?

Powell: We started usually from the office that we were involved in, although I've worked in places where our time didn't start 'til we got out to the dam site or to the job site. Both ways, sometimes you'd be paid for driving out on their time, coming back on your time, or vice versa. It seemed to depend on the policy of who was in charge of the office at the time or what he thought the instructions were from the regional office, or whatever. It was very changeable. It seemed at times like nobody was for sure what we were to do, and that was because some of the policies changed, some of the administration changed. But most of the time, I think we pretty well went both ways on government time on most of the projects, but we did have those little idiosyncracies pop up.

Storey: For instance, out on the Loup Project, was there an office?

Powell: Well, when we worked out of the Loup City office, there was a main office that they had rented a building, and we all operated out there. We went different directions because we had a large project, but if we went as far away as Arcadia, which was like, I'm recalling, fifty miles, then they might detail us up there. If they detailed us up there for a six-month period to do some work–maybe its seventy-five or eighty miles–then if we still lived in Loup City, because that was our permanent residence, or semi-permanent, then we would drive up there and back in our own personal cars, on our own time, each day just so we could stay. They didn't care, as long as you reported to that office at eight o'clock and left at four o'clock, or whatever the time was, five o'clock.

We ran into that sometimes, or they'd pay us a subsistence. Like in those days, was three, four, five dollars a day. If that was the case, then we'd stay up there during the week. So, if there was no subsistence, then we'd drive on our own. That was a policy that was changeable, too. Its always up to the whims of somebody else that usually was confused.

Storey: Were you often long distances away from the main office?

Powell: Not often, but sometimes maybe as much as sixty, seventy miles, you know. But only for a short period of time. What we did here on this project, and it worked pretty good, we recommended to the office, on surveys, and they worked with us on it, and it saved the government money, if we were somewhere that it took an hour to drive each way, we might try to work a longer day so that we'd get the same amount of work in, and not have to send somebody over there on per diem, which per diem rate was higher than the lower paid surveyors, some overtime. So, we would just work a ten-hour day and still get eight hours in the field. If we had to pay per diem, that cost more money ultimately than anything, and the guys were away from home.

You have to look at the interest of what's good for the employee, too.

When I first came on this project in June of 1968, the Bureau of Reclamation had a horrendous program; that was, if the guys were out of town ten days and back in town four days.

Storey: That was a fairly typical pattern for survey crews, I believe.

Powell: Yes, but it raised havoc with families. I don't believe that the Bureau of Reclamation, and I understand their problem, but ever really totally considered the problems that it created with families when they did that. Most of them were young men, had kids in school, a wife, so on and so forth, probably only had one car, so on and so forth.

As soon as I could get away with that, get that out, I got rid of that program. When we got into construction, we couldn't do that anymore anyway. We were more locally organized. We did send a lot of people like to Parker–well, that's 160 miles away–on per diem. We had to. Then later on when I got in construction, we set up an office and then people were transferred to the office, and that eliminated that problem.

Larry King was in charge of that particular office, and then when he didn't have the correct training or needed somebody, we'd go over and help him, send a crew over on detail to help him get through with the road. They'd build a road out to the tunnel, and so on. We helped him teach his crew how to do that. Worked real well working with Larry.

Storey: What kind of places did you stay out at when you were on per diem?

Powell: Pretty much about the medium-rate motel in whatever the closest town was to where we were doing the job. In Parker, they had four or five motels that were adequate. All of them were pretty adequate. The government would pay us a per diem rate that would usually cover your motel and your food, so it worked out pretty good. Expense-wise, there wasn't a problem that way.

Storey: Was that back in the days when they just paid you a lump sum per day?

Powell: Yes. Sometimes they would pay maybe sixteen dollars a day, and it was up to you to find your motel, so you'd try to go out and find a seven-, eight-dollar motel so you'd have enough money left to eat on or to make a phone call home or whatever. Then, of course, they went to the rate where they paid the motel bill plus a certain amount. I think that was better. It got them into a little better motel, possibly, for some of the guys. But that never really had too much of a problem with the per diem. The Bureau treated them pretty good, the government. I don't have any kicks about that, generally. Occasionally we might get somewhere where they had a high rate for some incident that was going on, we might lose a little bit of money, but not generally. It worked out pretty good.

Storey: Do you remember any particular incidents on the surveying in Loup City?

Powell: As to regarding what?

Storey: Any interesting stories? Let me put it that way.

Powell: Interesting stories. You're asking me to recall a long time, you know.

Storey: We can move on until later.

Powell: Of course, there's always humorous incidents, things that happen, incidents that happen when you're working with people in the snow, maybe, is an example, or in the mud. We had a lot of times two-wheel-drive vehicles we had to put on–in Nebraska, there's a lot of muddy roads when it rains, and we still had to work, so we'd many times have to get out and put chains on to get where we were going. They had governors on the vehicles; you could only go 45 or 50 miles an hour, and then when you're in mud and plowing with chains, that made it a real tedious procedure. I don't remember any one specific single incident that was humorous, but there were many smaller incidents, of course, and some of them of a personal nature that you wouldn't want to talk about. (laughter)

Enjoyed Working for Reclamation

The Bureau of Reclamation always had a good group, whether it was the inspectors, the drillers, the surveyors, we had a camaraderie that was pretty good. The people were pretty close-knitted, and I always appreciated–I worked in, like I said, Paonia, Colorado, on a couple of small dams, and Durango, Colorado, on a small dam, in Nebraska. When you had the small offices, maybe you had forty-five, fifty people in an office, inspectors, surveyors, drillers, office personnel, construction engineer, project manager, whatever, we'd have our Bureau parties and our Bureau picnics, and we were a pretty close-knit group.

When you move in a small town, you're kind of the outsider, so the Bureau people kind of banded together all the time, although we all did work with some of the town people, maybe got involved in some of their activities, helped with the school functions and got involved in their softball teams. The Bureau, when I lived in Phillisburg, Kansas, the Bureau of Reclamation there, we had a softball team in about an eighteen-league, and we used to beat everybody. The town people liked to come and "boo" us because we had some real good Bureau of Reclamation softball players.

Anyway, I liked a small-town atmosphere because of the closeness. When you move to, for instance, Phoenix now that's an altogether different world, because you may be working with a guy that lives forty miles from you and his kids are in another school, and the other kids are in another school. Its very hard to have any of that type of close relationship–through no one's fault. I mean, that's just what it had to be. We did have our maybe a Christmas party once a year, but it lacked the close affection, I think.

For example, in Durango, Colorado, Maury Miller [phonetic] was our construction engineer, and Gordon Hill was our field engineer, and Harold Deming was our chief inspector. We were in surveys. I was in surveys. We had a relationship along with the office and the office engineer was Ben Babbitt [phonetic]. We had a real camaraderie there that was so outstanding, and we worked hard together. In fact, I think Bordon and Walker from the Denver office come down and complimented us on the quality of the workmanship in all phases of the Lemon Dam, that it was just such a good job completed by the Bureau of Reclamation for everybody involved, not just a surveyor or an inspector, but everybody. That, we considered a real treasure to get a blessing from those two guys who were considered the experts in the Bureau of Reclamation at that time.

Storey: This is Walker, Brig Walker?

Powell: I don't recall the gentleman's first name, and then the other man's name was Bordon. I don't remember his first name either. I did for a long time, but not anymore. I think everybody on that project would like to go back and do that one over again because of such a good feeling we had.

Storey: How did you move from Loup City to Beloit?

Powell: When Loup City office was starting to complete their project, then they were going to have to cut down on some of the people, so these jobs opened up in Beloit, where they had some work to do yet, didn't have enough people, so some of us thought, "Well, we might as well move on and move to Beloit." I think there was only about six of us that went, so that helps alleviate the pressure on some of the other guys. They were getting ready to go through an R-I-F, and, I don't know, maybe we were lower on the totem pole and we would have had to go somewhere else anyway.

Storey: Through a RIF [Reduction in Force]?

Powell: Through a RIF, reduction in force. But it turned out real good for me when we got down there. I got to run the instrument more, and then we moved to Red Cloud in six months only, and we were there only a few months, and then we moved to Kirwin Dam.

Storey: You went from Beloit to Red Cloud, and then on to Phillisburg?

Powell: Phillisburg, where we worked on Kirwin.

Storey: What was the process here? Did somebody come to you and say, "Hey, you want to go to Beloit?"

Powell: No, not really. We had a lot of projects that we'd go to, or maybe only six months or a year job, or a two-year job, and we all knew that when we completed the work that was assigned to us, then we would have to look for somewhere else. The Bureau was very good about saying, "Look. This job's going to be completed on June 15th. We need this whole office to move to Beloit." In that case it wasn't the whole office, but some. So, then we would get orders from the main office, come out and say, "Here's your travel orders, and this is when you'll be required to move to this place. We suggest you go down and look for housing." They'd tell us what they knew about housing available.

So I'd come home and say, "Mary Ann, we're going to have to move in a month," or three weeks or two weeks, and my wife would say, "Okay." She was a great packer, and she would start getting everything together. We were talking the other day. During my career, my forty-two years with the Bureau of Reclamation, and sometimes it would involve a couple of moves in a town, two or three moves in a town, we moved twenty-five times. Fortunately, it happened that we didn't have our kids until we were in Paonia, we started having kids, but they were all able to go, after we moved to Phoenix, to the same grade school, and all graduated from the same high school. So, schooling was never a problem to us. But in all the moves and all the places I've lived with the Bureau of Reclamation, we still have a lot of good friends, people that worked for the government, people that didn't work, that lived in the city, that lived in that small town. We lived in towns of only 500, some of them, and up to 10,000, before we moved to Phoenix. But we still correspond with a lot of people, have a lot of good relationships with a lot of those people.

I never lived–neither did my wife–in a town with the Bureau, that we had to go to, that we didn't like the town or the people. Even adapted to the weather. Weather is not really that big a problem if you have friends. But the Bureau was pretty good to us. I mean, they did the best they could, paying for our expenses to move, getting us relocated, giving us enough time to get the kids in school. I have absolutely no complaints. I knew when I went to work for them that we'd have to move some.

Storey: What I'm hearing you say is that they would come in and say, "Well, we're going to be done in this office with your job X." But I'm not hearing you say that you were scrambling around looking for a job to move to next.

Powell: No. I never really ever had to, in the whole forty-two years. I did apply for different jobs that maybe I–like, for example, when I was in Buena Vista, we were kind of slowing down a little. I had been in charge of the surveys we were doing over there on Sugar Loaf Dam.[10] Well, we were getting quite a bit of that work done, a very good opportunity, and they were starting to cut down, having a little RIF. So, I applied for a job in Phoenix. Phoenix was interested. I sent them my resume, and they called me up and wanted me to fly down and interview me.

I flew down, they interviewed me, they offered me the job at the interview. I said, "Wait. I've got to go home and talk to my wife and make sure that everything's okay," because the kids were really doing good in Buena Vista and the schools. So, I flew back, and Mary and I discussed it. We said, sure, we thought it would be a good career move, and it was a promotion for me. Its kind of hard to turn down a promotion.

So, they had accepted me, and then we moved down, June 1, 1968. But it's the same way throughout my career. I applied for jobs before I moved to Kirwin, Kansas, and they accepted me for a job in Kennewick, Washington, and another one at Irwin, Idaho, building the dam on the Snake River, as a promotion. But in the meantime, I had got a promotion here, so we didn't want to move up to Boondock, U.S.A., if I already got a promotion. So the Bureau allowed you, anytime you saw a job you thought you could qualify for and wanted to move to that area, to apply for it. It worked out really great and a real good time frame, I think, for Mary Ann and myself.

Storey: Well, I'd like to keep going, but we have been talking for two hours now.

Powell: Sure doesn't seem like it. I didn't think we'd have enough time to talk for thirty minutes.

Storey: I'd like to ask you whether you're willing for researchers to use the information on

10. Sugar Loaf Dam is one of the units of the Fryingpan-Arkansas Project, see USDOI, Water and Power Resources Service, *Project Data*, 487-8, see also Rogers, "Fryingpan-Arkansas Project."

these tapes and the resulting transcripts for research purposes.

Powell: Absolutely. I would welcome anything that they need to know or if there was something that was not quite accurate, I'd be glad to straighten–

END SIDE 1, TAPE 2. APRIL 23, 1996.
BEGIN SIDE 1, TAPE 1. MAY 20, 1996.

Storey: This is Brit Allan Storey, senior historian of the Bureau of Reclamation, interviewing Vernon Powell at his home at 17634 Calico Street, Sun City, Arizona, on May 20, 1996, at about nine o'clock in the morning. This is tape one.

Mr. Powell, last time we talked about your career in general. This time I'm wondering about the details of how you do surveys. For instance, on the Central Arizona Project, as I understand, it was built in various sections. So, for instance, Reach Eleven, I believe it was called, here in the Phoenix area was built in order to preclude problems with urbanization. How does Reclamation's surveying crew and its engineers, working together, figure out exactly where Reach Eleven's going to be and make sure that it connects properly to the rest of the project if they're building it out here in isolation by itself?

Work on the Central Arizona Project

Powell: That's a real good question, and its fairly easy to answer. Some of the projects or canal were built earlier in this section because of right-of-way purchases and prices of land accelerating because of the Central Arizona Project, so it was probably wise to build some of the sections through Phoenix as well as to begin at Havasu with the pumping plant.

One of things that the surveyors do when you go into each state to work with the federal government on a project is to determine what type of a coordinate system that state has, whether it's a Lambert or a Mercator system, depending on whether the state is more north and south or more east and west. What it does is take into account the effect that the curvature of the earth has throughout that state. Of course, elevation-wise, everything is from sea level so that each state, each project, everything fits. So we could go from here to, as an example, the Empire State Building in New York City if we could establish a coordinate, depending on their state system and a coordinate here, we could set up an instrument called a theodo ladder of transit, turn an angle off of a baseline that had a known azimuth or coordinate on it, turn an angle and know exactly what angle, if we could see that far, to turn to see the Empire State Building and know exactly how far it was within limits.

So within this state, when we started the project, I came here in June of 1968 and the project was authorized in September of '68, we then began to do what was called pre-construction work. In other words, we'd go out and start to locate the section that the designers thought maybe, and the Denver office would want us to begin on.

So what happens, as you suggested, is how do we know its going to fit? Well, at that time we had to utilize a system that was brought up by the U.S. Coast and Geodetic, then evolved into the N-G-S, National Geodetic [Survey]. Their job earlier in history was to place state-plane coordinates on monuments that were three or four or five foot into the ground with the brass cap on the top of it, that was more or less of a permanent nature. That was all through the state of Arizona and other states. Elevations, extremely accurate elevations and coordinates were placed on these points. So then a surveyor knows how to compute distances and angles from coordinates and how far it is to where.

If we hadn't had this system, we would have had a more complex system of our own, all the way from Parker to Tucson. We relied on this system a lot to do our checks and counterbalances. In other words, we would go ten, twelve miles possibly, maybe closer, maybe further, and then we would make a distance and elevation check into this monument. If there was a slight amount of error, we'd correct up and continue on. That's why we were able, through mathematics, to determine exactly where to place this canal in Phoenix, 200 miles, 165 miles from Parker, and also have the elevation and the location of it to fit the canal that was to come and meet up with it at some other prearranged date. It sounds fairly simple, but there was a lot of sweat and accuracy to be involved with accomplishing this feat.

The elevations posed somewhat of a problem to us also, because when we started on this particular project we had some of the older leveling equipment, even to some that is some of what we call the dumpy level, which was a level that you manipulated with your hands to see a level that was through some marks on top of a bubble not unlike a carpenter's level. You carried your levels that way, and it was an extremely tedious and time-consuming job, especially in Arizona in the summertime where the heat waves were so that you had to keep your sighting down to 150 foot or less or you'd get too much distortion in your readings.

Storey: From the heat waves in the hot temperatures.

Powell: From the heat waves that bounced off of the ground. So then about that time we were fortunate that they developed what was called an automatic level. It wasn't necessarily simply automatic, but it was a great advance over the old dumpy level. You only had to assemble, put a bubble in a little bit of circle that was about the size of a quarter, and you didn't have to rotate the instrument all around and around to make sure it was level. Then this instrument had a compensator inside of it. When you got that scope or barrel of that instrument, if I can use that term, to that degree, then it would automatically level itself and would stay right within that range. But you had to get it pretty close before it would automatically accomplish this.

So those two features, a coordinate system and the elevation system, was what we depended on, and we knew that the N-G-S had made a thorough survey over the years throughout each state so that their monuments were very, very accurate. However, there were times when they did have an error and we would find that. Something wouldn't fit, and then we'd go do another point, and then we'd find out that there was an error. We'd let them know and then in their records they would correct it at some time in the future, so that other people could use it.

They had different orders of survey, a first order, a second order, a third order, depending on what the monument was to be used for, how accurate you wanted the coordinates. Most of the time we'd use the first order, which was the best one foot in a hundred thousand, something of that accuracy, so that you knew that the work you were doing was extremely accurate. That way we could start one project at Parker, one at Phoenix, and one down at Tucson, and know that eventually it was all going to fit together like a glove, and it did. We did not have any problems with anything even resembling that on this total 320-some-mile project, simple because of the state plane coordinate system and knowledge that the surveyors had in making sure that that all would fit.

I can remember kind of humorously at one stage along the line after we had built quite a few of the sextons, the construction engineer approached me one time and asked me, well, he got a little concerned about–

Storey: This would be Andy Dolinek [phonetic].

Powell: That's correct, Andy Dolinek. He wanted to know, just make sure that we knew for sure what we were doing up there, that everything was fitting, and that we weren't going to have any problems with the pumping lifts and the drop structure, check structures, and each canal has a lot of checks in it, and then you drop to a certain elevation. Then I assured him, of course, that we had done the proper checks and balances.

Surveyors always have to–you don't ever assume anything in surveys–never. If you do, it will catch up to you sooner or later and it will cost you. So that we performed our checks and balances at all times, even though it took some time and effort. That was one of the differences between the Bureau of Reclamation having their own surveys and the contractor doing their surveys. Contractor beat to a different drummer. He was always in a hurry, and he had contracting deadlines and they were more apt to not be as thorough as we were. That's why we thought it was extremely important for us to make some checks during the construction and at the beginning of it.

When we would locate a pumping plant of all the fourteen that go from Havasu to Tucson, designers would give us coordinates, and we'd go out in the field and locate that pumping plant accurately according to the coordinates so we know that it would fit the canal later on in the elevation. We set all the points that the contractor would be using for reference to make these pumping plants to put in his pumps, which was to the thousandths of inches for accuracy of elevation. We give the contractor his initial system to begin with, and then we all use that system throughout the project, through the beginning and the ending of the construction, so that there was not a conflict on, "Well, we have this, you have that." There was a meeting of the minds always to make sure that everything was all right.

Buckskin Mountain Tunnel

It's the same thing as I think that I mentioned to you on the Buckskin Mountain Tunnel, when we first started that project over on the Havasu Pump. The Havasu Pump took water out of Lake Havasu, raised it 800 foot, and then went through this seven-mile tunnel. Well, 6.8 miles, I think. You went a mile in the tunnel, then you had a curve, big curve, you had to go around another six miles before you got to the outlet end. When we surveyed that tunnel, it involved about eight or nine miles of surveying for us over an area where there were no roads and extremely rugged terrain. We had to walk in to a lot of it. Occasionally, there would be a helicopter available to us, but not in the beginning when we had to survey.

We used a coordinate system. Denver would send us coordinates of the outlet of the tunnel, the inlet of the tunnel, the P.I. that was in the middle so that the curve would go around at the right place. So in order to make sure this was right, we had to construct the line over the top of the mountain, through the rugged hills and valleys, to get to the other end, to make sure that when we started at the outlet, because they were going to use a mole, in other words, would drill a hole right through the tunnel all the way to the P.I., around the curve, and then another mile to the inlet, so in order to make sure that that fit–

Storey: P.I. is?

Powell: Point of intersection of two different lines. A good question. Sometimes surveyors use phrases that other people wonder what it means, and we forget that its so common to us, we don't always explain. But the interesting part about–

Storey: And the mole would–I'm sorry, I interrupted.

Powell: Go ahead.

Storey: You were talking about the mole going through the mountain. I don't think I let you finish that.

Powell: Well, you did. I'll get into that in just a second, but I wanted to explain a little bit about the survey and what it took. I was real proud of the people that we had that worked on that job under our Survey Section, because of the extreme–its probably the best tunnel job the Bureau of Reclamation ever did.

But anyway, so what we had to do was run the line over the top, put in some monuments of a permanent nature over the top, go to the outlet end, set some permanent monuments, and then make sure that everything fit. Now, the problem in Arizona, again, when you're doing a tunnel or that accuracy that goes that far, we had to do some really precise surveying. We had to go out at night a lot, because the heat waves were too bad during the day. You just distorted the line too much. It wasn't a matter of setting up an instrument and siting a pole a half mile away and flopping it over, in other words reversing it 180 degrees and siting ahead, and moving on. We had to turn 180-degree angles many, many times, and keep adjusting that line just by the thousands of an inch 'til we got it down precisely through maybe fifteen points in that seven miles. Each one of them had to be precisely 180 degrees.

So when we started at the outlet, in order to go into the tunnel, we had to have certain monuments that we're sure they weren't going to move. In other words, we'd dig a hole five, six foot deep, place it with concrete a foot in diameter, and a brass cap in the top, with the protective points around it so it wouldn't be disturbed. We were not dealing with any subsidence in that particular area, so we're concerned about movement horizontally or vertically.

Then after the tunnel got started and the contractor started to build it, then we had to project a line into the tunnel. Now, the contractor's surveying group were supposed to be doing the surveying. The Bureau at that time, as I think I mentioned before, was at the point where they had got a new Reclamation commissioner named [Ellis] Armstrong, who changed the theory that the Bureau shouldn't do their own surveying, that they should let the contractor be responsible. That had a lot of holes and errors in that theology. I don't know whether I should discuss that.

So anyway, in order to get a line precisely in the tunnel when you're going from bright sunlight into a dark hole, the rays of the line of site you're giving bend, because you're going from bright light into dark. You cannot run a straight line from bright sunshine into a dark hole. So we had to, again, go back out at night and use bright lights and small little pins to be able to project that light and line into the tunnel far enough after they got started so that during the daytime they could go in and project the line ahead without having to look outside into the bright light. You can't go into a tunnel and look back out into the light the same as the other way. Sounds simple, but there's a lot of sweat and concern about how good is our line before we can get this tunnel on through.

So at that time we had a problem trying to convince Larry King, who was the construction engineer at that time in the Parker office, and Andy, that we should do some checking, because they were kind of thinking that, "Well, the contractor has the survey. This is his responsibility. Let's let him do it." So after talking to them over a period of time, they begin to understand my concerns about, "Is the contractor doing this right? Maybe we ought to check and see." So we performed our survey a couple times, and the contractor was a foot and a half off a line already the first mile and a half into the tunnel, which is disastrous if he keeps multiplying that and carrying that around the curve and goes out the other end.

The reason I bring this up is because I was so confident and proud of our people that were doing all this hard work that I wanted it to be a matter of history that all of the sweat and preciseness was then to keep this tunnel the way it should have been.

Okay. So getting back to the mole, when the mole started in through the tunnel and then got into the tunnel a ways, the contractor was placing concrete behind this mole as the mole went through the tunnel, as it proceeded. They would get up to within maybe a hundred foot of the mole with their concrete. One of the reasons they wanted to do this is so it made the tunnel safer behind for if there were any cave-ins, or any dust, and so on and so forth. But even with that procedure, we still had a lot of contamination of air and noise, and it was a kind of a dangerous kind of a place to work, although we had a pretty successful rate, because our safety program was very sound and thorough and we did a good job, the Bureau did.

This was what happened to proceed all the way through the tunnel. Then when the mole–we went in and did our survey checks a couple of time on the contractor. One time the contractor was off in about three miles or so in the tunnel, as I recollect, he was off like four feet or so in his alignment, so eventually they corrected up to our line and went around the curve. One of the reasons that the Bureau was a little reluctant for us to do the surveying, if you have two different lines, whose line are we going to use, and then if we're wrong when we come out the other end, whose fault is it going to be. Fortunately, the contractor pretty well checked up to our line and proceeded with that on throughout the tunnel. It gave us a little bit of pause and concern, because here we were responsible for a 60-million-dollar tunnel that was going to pop out of the mountain in the other side, hopefully where the designers had intended it to be, so that it would hook up with the penstocks that came from Lake Havasu Pumping Plant. With much of an error in that particular survey, then it would have created huge problems and change in design and all kinds of delays and problems.

Fortunately, when the line came through and the tunnel out came through, the holing-out party, we were within sixteen hundredths, which is two inches, which is a remarkable feat for that far going around a curve and coming out. So everybody was happy with that. We didn't have a problem. But that involves a little bit of what it takes to survey, what you have to do.

Using Lasers to Conduct Surveys

We also had, at that time we had a Geodimeter Model Eight laser, which was a helium laser that projected a red light six, seven miles away the size of a dime, maybe a little larger than a dime, right at the instrument. It came out of the instrument the size of a dime. It was a brilliant, beautiful red laser light that at that time was–we didn't want to look directly into, because it might have some harmful effects on the eyes, so we were careful about that. But that had the ability to shoot a distance thirty miles within an accuracy of an inch, which was phenomenal for us. I mean, we were overjoyed, the fact that private industry had came up with some instruments that would utilize a laser beam. Up until that time, in the beginning when we were doing some surveying on this project, we had a Geodimeter Model Four, which was a light, an amplified light beam, but the problem with that is it wasn't as accurate, although it was very accurate, but the light would be diffused very far during the daytime in the sun. Maybe if you could get a little over a mile, mile and a half, you were very fortunate. We did go out sometimes at night with that instrument also. I think I brought that to your attention one time in the Tombstone area, having to work out in the real heavy rattlesnake area, which we were all a little leery about. Interesting.

That pretty much basically tells you some of the tools that we had to complete this project of canals and pumping plants and check structures.

Storey: How would you avoid looking at the laser light? You had to use it at the other end, I presume.

Powell: For instance, if we were running a traverse line–a traverse line is a line that zigs and zags. It goes through an area that maybe, as an example, on the first part of our canal we would go ahead and map that with area photography. The designers would come out with some coordinates that they wanted us to map an area so that they knew the canal would fit within a 3,600-foot-wide strip. They knew the elevation from the old quad sheets, which was old maps of various scales. So what we would do is we'd run a traverse line through there. Well, when you'd set up your instruments, your laser, then you would maybe go a half a mile away and set another control point, which would maybe be of a temporary nature, maybe a two-by-two hub, or maybe an iron pin driven in the ground, thirty inches, two and a half feet or so. We would set up a tripod and we'd put a series of glass reflectors on it. Maybe the glass reflector at that day and age was maybe eight or nine inches across, or in diameter. It had a series of reflecting glass. Well, we'd set that up and point it right where we knew that the laser was, then move off to the side and let the laser beam go ahead and record the distance back and forth to that instrument.

Storey: So you were in radio contact?

Powell: We had radios. We had portable radios that we could talk to each other. At that time the radios were becoming pretty good. In the old days we had little walkie-talkies that weren't worth much. Couldn't hear around a large bunch of trees or anything like that. The radios were good. We made contact. We'd say, "Okay, we're done with that site; we'll move ahead." Everybody'd leapfrog to the next point. We'd already set the points according to the coordinates that the designers wanted. Then we would run this strip through maybe a fifteen-mile stretch, make sure that that all fit with the coordinate system that the Geological [Geodedic] Survey had established, make sure everything was right. Then we would contact and get various aerial mapping concerns, have them give us a bid, fly an aerial mapping run over our designated area that we'd placed elevations and coordinates, and we gave that information to the contractor. The contractor would take that information and compile that, come back up with some months later and give us the maps. We'd go in the field and check to make sure that their maps were accurate, their contours were accurate within a foot or so, two feet, that their coordinate system was right, so that the designers could depend on the information they were getting from this aerial mapping contractor was accurate enough so that they could locate the finishing touches on this canal that we would then go out in the field and stake precisely. Then you made a leapfrog, as you mentioned before, and go another thirty miles down the road before you did the next canal section.

Storey: This traverse, was it as a specific elevation? Was it for mapping purposes?

Powell: It was for mapping purposes along as it was inside this 3,600-foot strip. We tried to keep it as close to the middle of that strip we knew we were going to map as possible. Then when the aerial contractor come up with the big strip of mapping, 200 foot to the inch is what we mapped those, all that canal with. Then we precisely located in what would be called our P-Is for the canal, or actually, traverse, another traverse, but that would be run very accurately for elevation and coordinates. Otherwise, just to locate for the mapping, didn't have to be quite that accurate as far as location. I mean, if you were off fifty foot of where the canal was actually going to be in that 3,600-foot, that didn't make any difference horizontally. It did elevation-wise, of course.

So that was just a series of those same circumstances over the whole Central Arizona Project canal system and pumping plants.

Storey: What I'm hearing you say is the designers in Denver, who were sitting at a desk most of the time, much of the time, would tell you where to survey, and what I'm missing is how did they know where to tell you to survey.

Knowing Where to Survey

Powell: Well, to begin with, see, the whole state was mapped from U-S-C and G-S or Geological Survey, N-G-S if you may, and they come out with a series of quad sheets. I'm sure everybody knows what the topography quad sheets are. They've all seen them. It shows where the mountains, with different elevations, and the valleys. So before we ever started this project, to see if it was feasible, Denver already, working along with the planning people we had here, our planning people and our design people in the Phoenix office, worked direct with the Denver people, so that we could accomplish what they wanted. It would have been real hard if we had had to work strictly with just people from Denver, but we had our own design people and planning people here. Joe Quoits [phonetic] was one of the people that was involved in the Planning and Design Section that I worked with my whole career here in Phoenix real closely to see to it that we would get what the designers wanted, not only for this project, but feasibility studies on some of the many other projects we've studied–Charleston Dam site at Tucson, Hooker Dam site in New Mexico, and Conner Dam site in New Mexico, both of them on the upper Gila River, the Flagstaff Project in conjunction with the city of Flagstaff for additional water. So we worked closely with those people to begin with.

Then as the dream progressed of someone that I don't even know who initially started the idea of bringing the water from the Colorado River all the way into Phoenix and Tucson, as the dream progressed and got more into reality, designers began to look at it and study it from quad sheets saying, "Could this be possible? How would we transport water 3,000 second-feet from the Colorado [River] to Phoenix? Look at the obstacles. You've got mountains. You've got valleys. How do we do this? Can we get pumping plants? How high can we lift the water? Eighty, 90, 100 feet, 110 feet, some of them were. What are the obstacles?" It was a tremendous team effort with a lot of Bureau of Reclamation people, not just the people that were in Phoenix, but it started with dreams of a lot of people and ability of the civil engineering designers to come up with this wondrous project.

Teamwork of the Central Arizona Project

The thing I liked about it so much, too, working on this project, it was so huge and we had so many different people, up to as many as 600 people of all walks of life, from the construction engineer right down to the surveyors and secretaries and the inspectors and the designers and just everybody that had a part of it, it isn't just that the construction engineer was the wondrous individual that did this project. He couldn't do any more than any other single individual, but it was a group of people from Denver clear down to here that accomplished this whole project. You realize that when you work on a project this big that everybody has a part in it. We couldn't accomplish it without–I don't know one phase of it or one office part of it that we could have got along with. The drillers–how are you going to know if that canal is going to be in the right place or in the right type of rock, or that dam, or that if the drillers don't go out and spend a lot of time drilling holes so far down to find out what kind of rock we've got that's feasible? If we have the right kind of soil, the drillers have to let you know. Do we have the type of rock we need here for the concrete? How far are we going to have to haul the dirt to make the canal? Is it too far we just can't do it? There's nothing but sand? So anyway, the surveyors and the drillers especially were–

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Storey: You were saying that the surveyors and drillers had to work closely together.

Powell: Yes, we did. They had to know when they'd go out in the field, we'd locate–maybe Denver would send us coordinates and say, "We'd like some holes drilled in this area." We'd locate them for the drillers, set up a flag or something that said Drill Number 129 that the driller had maps and we had maps. We'd set them for them so they knew precisely where to go. They'd go out and drill the hole, and then if it was a completely feasible hole that they completed, then we would put final coordinates and elevations on that so the designers would know exactly where the sample came from. So you plotted on their series of maps that we had.

That was all through the project, whether it was on a dam itself, or on a pumping plant, or on the canal, any part of the Central Arizona Project, the drillers and the surveyors were kind of hand in hand.

Storey: Do you see a lot of changes as this process went on–relocations, that sort of thing? What was going on?

Powell: You mean as far as the type of work we did?

Storey: Say the designer said, "We want you to look at this area."

Powell: Oh, sure. Sure. Designers aren't perfect either. They have to go by trial and error. They'll say, "Well, it looks pretty good here. Let's run a line up through here for half a mile back up in this little valley, see what kind of a fill we would have to have or what kind of a siphon we'd have to put. If we go up this job very far, what kind of a siphon, how long a siphon, what type of rock on both sides, what are we going to run into?" Then if results of that survey and drilling program didn't give them the information they wanted, or was not pleasing to them, they would have to relocate it, maybe only 100 feet, maybe 500 feet in the location of the canal itself. That was very important. That's why I say it all had to work together.

Storey: There were a lot of these little–I guess these would be termed "small changes"?

Powell: Well, not maybe a lot, but surely some, because the field always isn't represented exactly as it is out there or doesn't look underground after the drillers get some samples as good as they thought it did, so they had no choice but to move it a little. Maybe a pumping plant didn't quite fit their expectations, and maybe they wanted only an eighty-foot lift and they ended up having to have a 105-foot to accomplish what they wanted to do.

So that was a constant looking and shuffling and movement of that canal all the way until we got into construction. The specs came out of Denver then and were sent to us with all the coordinates and elevations and preciseness, and the spec would come down from Denver. It would have the location of the pumping plant, exactly where you wanted it, exact elevations, where the pumps went, exactly where they had to be set, thousandths-of-an-inch accuracy of the pumps. We had to have special equipment for that. We had to have levels with micrometers on them to get that part that the pump sat on. The plane that they sat on had to be so accurate and sanded off to such a degree of exactness so that the pumps didn't have any binding in them at all that they were set exactly level.

So they gave us our instructions through the specs and we had certain limitations that had to be built within the limits of the Denver designers and our designer decided that that had to be. Maybe they give you within the limits of a quarter of an inch in location, something of that measure, or less.

Same way with the check structures as you go down the canal, or a drop structure, you wanted to drop the canal down a little bit in elevation, maybe eight-foot drop. They wanted it exactly 8.2 or whatever. We just took what some many of us called the bible, which was a set of specs, and the contractor used that same spec. We all had to abide by what was on there. The inspectors were there to make sure that the contractor was doing what the specs had told him to do, what limitations they wanted, what type of concrete they were to use, what the limits were, how to ice down the concrete when it was so hot. Just about every conceivable thing you can come up with was in the specs. So we relied heavily on that. We couldn't operate without it, of course.

Storey: The construction inspectors, were they using your survey crews as part of their construction inspections somehow?

Powell: Yes, they did.

Storey: How would that work?

Working with Contractors

Powell: If the Inspection Force–and that's another group we worked closely with on each project, and each section of the canal, or each dam, or each pumping plant–wanted us to check what the contractor was doing to make sure everything was going all right maybe before they placed a heavy section of concrete, or maybe before they started a couple of small tunnels that we had on this project, we would go out and check the alignment, the elevation, and everything, to make sure that they were going to start out right, because if you start wrong, then its very hard to ever get it corrected and get it right. It's like when you build something. You get it in a bind that's very hard to get it corrected back up and started level and plumb.

So the inspectors would ask us, they would leave a message in the office, "We need a checkout on this pumping plant for the next pump section. We need a checkout on that at eight o'clock Wednesday morning. Have a survey crew there." They'd get hold of me and I'd get one of our guys to get them lined up to go out, so we'd be out there whenever they wanted us to.

Sometimes on the final sections the contractor did an excavation. In other words, he dug a big hole before he started putting the pumping plant in there. He'd ask us, "Okay, they're done excavating to what I believe the spec calls for. Send out your crew and we'll take some cross-sections of that area to make sure we know how much dirt they took out of there, what the quantities were, how big the hole was, is it right," so we'd go do that.

Storey: This is the construction inspector would request this, not the contractor.

Powell: Yes. The Bureau, not the contractor. The Bureau of Reclamation inspectors that were on each project.

Storey: Of course, that has to do with our payments and so on.

Powell: That has to do with our payments and so on.

Storey: Plus the accuracy of the work.

Powell: Plus the accuracy of the work. Is it the right place, the right amount, is it deep enough? So that's what was used. Those sections then were used for pay quantities to pay the contractor the amount that he thought he had in that particular excavation. Sometimes they didn't always agree. The contractor would say, "Well, you told me to over-excavate this area," or whatever. "That's more than the spec called for," so our surveys would prove that. Then it was up to the inspectors to argue or discuss what was said prior to the excavation. So it was the same on every pumping plant and every section of canal as far as the inspectors and the surveyors working together.

Storey: Earlier you mentioned the problem in the tunnel with the contractor and the accuracy of their location. Did you find that happened on things like canals and pumping plants also, or was it less of a problem then?

Powell: Not so much on the canal to that extent, because you were outside where you could see. Yes, we had some little problems. The contractor, I remember one time after we first come out of the Buckskin Mountain Tunnel and we ran across the first road that the canal had to cross. Whenever we cross a road, naturally, we had to build a bridge. The contractor surveyor had surveyed this bridge that was to be concrete that went across the road, and the inspector asked us to come out and check. Well, the contractor surveyor had the bridge reversed, run backwards. So when we, of course, went out and did the survey, we found that out and they had to resurvey the whole thing. We had incidents like that all the way through.

Storey: What do you mean it was run backwards?

Powell: Well, it sloped the wrong way, which is a problem. It's a mistake that can happen. What you're dealing with is human beings, and anybody can make a mistake, and that's why the checks and balances kind of keep the Bureau and the contractor from looking bad on some projects. Its just like you may have a brilliant person, but I'm a firm believer in two or three minds are a lot better than one. We had some incidents like that on the whole project. Of course, we had different contractors on different sections of the canal, but the basic part of it is the contractor did fine, but there were some mistakes that we helped them with. We had the contractor go in first and take the information that we gave them. In other words, we'd say, "Here's the centerline of the bridge, here's the reference lines on the side that you're to use to build this bridge," so his surveyors would come in there and use those reference lines. If we set the lines wrong, then it would be our fault. So we were pretty careful about that. Then the contractor was free to go ahead with his survey, and didn't tie us up, and we were out doing something else on another phase of maybe pre-construction on down twenty miles ahead of them or something for the next contract. So we weren't permanently tied up on that project.

I did like the way the Bureau did it originally where a crew was assigned on, say, a pumping plant and a reach of canal. You'd stay right there just one three-man crew and be there every day to work with the contractor to get their work done. It seemed to go better, and we had very good working camaraderie between the contractor and the Bureau, and we seemed to have a little better quality of work on the overall project, the ones I worked on, and I'm sure it was the same on other projects. I talked to other Bureau surveyors on other projects. It was the same thing.

One of the guys that's here, I don't know whether you want to talk to anybody else that surveyed quite a bit, in fact, he worked with me clear back in 1960, then he went to Utah and worked on a couple of projects, and then he came down here and worked with me again. His name was Allen [phonetic] Heer, H-E-E-R. He worked on Morrow Point Dam and a little bit of Crystal Dam on the Gunnison River in Colorado over by Mount Rose. He might have some interesting things to relate on this project and on some of the other projects.

But that's about it as far as–there were some arguments that would come up between the inspector and the contractor surveyor and our surveyor sometimes, as to how close does this have to be. The contractor would say, "Well, that's close enough. It doesn't have to be that accurate."

Well, the spec calls for–if the spec says, "Hey, we want this finished concrete to be within three-eights of an inch when its complete, no more," the contractor wants to take the three-eights of an inch before you ever start building it, and then if the concrete moves during placement a little bit, or their elevations are off just a little bit, you've got a problem. Nobody likes to go back and grind out concrete or tear it out and replace it. So that was a constant abrasive nature between the contractor and the Bureau. I guess you'd call it maybe a necessary evil, but inspectors and surveyors had to be on their toes all the time in working together. What you tried to do is let the contractor know he could trust you and you could trust him, and we had a lot of that. Then when you had that type of working relationship, it made a real good job, a real big stress reducer. That seemed to be not be that bad on this project. We had a pretty good–

Storey: You've mentioned several times "checks and balances." What are we talking about here?

Checks and Balances

Powell: Well, for example, after we excavate, let's say, a pumping plant, maybe we've got a hole out there that's 75-foot deep, and maybe its 150-foot wide and 75-foot deep. They get the ground all prepared, and we've taken cross-sections, you want to start placing the concrete slab for the bottom part of the pumping plant that the motors are going to set on, and the pumps. So you wouldn't just go in there and put an elevation on the concrete and say, "Now, the pump has to sit right here on this mark and on this elevation," and then pull up your instruments and leave, without taking your instruments and perform checks by going back out to your original reference points on the side and make sure that when you went down you did it right. So when you go back, you're completing a loop, a full circle, let's say. You want to make sure there's 360 degrees in that circle, or 180 degrees in that triangle. You want to make sure everything fits to what its supposed to be to guarantee that you're right. That's checks and balances. That's a surveyor's life. If you have a surveyor that doesn't perform checks and balances, he's not a good surveyor. It's just that simple. Since everybody is careful about placing concrete, they don't want to tear it out, you do that all the time.

Storey: You mentioned subsidence earlier. Did you have problems with issues like subsidence in the movement of monuments and so on? And if you did–maybe I ought to ask this question different. You've got a survey point established by the Coast and Geodetic Survey, is it?

Subsidence Problems on the Central Arizona Project

Powell: Yes.

Storey: And you work from that, and you go out to a point on the canal, and then you work the canal, and you go back to that survey point. Well, if that survey point's wrong, then how do you catch that its wrong?

Powell: Very good question, and I'll tell you how we had to do it and how we had to rely on it. We didn't run into subsidence when we first started in the Parker area and so on and so forth in that area. We knew that there was known subsidence clear on down on the other side of Phoenix, between Phoenix and Tucson, and the Ajo area, as much as fifteen foot of ground that subsided, fifteen foot in elevation. We hadn't run into any subsidence yet, and the reason we knew, when we were working in the Apache Junction area, which is a very far eastern part of the Phoenix area already in the beginning of the Tucson Canal, we were running elevations out in that area. Then when we would make some checks into other monuments, we were running what appeared to be very unstable levels, and I was becoming concerned about, "Now, wait a minute, this doesn't make sense. I mean, I just don't believe that's happening." So then it dawned on me that, hey, we're running into subsidence here. That's what our problem is. It isn't that we can't run levels, because we're as good as anybody.

So what we begin to realize that we had to make sure that in order to see if there was any subsidence of land settlement, that we had to run into brass caps that were set in solid rock, in other words, rock that were in granite or that had projected down into the earth that geologists told us that, "Hey, this is a solid rock. It isn't just a piece of boulder sticking out of the ground."

Then after we got smart, we began to set special monuments of our own, for our own survey section, into rock, and sometimes it was maybe a half a mile from the canal or maybe even a mile from the canal. So when we would run some levels, vertical control, we would have to run over this place in the rock and back, make a 360-degree circle and make sure it was right, before we could tell you exactly is that ground sinking or isn't it. And we did that all through this project, and all the way on down into Tucson.

Then after that, then we detected huge cracks in the ground. In fact, the Denver office made extensive research into that area in Apache Junction, which did affect the design of the canal, because we found cracks that were deep, you couldn't see into the bottom because they were irregular, and maybe sometime a crack would be eight feet across and fifty foot long, but you could see the cracks, especially in this one area, and then on down by Picacho Peak we found huge cracks in the ground where these big citrus farms had been pumping with maybe twelve-inch pipe with diesel [pumps] sitting on them pumping water twenty-four hours a day for many, many, many years, irrigating their citrus crops, and they had the huge crops from land subsidence.

So then we found out that and we reported that, and Denver then got nervous about it. We started looking on how to design the canal according to the subsidence areas, and Denver obviously couldn't put a rubber canal out there. Fortunately, in the subsidence, normally its not an area that you run along and then you have an abrupt lift of a foot or six feet or something drop like that. It's a huge swale or belly that maybe goes over thirty, forty, fifty miles, and it's a little more in the middle than it is anywhere else. Yes, Denver had to look into that. "How's that going to affect our canal? How do we make sure our elevations are right? What do we do?"

We ran into an area out here in Apache Junction area again that one of the guys that was in the Engineering Section that was going to be on the construction of that, responsible for the construction of Reach Two of the canal on the Salt-Gila, I told him that we were finding subsidence in monuments that we'd set alongside the canal, and he said, "Well, I don't think so. That soil doesn't have any elasticity, and I don't believe that that's going to be settling. Your elevations must be wrong; your levels aren't good."

I said, "Okay, I'm going to prove it to you."

So we went out in the field and we had ran a line of vertical control levels along the–we had monuments every couple of hundred feet along this section where the canal was going to be built for the contractor. Wherever he had his contractor set his waterline in there, wherever it was leaking and there was a lot of water, the monuments would be subject to movement of up or down, or if they had had rain before they put any waterlines along there, if water was setting in certain areas, wherever there was water the monuments would move up, because you'd think that they would settle, but what happens is the elasticity in the soil would force that concrete monument up out of the ground three-quarters of an inch or something. So it wasn't a very reliable source of elevation. Anyway, we learned to deal with that at the same time.

A lot of areas didn't have the type of soil that that would be a problem with. Not only did the ground subside from pumping too much water from underground, but then the soil conditions and the moisture also had some problem. It was a continuing learning process for us, for everybody on this project, as to what can happen to your soils and your alignments.

Storey: So I think what I'm hearing is that first of all, you didn't operate just from a single brass cap.

Powell: No. No.

Storey: You would cross-check them.

Powell: Yes.

Storey: I'm also hearing that we set up our own system of markers which we were continually rechecking.

Reclamation Markers: A System of Cross-Checks

Powell: Yes. We set up a system of markers along, let's say, alongside the canal. Let's say our right-of-way, just for simplicity, was 200 foot on the right side, say. So we'd set monuments every 200, 300, 400 feet along the right side, a monument being a piece of concrete maybe only two-and-a-half-foot deep and six inches, nine inches wide, mostly six inches. We'd use stove pipes to set the concrete in the ground and an auger to dig a hole. But anyway, then we put coordinates and elevation on it. Well, the contractor was to use this as a reference line to keep his canal where it was supposed to be, and the Right-Of-Way Section used these coordinates to purchase their land from to come up with their tracts. They were tract maps that they'd use to contact the landowner with and say, "How much land are we going to take from you because of this canal that goes through here?" Maybe it went right through the middle of his, or along the edge, or something. They would use the monuments then as precise surveys to determine exactly how much ground they were taking from each landowner, all the way from beginning to the end. We did that all the way along the canal. The monuments are still there today. They used the monuments then later on when the Bureau of Reclamation had contracts put out to put fence along the right-of-way. The fence line was established by the right-of-way monuments. If we had a place where the right-of-way had to be extended for a borrow area something like that, we would put monuments further out on both sides of the canal. So we did that all the way from Parker to Tucson, also.

But they were worthwhile for both, not only the Bureau, but the contractor also. He used the elevation on the monuments to set his elevations on the canal. If we had a problem with any monument because of settlement or soil movement, we would tell the contractor, make sure he got the correct elevations also.

One of the ways that we proved, even though they at first didn't believe that the soil had enough clay in it to move when it was wet, is we'd set up an instrument right between, perfectly between, maybe two monuments that were, say, 300 feet apart. We'd shoot just the difference in elevation between the two, between one that was on a dry point and one that was wet. Big difference. But we finally convinced them. I mean, now, that's irrefutable proof. So it kind of indicated our position. That was another problem that was solved during the construction of this whole canal.

Storey: I heard about monuments rising, I heard about monuments subsiding. Did the cracking in the soil cause side wise movement also?

Powell: No, we didn't really detect any of that. We made a lot of checks to make sure that there wasn't any of that going on. We had to perform those checks from points that were in solid rock, but we never ever really detected anything of any significance at all of a horizontal movement. We were a little concerned about it, although we knew there wasn't anything obviously moving enough to affect the canal or anything, but still we needed to know, hey, is there any movement? Denver would want to know if there was. So we spent some time on it, but we never ever found anything of any significance at all, and so on.

Storey: One of the things you mentioned earlier was that the mapping and the placement of the monuments was done to different levels of surveying. One of the things I'm very unclear about is you put in Reach Eleven sort of independently. Does that mean that there has been some level of survey clear from Parker Dam and Lake Havasu to Tucson so that you know where to place the final surveys for Reach Eleven? How does that work?

Powell: Well, no, again, we relied on the N-G-S coordinate system and elevation system of monuments that were throughout the state. We'd find the closest one to our reach of canal that we wanted to do. We'd already performed the mapping, of course, through that area, the aerial mapping, so we did have coordinates, and we knew that this all fit together and that was in the correct location. That was done prior to the letting of the contract. So we knew that would all fit. That sounds like a canned answer, but that's a good question, and it's a question, when you think about it, how in the world did they know that this was going to fit elevation-wise and horizontal-wise in the right place? Holy smokes, what would happen if the got it quarter of mile off or some dumb mistake like that?

Storey: My understand is that say we're here in Phoenix and we're off a foot; by the time we get back to Parker, its multiplied and done all kinds of things that I don't understand.

Powell: Well, that's true, but it's true the checks and balances that a good surveyor would perform and has been taught, that was just almost impossible. Not impossible, but almost. If you have good surveyors doing good work, and at one time we had as many as about seventy-five surveyors on this project working from beginning to end, depend on how fast the contracts were coming out how many surveyors we really needed. Not only were they working on this project, but they were working on some of the other projects that the Bureau was still investigating or in the planning stage, etc.

But, yes, that never became a problem because of the exactness of the survey. The Bureau of Reclamation, when they had a contract or they had money to do the project, gave you excellent equipment, the best equipment you could buy, the best training if we needed it, so that we were able to perform surveys as good as anybody in the world. I think, as I mentioned once before, the Bureau of Reclamation taught the world how to build dams and canals to the exactness of what we could do. Everybody asks the United States and the Bureau of Reclamation, U.S. Army Engineers, how to do. So that education was passed on to other countries.

As I said before, we were fortunate that our instruments and that really developed so quickly at the right time for us. It really helped. Now we have the G-

P-S system, Global Positioning System, that we use the satellites. I think there's twenty-six satellites that are flying over the country now that we control over the world. Through a series of special antennas and equipment and the special calculations that we do in our office and are still doing even on other projects now that the canal is done, we can set up this antenna out in the field, take elevations off of a point that's in rock. We can't just set up in it.

END SIDE 2, TAPE 1. MAY 20, 1996.
BEGIN SIDE 1, TAPE 2. MAY 20, 1996.

Storey: This is tape two of an interview by Brit Storey with Vernon Powell on May 20, 1996.

You were talking about the Global Positioning System, I think its called.

Impact of Technology on Surveying

Powell: Yes, that's correct. We've used that here on this Central Arizona Project and are currently still using that and will because we get the information we need, precise location of satellites from the military. We have telephone numbers that we can call, and so does private industry now, that they'll give you the exact location of a satellite at a certain time passing over the United States.

Used to be that we had to even go out at night to do this a few years ago because we didn't have enough satellites, and the space between the satellites was so that you didn't have enough of them going over at one time. You'd have to go out at night and sit there quite a while to make sure you got at least two or three satellites that would record information to you so that you would make sure what you were doing. But now they have so many satellites that we can go out anytime during the day and pick up some satellites that are going over, that you don't see during the daytime. You can see them at night if you're observant.

So we use that information that's given to us by the miliary to give us a certain locations in space, and then through a series of calculations and the atomic clocks that give you the exact time, precise time–we have to have that or you can't calculate or anything–we can get an elevation on the face of the earth within a quarter or three-eighths of an inch, and the location within a tenth of a foot, precise location anywhere. So by using the satellite system, that's what the miliary used before to locate targets and to zero a bomb or a missile right down the smoke stack of any building in the world, by the satellite system and the coordinate system. Same thing we've always used, only a lot more elaborate and precise. But because of the satellites, its phenomenal, really, to a surveyor, what you can do today compared to what you could do only twenty years ago. That's a short time.

Storey: I think I went to a G-P-S demonstration about four or five years ago, and it wasn't a matter of doing calculations; you pushed a button and it gave you a location. But it was only accurate within thirty feet or so. So we're talking a different system here?

Powell: No, we're talking the same satellite system, but you're talking about an instrument you pay a thousand dollars for, so that is not meant to be as precise as what we're doing. If you're talking about an instrument you can take up when you're hiking so you won't get lost anymore, a system that you can take out on a boat to locate a fishing spot, if you catch fish here you say, "How do I ever get back here?" You put the coordinates in from the G-P-S unit you have. Next time that will show you how to get right back within that same thirty feet, or nowadays they're even a little more accurate than that. But our system was so refined that we've gotten it down to the numbers I just mentioned.

Storey: When did we start using that?

Powell: We started using that about, oh, in the eighties sometime; about '85, I would say. When I left in 1983, we were just starting to get interested in that. Then we got more and more interested in it.

One section of the government had that system, I think it was the B-L-M [Bureau of Land Management], but it wasn't that precise at that time that we wanted. So we waited until it got more precise.

Then the military, of course, they have the option to move a satellite anytime they want to for military reasons, for security. There may come a time when they don't want the world to know where the satellites are. They don't want them to be able to use our own thing against us. So the military will, on purpose, relocate satellites and so on and so forth, so you have to keep up to date with them. Whenever you use the data, you have to call in and make sure, "Does this work?" and so on and so forth. They're very cooperative with the public and private industry to give them the information, and maybe the government's missing out on a little bit of opportunity to make little bit of money, as a matter of fact, because they're going to put these G-P-S systems in automobiles before very long, so you'll be able to say, "Well, here I am. There's the coordinate on Grandma's house." The car can direct me to that coordinate. Or you can use your coordinate system on your map in your car and say, "Where am I? I don't know where I'm at." and the coordinate system will show you where you're at as far as the map is concerned.

Storey: I saw a demonstration unit of this installed in a car in Huntsville at the NASA Visitors Center quite a number of years ago, using American Automobile Association maps, you know, like a James Bond thing, and they were predicting at that time a couple of years, but it's been, oh, that was about eight or ten years ago, I suspect.

Powell: Well, they're always a little more–

Storey: They're getting there.

Powell: Yes, a little more optimistic than could be, but sure, it will be, and its just one of the wonderful things. There won't be any reason for a guy to go in the forest and ever get lost if he has a little unit with him, because it'll show him what direction to go and how far it is to get to where you want to go. Even in a snowstorm. It doesn't make any difference.

Storey: What did these technology improvements do in terms of the number of people on your survey crew? Did it affect that in any way?

Powell: Sure it did. From the beginning of this project to the end of the project, we easily went from a four- or five-man survey crew to a three-man crew. We can even operate now with a two-man crew. You can do a lot of work with just two men with the proper equipment today.

Storey: To the accuracies you've been talking about?

Powell: Yes, to the accuracies I've been talking about. Its really helped. The equipment is expensive, of course, but when you figure manpower and everything else involved, the equipment is well worth the expense, the training, to get the equipment. We have computers today where we can draw maps right on the screen. I mean, that was unheard of twenty years ago. Its just been a huge, huge increase in the ability of computers to come up with quantities. Everything used to be so much handwork done. Actually, you had to be more cognizant of your math and that than you do today. You have to know how to operate a computer, but you don't have to have the real background that you did before. But you do have to know how to operate a computer and to program it, and, of course, be able to use programs.

Storey: Over the years you mentioned that you had various crews and they'd be sent out to do jobs, and as many as seventy-five folks involved. So I'm assuming we're talking about, what, fifteen crews at the maximum?

Powell: Twelve to fifteen crews, yes.

Storey: Who told you what to do with the crews?

Managing Survey Crews

Powell: Nobody. That was my job to determine what we did with the crews, and it was my job to talk to–I had people working with me that were responsible for assigning the work to the crews. I had maybe three assistants with that many people. What would happen is I'd go into the office, talk to Joe Quoits, who was in planning or in design, or Lowell Heaton [phonetic], who I worked for for so much on the Central Arizona Canal. He was one of them that designed so much of this canal himself. Lowell and I would talk, and we'd come up with some objectives. What do we want to do? I was the expert in survey. I was who decided what order of work we were going to do, what preciseness, what crews to put on there, how to train my people by rotating them from different assignments, from different jobs. Who could best do this? Who do I need to do this mostly precise work? Here's a beginning crew, a young crew; we're training them. They'll do some of the lesser work. Where do we go? What kind of per diem do we pay? How long are they going to be out of town? What vehicles do they take? What equipment? And again, what order of work is it going to be?

Then we had our safety programs and our problems with safety. We constantly had safety meetings at least once a month with our people to sit down and talk to them about the importance of working in hot weather: sun stroke, heat exhaustion, snake bite, scorpion bite, traffic. We did a lot of freeway driving. That was my biggest fear of all was the total commitment of miles we had to put, that we had, through our safety program and the safety people that constantly gave us information on vehicles and how to drive safely, and give us reminders that we put up on our bulletin boards, and training programs, and drivers' exams that they don't have now, but they did in those days, and working hand to hand with them, too. We had very, very, very, for the millions of miles we drove, few accidents. I can only really think of about three accidents in all the time I was here that were of any consequence, other than scraping up against a tree or something like that, out in the boondocks. And these guys had to drive basically 300-and-some miles across the desert, through washes, and around trees, and in the desert, and in the sand, and up the sides of banks, and around the sides of hills, and over rocks, and everything else. They did a tremendous job of work just facilitating their vehicles through all of that, plus working in extreme heat. It maybe sounds like maybe I'm patting the surveyors a little too much on the back, but for someone that really knows that they accomplished, I can't ever say enough about what they accomplished on this project.

Storey: You mentioned one person was bitten by a rattlesnake.

Powell: Of all that time, we had one man bitten on his leg, with a rattlesnake, and it happened to be a spring where we had a lot of rain and a lot of grass, and out on Orme Dam, which was right out on the Salt River just to the northeast part of Phoenix. He was working in an area and a rattlesnake just kind of rose up and bit him right below the knee. Fortunately, one fang went into the double crease of his jeans, and the other one went into his leg, and we were able to get him to a doctor in less than an hour. They gave him anti-venom, snake venom, shot. It took care of the bite and he was able to come back to work the next day. I always told him the reason he could come back so quick is because he didn't really know how serious that was. (laughter) But he was a tough guy.

But we had a lot of near misses, had a lot of near misses. There were people that can tell you about stepping on a rattlesnake and not getting bitten, and going to sit down by the shade of a tree too close to a rattlesnake. We preach those kind of stories all the time. At all safety meetings, every spring when the snakes start to come out, we really hit hard on rattlesnakes, because they're dangerous. You can die from it. There are a lot of times the surveyors are way out in the boondocks where you couldn't get to a doctor that had anti-venom, or a hospital maybe two or three hours. They want you to get to a doctor within two hours if you can. So that was a problem that was not exactly a glamorous-type thing, but something. They learn, you learn. When you're working among the snakes and the scorpions you learn don't stick your hand here, careful where you walk.

Storey: Don't put your hand above your head on the rocks.

Powell: Exactly. Exactly. Although, you know, the funny part of it is, when I worked in Kansas, we had more scorpion bites out there than we did here in the desert. The most serious guy that we ever had that was injured in the field by insects or that, was that we had a guy, and it was in his motel, he was sleeping in a motel at the El Rancho Inn in Parker, Arizona, in about 1973 or something like that, '74. There was a black widow spider in his bed, and it bit him. He become partially paralyzed from it. When they called me, I hurried up and went over there and we got him in the hospital in Parker, and he was in the hospital for a couple of days to get rid of that–you have to worry about the infection from the bite and everything. He was the most serious, believe it or not, and that's the smallest insect, a little old black widow spider. But that was not on the job.

Storey: Not technically, no. He was on per diem?

Powell: Twenty-four-hour per diem. Yes. Strange story. Strange.

Storey: Speaking of stories, though, I'd be interested in some stories, either humorous or sort of odd errors that were made or anything like that that you might be willing to talk about. You said, "I want you to go do X," and they thought you said, "I want you to go to A," or whatever.

Powell: Well, we didn't really have anything that bordered on that, anything that ludicrous. Just letting my brain calculate here a little bit, I can't really thing of–other than people falling and sliding down on their rear end or something like that, where they weren't hurt. We had those type of incidences and things like that, but nothing that probably would really reflect on the good times we had in surveys, too. We had a lot of tough times where the wind blew and where it was so hot, and sometimes so cold, and the sand blew, and all kinds of problems, but nothing of any tragic nature, I guess.

Storey: I'm not interested in the tragedy, I'm interested in these everyday kinds of problems like the sand and the heat waves, those kinds of things. Problems with an instrument, maybe, where it got knocked out of calibration or something.

Powell: We did have guys that when they were working around a stream or lake, which was a rare occasion, would accidentally fall in if it happened to be hot enough out. (laughter) In fact, the first time when I came to this job, Tom Schlicting [phonetic] at that time was the head of our Planning Section in there, and he was going to be my boss. We were concerned about the Central Arizona Project being authorized, and he said, "Vern, you've got a couple crews over at the Parker. I'd like to have you go over there and get acquainted." I thought, "I don't even know where Parker's at. I don't even know any of these guys." At that time we had five crews with about twenty surveyors working here. They hadn't begun to build up at all because the project at that time wasn't authorized yet. So I said, "Yes, okay, Tom, I'll go to Parker."

I had transferred down here from Buena Vista, Colorado, which was thirty-five miles from Leadville, that was 10,600, and it was still cold and a lot of snow up there yet around the first of June. So anyway, I said, "Okay." I hopped in the car and got me a map and went over to Parker, and he told me where they'd be out around Lake Havasu, by where Lake Havasu Pump was to be built. I pulled up in this little place that pulled off the side of the road. It kind of been built out a place to park and a rock wall, and I got out and put my arms up on this rock wall to look over into the lake, and that's the first lesson I had about how hot it gets in Arizona, because that was extremely hot. Didn't burn my arm, but it was very uncomfortable.

I looked down below, and there was the survey crew down there that I thought to be–at that time we were shooting sounding surveys on the bottom of the lake there, trying to figure out for the intake channel coming into Lake Havasu Pump, here these guys were down there swimming. I thought, "Holy smokes, that can't be the survey crew down there swimming. Somebody'll drown and I'll get blamed for a survey crew drowning while they're working." But after I met the crew and talked to the guys and begin to understand what Arizona was all about, I began to understand why somebody would want to take a jump in a canal or a small canal or a lake or something, to cool off because of the heat.

Of course, we had the water. We always carried a lot of water in the back of our vehicles. You have to when you're working out in the desert. We never ever had a crew get lost or have a car break down where they didn't have enough water and we had anybody get hurt where we had to have a sheriff or somebody out looking for them. We never ever had that. The guys were always good enough so if they had a problem they could fix it there. We had extra tire pumps with us and patching kits, so we could get a car back out to a road.

We always made sure. If you have water you can survive in the desert. Without water you don't survive very long. So we had many pounds of ice and water put into the vehicles each day. In those days, the government wouldn't let us have–we didn't even have air-conditioners. The only guy who had an air-conditioner was the project manager and maybe one other person.

Storey: Or a radio, I'll bet.

Powell: Or a radio. Yes.

Storey: I mean an AM/FM radio.

Powell: That's right. But they begin to get a little smart and lenient and begin to understand why we needed air-conditioners. It wasn't for the convenience of the employee, it was to keep him alive. A lot of times we'd drive fifty, sixty, seventy miles in a day each way, so the air-conditioner would kind of help the guys cool off.

We did have one incident one time over around Salome, Arizona, which is right out in the middle of the real desert country. We had a crew. John Harrison was out running a crew, and I happened to be coming back from Parker, and we had radios in our vehicles. I called John and I asked him how he was doing, because I knew where he was working. That was part of my job to know where the crews were all the time. We had an emergency, I had to know where everybody was, where the roads were to go find them. That was my job. Somebody had to know where everybody was all the time. So he said, well, he don't know. He lost a man. I said, "Well, what do you mean, you lost a man? You mean he's out there you can't find him?"

"Well, no. We sent him over with the reflector this morning so we could measure distance, and we haven't found him since."

This was in the summer. I think it was July. We thought, "Whoa, man, this guy had a sunstroke or something. He's in a big hurt. He's out there somewhere." So then John was looking for him. They were driving around, where the guy was, trying to figure out where he was. I thought, "Well," I said, "John, who was this?" And he told me who the guy was, and I knew who he was. I said, "Well, he didn't go back to town?" I mean, this was out in the boonies. There was just a little old road, and on down was an interstate another twenty-five miles or so.

John said, "No, I don't know how he'd get back to the place." He was like twenty miles from this town that they were staying in on per diem. In those days the guys would go out for ten days and they'd come back for four days. It created a little problem with families and that, and people got a little bit lonesome, and so on and so forth.

I said, "I'll tell you what. I'll go back to the town of Salome, where you guys are staying, and I'll check with the man that owns the motel, to make sure that he didn't end up there some way or other."

"Well, okay, but he won't be there."

I said, "Then I'll come back, I'll check in with you."

"Okay."

So I drove up, checked with the motel guy. "Yeah, he came back to town and checked out, went to Phoenix."

I said, "What do you mean, he went to Phoenix? I mean, he didn't tell anybody."

Well, that's what he did. He checked out of his motel and he called his wife, she came and got him, and there he went. The guy was so disgruntled and so bothered with working in the heat, and so bothered with being away from home all the time, it just got to him. He must have been thinking about it all the day before. He got out on the job, he just set the reflector up, hitchhiked down to the road, caught a ride right away back to Salome on this gravel road. Didn't tell John or anything. That's the way he quit. He resigned right then. Well, it was very disturbing. It was kind of funny, but it was very disturbing, because if you get a man with a sunstroke, heat exhaustion, he needs to be treated by somebody that can help him, get him cool, otherwise he's going to die in a short time. These guys were frantically running around out in the desert looking for this guy, and all he did was quit.

Then later on, I guess, he came in and filled out his papers and took off. But that was a humorous but serious thing. Only one time that ever happened to us, but that is something that happened that nobody ever forgot.

Storey: Tell me about a sounding survey. We haven't talked about those, I don't think.

Sounding Surveys

Powell: Well, in the old days–I love to talk about the old days. But in the old days, the way we did sounding surveys is we'd take boat and we'd tie a rock or a heavy piece of metal, a torpedo onto a tape, and we would go out in a boat and we'd shoot stadia from shore out to the boat whenever they'd let a rock down, or this piece of metal, to see how deep the lake was, so that, for example, coming into Havasu Pump, we had to have a channel that we knew we could rely on that would bring the water into the pumping plant, because the pumping plant was going to be so deep in the ground. So they wanted to know what kind of soil and how deep it was, and the drillers then later come out on the floating platforms and drilled down just to find out what type of material was there that would support this intake channel. Then we placed a dike that also channeled the water out in the lake that would channel the water into the pumping plant. But anyway, that's the way the soundings were in the old days.

What you would do, what it means, is that you're making a topographic map of the bottom of the lake. We did that for quite an extensive area in the lake, fifty, sixty, eighty feet deep, a hundred feet deep, depending on where you were. So we made a map of the bottom.

Now its advanced from that to the point where you can drive out in a boat, put in your electronic equipment, drive all around the lake, and this makes a map of the bottom of the lake through sound wave, and the boat, you put some points on the shore that have coordinates and elevations on them, and this instrument locates these two antennas on the shore, and precisely locates itself on the lake at all times, at the same time measuring the depth of the water to the bottom.

Now, that's how easy these guys have got it today. I mean, they don't even know how to have to roll up a tape. (laughter) But it's a wonderful way to do it today, and its more precise. The Bureau of Reclamation has its own special boats and special equipment to do this now. We had different-sized boats, seventeen-footers, twenty-footers that the drillers and we both used to work in streams and lakes. We worked in other lakes, Bartlett and Horseshoe and different places that you have to take these mapping soundings of the lake. But that's just another phase that's moved up to the stage that we're at right now.

Storey: Of course, the Phoenix Area Office, or it used to be, what, the Phoenix Project Office, I guess–

Powell: Yes, Development Office, we called it.

Storey: –was responsible for more than C-A-P.

Powell: Yes, it was.

Storey: What part of that "more" did you see as the surveying crew?

Survey Responsibilities in the Phoenix Office

Powell: Well, even after I got there, and the main reason I came down from the Sugar Loaf Dam was to bring the experience I'd had in different dams and tunnels and survey, and they wanted somebody here that had that kind of experience to start out on the Central Arizona Project. So I qualified for that and they brought me down here.

But at the same time, when we were waiting, then that September the project was authorized and then we started working more on the Central Arizona Project. But at the same time, we still went into the planning of other projects. See, they didn't know at one time what the participating projects were going to be on the Central Arizona; as an example, Orme Dam. So we did surveying on Orme Dam at the same time that this part of the Central Arizona Project was just starting up. Part of it was going to be Charleston Dam site and railroad relocation down by Tombstone, Arizona. So we did quite a bit of surveying and mapping down in that area.

They didn't know if they were ever going to build Hooker Dam on the Gila River in New Mexico in Conner Dam site. Conner was a hot prospect. So we had to continue doing different work on that project to try to find–the planners would say, "Well, we think this is a good location for the dam site, so we need the surveyors and the drillers to get us some information." So we would send a crew over there for six, eight weeks, two months, or whatever it took to get the data they wanted.

Again, as I mentioned, we worked with the Flagstaff city for a while in a cooperative effort. By the way, if the drought continues, they're probably going to really look hard at that project again, because they didn't get any snow up in the inner basin, and their Lake Mary leaks so much it won't hold water, so they might want to look at the Bureau about that again, I hope.

Then we had a lot of other small little projects. They were looking at a dam site over on Clear Creek, which is over by Winslow, Arizona, to bring a pipeline down into Lake Mary at Flagstaff. We had little investigating elevations and project for a pump lift station out of the Little Colorado River at a place called Blue Springs where they did some 400-foot-to-the-inch mapping up above on the cliffs to see if they could put a pump station up there. Just numerous small projects like that.

We did a little work on the Colorado River itself. We did some work over into New Mexico, helped a little bit. We sent a crew up on detail up to Cortez, Colorado, to help the Cortez office, who was short of people–

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Storey: You mentioned loaning a crew to the Cortez office.

Powell: Yes. We sent a crew on detail up to help them. They needed some of the expertise we had to help them, and they were shorthanded, to work on the dam site that's on the Dolores River, right on out of Cortez between Cortez and Dolores. I don't recall the name of the dam.[11]

Storey: I think it's the Dolores Project. I'm not sure about the dam name. I think it may be the Dolores Dam.

Powell: Yes. So we helped other offices, and we're doing that today. We work currently today–I don't know if you want present-day problems.

11. The Dolores Project, in Montezuma and Dolores counties, Colorado, has two storage dams: McPhee Dam and Dawson Draw Dam, for more information see USDOI, Water and Power Resources Service, *Project Data*, 431-5; Garrit Voggesser, "The Dolores Project" (Denver: Bureau of Reclamation History Program, 2001).

Storey: Sure.

Powell: Bureau of Reclamation surveyors are helping the Bureau of Indian Affairs. We're working on the [unclear] Project that's involved with the Pima Indians down at Sacaton [Arizona], working with them to help them come up with a way to use a distribution system for the water rights that they have.[12] Sometimes we might work a little bit. We have worked with B-L-M, the Bureau of Land Management, that is, in conjunction with the coordinate system we have, the right-of-way tract maps that we have. The B-L-M, as you know, is responsible for land surveys and legalities of the section corners and the quarter corners so that they're pretty well–they have to update their program, because in the old days, when they located section corners and corners, and they'd mark "X" on a rock and put the rock in the ground a little bit, all they had was a 100- or 200-foot metal chain. You had to learn to become an expert at the chain. It was hard to be a good chainman. Its simple to measure distance today. In those days it was hard to measure a mile, 5,280 feet, with a chain over rough terrain and through rocks and heat, and you had to know that the expansion of a chain was .3065 for every degree change of temperature above or below 68 degrees for every hundred foot, so you had to apply temperature correction and the curvature of the Earth if you were going to go very far. So it was of an exacting, hard, tedious work to be able to chain long distances accurately with the metal chain.

Storey: Did you work with the chain when you first started?

Powell: Sure did. Sure did. One of our important tools was the chain. If you're on a lot of work that's at the beginning of a project or an investigative state or planning, then you use a stadia board, where you measure distance by, say, the three hairs in a transit for every foot that's covered by those hairs is a hundred foot, and so you measured. You looked at a board that was possibly four feet wide by twenty feet

12. Powell is perhaps referring to the Pima-Maricopa Irrigation Project.

long marked in tenths of a foot, and twenty foot long, and then you would measure how far out that rod was from the base that you were setting on, with say a plane table. You would measure the distance and the vertical to get the elevation up or down, and you plot that on your map. That was called topography–100 foot to the inch, 200 foot to the inch, 400 foot to the inch. We even did some 1,000 foot to the inch.

We went over into New Mexico and did some investigative survey study of 1,000-foot-to-the-inch of a reservoir site called Yellowtail Dam, I think it was, on the Zuni River, right by the Zuni Tribe, about thirty miles southeast of Gallop, New Mexico.

Yes, we did a lot of traveling. We did a lot of traveling. That's why we had so much of the ten-four in those days, where because you couldn't just send people out somewhere one day to get there and one day to get back and three days' survey, so we'd give them ten days to work, four days back at home.

The only problem with that, people are human beings, and their families like to have them home so that they can be with the kids, help with the raising and training of the kids, and support of the family. I got rid of that as soon as I could when I got back because of the detrimental effect that it had on families. The Bureau understood that, too. They've become more resilient about that.

Storey: Before we go on, tell me what a chain looked like.

Surveyor's Chain

Powell: A chain is a piece of light metal that's probably a quarter of an inch wide by a thirty-second of an inch thick that measures a hundred feet long, that the beginning of a chain is marked off in hundredths of a foot, and then the chains we used, every foot was marked with a slight crease in the chain that was placed on a piece of lead. There was a piece of lead placed on the chain every foot, and then a line drawn through that. That was exactly one foot, in case you wanted to break the chain down into less than hundred-foot increments. Some chains only had marks on each end and in the middle, as an example. But it depends on what type of chaining you were doing.

Then in order to set standards so that we could check those chains, then we had to have what we called a chrome steel chain that was probably a hundred feet long or two hundred, whatever you bought, that was much less subjected to the temperatures. Instead of a 3065 for every foot, it was like 5065. The temperature had to be quite a contrast above or below 68 degrees before that chain would be affected.

So we would set concrete monuments in the ground at our base station, but exactly a hundred feet apart, put an X in the top of the brass cap, and make it exactly a hundred foot. Then the guys could bring in their chains, because sometimes they'd get bent or kinked or that, and we bought brand-new chains from factories that come in that were a hundredth off, which was too much. We would either send the chain back or get them to replace it. So we would check our chains all the time with that. That was the standard we had to use.

Storey: So the image I'm getting is sort of a skinny tape measure.

Powell: That's right. Skinny tape measure, yes. A little tougher, because you had to put like thirty pounds' pull on it. You had a spring tension that you'd put on the front end of your chain, so you would figure out by some computations that for every hundred foot that you wanted, you had to put twenty-two pounds of pull on that because your chain had a sag in it. You can't pull a chain exact unless you got it on a piece of flat ground. If its got a little sag in it, you have to pull it hard enough to make sure exactly how far it is.

Storey: Is there a way to measure that twenty-two pounds?

Powell: Sure. We had a spring tension, and on that spring tension it had calibrations. It would go zero, five, ten, fifteen, twenty, twenty-five, thirty, thirty-five pounds. That you'd hook right on a chain. It was made out of brass, had a handle and a normal spring run just like you'd weight something, a little old weigh scale for weighing fish or meat or something. We used those, too. But we got away from that. Now you can run out there with a little old pole that's about an inch in diameter and six, eight feet tall, with one little old glass prism that's about three inches in diameter all the way around, screw it onto that pole, run out there, and the guy measures out to that glass, and it bounces back into the instrument, and it tells you exactly how far away it is and how much above or below you it is. That's just how simple. Surveyors don't have to be near as tough as we were in the old days. (laughter)

Storey: Say you couldn't get twenty-two pounds of tension. Say you got eighteen. Was there a calculation to adjust for that?

Powell: Well, yes. Anybody that's experienced in chaining knew then that he wasn't quite getting his hundred-foot distance, and maybe he'd have to add a little bit to it, a couple thousandths of a foot or something like that.

Storey: Back when you were using this chain, how many folks in a survey crew?

Powell: Probably four.

Storey: On average?

Powell: Most of the time it was four.

Storey: And what were they doing?

Powell: You'd have a head chainman, and a rear chainman, an instrument man, and a party chief keeping notes. There was a four-man crew. If you had a topo crew, sometime you might even have five people if you had thousand foot to the inch, because you'd have to walk a thousand foot before you gave another shot, possibly, if you're in flat-enough ground. Instead of waiting for them all the time, you'd have an extra man.

We used to keep notes, too, of all the shots. Now you have data recorders that hook right onto your tripod, what you've just sited in your instrument is recorded on the data collector that you take in every night and dump in a computer that stores that data for you. You don't have to have a notebook.

Storey: And the crew now?

Powell: The crew now is three or two men.

Storey: Doing what?

Powell: You still have to have a rodman. He's got to have a guy that runs around. Let's say, for example, you want to go out and take some final sections of an area so you can pay the contractor so much that he excavated. You have to have a man that can run out there with the rod and place the rod in strategic places to get the highs and the lows and the breaks in the ground with that reflector on it. You have to have a man that runs an instrument that has the data recorder on it. You have to have a party chief that's there that's in charge of the crew making sure that the way their doing the work is correct, that their standards are up to what they're supposed to be, there's talking to the inspector, or the contractor, or some other duties that he's doing–maybe looking over another area to be surveyed while they're doing that.

You could get by with two guys now, but normally you're going to have three, because this instrument man is somebody that's in a trainee capacity. Maybe he's just learning, and maybe the guy that was the instrument man's on the rod. People like to rotate assignments. They don't like to, just because you're a rodman, you're never going to learn to run the instrument if you don't get some trainee time. The instrument man a lot of times is tired of standing by the instrument. He wants to carry the rod around, or he wants to play party chief, and the party chief carries the rod around. It's a tiring job, so you rotate people. That's why basically you're going to have three people, but two can do it. Two can do it.

They even have it so you can do it today by setting up a point somewhere and having one person. You can set up an instrument that will seek and find you according to what you have on the rod, and you could conceivably, today now, set up this instrument in an area you're going to survey, and only have one person. That's a little vulnerable. That instrument's a little vulnerable to wind, and problems, but you can do it. If a contractor's on a very low budget, he wants to get a job done, he wants to pay for one of these instruments, that instrument will seek and move itself automatically and find and record that reflector on that pole when you put it up. That's the next step.

Storey: These crews that you were running, were they all stationed out of Phoenix and did travel, or were they stationed up and down or throughout the area, or how did that work?

Moving Survey Crews Around

Powell: Well, pretty much mostly out of Phoenix, because so much of the work was out of Phoenix that we could go east and west and north and south, and especially with the construction. Sometimes we would detail a crew over to Parker, Arizona, to work when they first started. Larry King, the construction engineer, had one survey crew over there, but we would go over a lot and help them, because they were shorthanded and they needed some of our expertise, again. Like I said, we did do the tunnel work, and we did do some of the survey, and show them how to slope stake on the road over to there, but once we got everything settled for them, why, then they had a crew that could do the everyday occurrence right on the Havasu Pumping Plant, as an example.

Then we opened the Tucson office. When I left in 1983, one of the last things I did was set up to transfer a crew and be the first group down there to open an office in Tucson. The Tucson people knew the project was going, they wanted the Bureau to start establishing somebody in the area so it could become something that they knew was finally going to happen. So I sent David Phillips and transferred him and a survey crew down there to be there until the completion of the project in which they were. Then, of course, another couple of crews at a later date when it got into full construction in that particular area.

But pretty much basically worked out of Phoenix because the heavy load was here, especially because the projects jumped from one area to another. The crew or two in Tucson would come back up towards Phoenix up to as far as Picacho Pumping Plant, and work that area. Then we would work what was from this side back this way. We found that it was easier to work people longer hours and get them on the job and keep them in one place than to spread them out all over and pay moving expenses and disrupt families. You have to have a certain amount of loyalty to your people to get them to want to do their best job. It isn't a matter of just a C-E-O sitting up there drawing a big salary and getting a good job. You can't get a good job without good people. So you have to do a certain amount. That's what's called managing. A lot of people think they're managing, but they don't know how to manage. But that's what managing's all about, looking at all aspects to get the best job you can get for the same buck.

Storey: One of the things I'm interested in is the training. You've mentioned the sort of on-the-job training where people rotated through the various jobs. Was there any other kind of training that Reclamation did? I'd like you to do it back when you started with Reclamation and up to when you left Reclamation. Was there a change in the way it was done?

Training

Powell: Yes, there was a big change. The big change to begin with, in the old days I'm talking about, back now like when I started with the Bureau in '48, about the only training, of course, you got was on-the-job training. In other words, you went right out in the field and you learned from the very beginning in the field, and some safety training. That was about all they had. Schools were nonexistent for most people.

But as it progressed and we got a little further along, we would go into some schools. The Bureau of Reclamation wanted the surveyors, if they wanted to, for the ones that wanted to do extra, we would let them take correspondence courses in mathematics. In other words, they would do this on their own. The Bureau would pay for it. The employee would benefit from the training so that he would be able to progress more. Then they finally come up with some specific special training schools where we could go into maybe a fourteen-day special intense survey training school, mostly for individuals that appeared to want to progress to that state, and to put forth the effort it took. Then probably about that time in the sixties and seventies, they started into some management training school, some more intensive first-stage schools and that type of thing.

The Bureau was very receptive to the idea, if you said, "We want to find out about G-P-S, Global Positioning System. We think it will benefit the Bureau. Can we get some training?"

"Sure. Find out where there's a school available, and let's see what its all about."

So we've progressed to that state now. We had to send people to special schools to learn how to reduce the data that we got from these Global Positioning antennas. It was a very complex and intense training period. It took a lot of math to learn how, and computer work to learn how to do this. So we would send people for two or three weeks to California. The Bureau was always good about sending us to anything that they thought that we could use that would benefit the Bureau of Reclamation training-wise to keep us up with the current data and to keep us competitive with anybody else. If we're going to have to check a contractor or supply data, we surely want to be the first in the field to understand how to operate these precise instruments that we have today.

Storey: I wanted to ask you about the progression of your career. When we talked last time, you talked about where you were and what you did there, but I'm interested as you moved onto a survey crew, became a rodman, an instrument man, a party chief, and so on. What were the kinds of expertise that you had acquired that allowed you to advance? You mentioned that you wanted to advance, so I know you were interested in learning stuff and moving up. Also, what kind of grades were we talking about here?

Powell: Well, to begin with, when I started with the Army Engineers in 1947, we had in those days a grade called SP. Of course, as a surveyor, you'd start in like an SP-2, which was about the lowest grade. I guess maybe there was an SP-1, but an SP-2. Then later on, I think it was sometime around 1950, they changed the SP grade to a GS, General Service. Subprofessional, SP, to General Service, GS.

When I started with the Army Engineers, 1947, in Garrison, North Dakota, on the Garrison Dam, my job was a rodman. In other words, I had to carry a level rod or a chain around. We were working right on Garrison Dam, and we were also working in the housing area to be built to house all the people that were going to live there to work on Garrison Dam. That was right at the beginning of Garrison Dam. They'd already started a little bit of the construction. My job was to learn how to properly carry the rod, how to run vertical control on elevations, how to place a pin in the ground, simple things like how to carry it, how far to go, how to measure the ups and downs, how to measure 100 foot accurately, or 50 foot, or parts of a foot, with this steel chain.

Once you learned that particular job, you had to learn this job and do well at it so that somebody would think, "Well, he can be promoted to an SP-3," or in that case later a GS-3. So then you had to go into a GS-3 and you had to learn how to maybe begin to slope stake–how to place a slope stake, how to mark a slope stake, what a slope stake was all about. A slope stake being a stake that's maybe four or five inches wide and a foot long, you drive in the ground at an angle that will tell the contractor to cut the ground at a one-to-one slope, or fill this ground with loose dirt at a two-to-one slope for how far.

Once you learned to do those two things, why, then you could get to a GS-4, which was kind of a learner capacity. You'd start learning how to run a level. In those days it was a dumpy level, with the bubble like on legs of a carpenter's level. You learned to run that instrument, and become efficient with that and reliable at that, and good enough to be able to do it without errors so you could be relied on.

If you became good enough at that, directing instrument men and other rodmen, then, of course, then in your career you could move up to what was a GS-5, was commonly an instrument man. You could run a transit. You start to learn how to run a transit to measure distances with a stadia board, turn angles to ten seconds, repeat enough angles for triangulation, so that you could move into an area and put in a network of a coordinate system through triangulation. We didn't have in those days an instrument that measured distance, so you had to create a series of coordinates throughout maybe across a thirty-mile-long valley that you wanted to put in an irrigation system. You had to be able to run an instrument accurate enough to have a triangulation system, so that through a series of mathematical moves you could create coordinates on these points, so then you could do your mapping from that, your topography mapping of the valley of maybe 400-foot-to-the-inch topography. Later on, then 100-foot-to-the-inch.

So that's what it kind of took to get up to be a five or a six. When you got to a GS-6, then you were the better instrument man, more experienced, very reliable, somebody'd had enough time on that instrument so that he was good at it and reliable.

Then, of course, the next step, since we all wanted to make more money and we all wanted to learn more about the job, the two go hand in hand, then the next job you look at is a party chief. What does he do; how does he direct a crew; can he get the most out of an employee; how is he instructional; is he a very good teacher; is he reliable; is he honest; is he knowledgeable; does he really know math enough that he can teach me; is he a good manager? So when you learn those tricks of the trade and a vacancy come along, then you compete with other people to see who learned their job the best. Maybe that would put you in the position for the next vacancy. Or maybe you could apply for a job in some other area, some other state, some other government agency. So that's the way you progressed up the ladder.

In my case, then after I came down in Nebraska, then I moved to a couple of different projects, learning the various stages of survey that I just mentioned. Then we moved to Kansas and a couple of places and worked on a couple of dams. Then I became a party chief, because I had learned the tricks of my trade well enough to be depended on. Got another promotion to a GS-7. Then moved to Paonia, Colorado, and worked on a couple of dams there as a party chief.

Since I had worked on dams and tunnels, and gained this experience, and had a good-enough recommendation, they needed an assistant chief of surveys at Durango on Lemon Dam, because the chief of surveys that was there needed a little help, and he was very reluctant to go in tunnels. We had a two-armed ten-foot shaft house, and that was kind of my cup of tea. I didn't mind that. They had three survey crews that needed somebody to back them up. The contractor was giving them a lot of static, because they didn't really have the experience, so they weren't too sure, and I did, so my job was to come along and train them and teach them, "Hey, this is the way you do it. This is all you need to do. Don't be afraid of the contractor." We went ahead and progressed there.

Then I moved up on the Fryingpan-Arkansas Project and worked on a couple of projects there. Then they needed a chief of surveys who had all the experience I had in the Phoenix office, then I was promoted to chief of surveys, GS-9. Then as increased workload came, Clifford Pugh went to bat for me to get me a GS-11. In those days they thought a GS-9, in 1968, was the extent of your heaven, but Cliff Pugh knew better, and he went to bat for me to get me a raise, and then later on as the Central Arizona Project and all the problems arose, then they promoted me to GS-12 because of my experience and management abilities, and ability to work with people.

That basically is what it takes to progress from the beginning to the top, with a few lucky breaks and good projects and good people to work through. You don't do any job without good people. I was fortunate to work with a lot of them, some of them who were extremely good at what they did. So that's about what it amounted to.

Adjusting to Different Locales

Storey: You worked in quite a few areas–Garrison, for instance, North Dakota, I presume.

Powell: That's correct.

Storey: Clear down to Phoenix. Quite a change in climate. What kinds of adjustments did you have to make, making those moves?

Powell: Most all of those moves, until I went to Phoenix, were pretty much basically in the small towns, the biggest town maybe 10,000, the smallest one 500. We had three boys in the process, and we had a real good turn of events in all the towns. We met a lot of nice people, a lot of them we're still in contact with, a lot of good Bureau people. There's a lot closer camaraderie in your small groups and small towns than there is when you go to like Phoenix, where people are spread out all over a 200-square-mile area, it seems like. But we had real good results with the boys in school. When we moved to Phoenix, which is a big place, of course, but my boys were all fortunate. We all had a good grade school, and they all graduated from the same high school. So in my career, the movement into different schools for the family, which was the most important to me, worked out rather well. The adjustment into a city is a big adjustment, but the biggest adjustment was the heat, the desert, moving from the beautiful green country to the apparently brown, ugly country, until you learn to appreciate and be able to open your eyes and see the beauty of the desert. Its something that you acquire. Just like when you see wheat fields, some people think it's ugly. When you get smart, you see how beautiful it is.

Nothing that we had was really severe. We pretty much enjoyed every place we ever lived, small and large. All the people were what made it the most–Bureau people and the city folks that we run into everywhere. But when you're young, you can adapt to anything.

When I lived in Durango, we were just happy as a tick, and it snowed all the time. The kids were up skiing and running around on the ski slopes, and the field engineer and the chief inspector all broke their legs skiing. (laughter) We had one heck of a winter up there because of the problems that were caused by skiing. But its kind of a joke with us today, we laugh about that. No, I have nothing but good feelings about all the moves that we made.

Storey: What else should I ask you about? What haven't we covered that you think we might have covered, that we should have covered?

Powell: I don't know. I think you've got a lot of data there that pretty much tells you what the surveying part of it was in the Bureau of Reclamation, and I think what I've exposed to you has been pretty much what other surveyors on other projects, and I've known a lot of them rather well, have experienced pretty much the same thing, the same training, the same aspiration, the same belief that what the Bureau of Reclamation has accomplished over all the years is serving mankind. We have our critics, but as you know, I believe strongly in what we've accomplished, what the Bureau has, I believe in this Central Arizona–

END SIDE 2, TAPE 2. MAY 20, 1996.
BEGIN SIDE 1, TAPE 3. MAY 20, 1996.

Storey: This is tape three of an interview by Brit Storey with Vernon Powell on May 20, 1996.

You were talking about Reclamation and your feelings about it and about the Central Arizona Project.

The Importance of the Central Arizona Project

Powell: I think I was going to mention, too, about the canal that comes through town. There have been those that think we don't need a canal, because one of the gentleman that's a civil engineer in private industry used to say, "Well, we have enough groundwater for a hundred years. We don't need this canal, its too expensive." But I think what he, in my opinion, forgot to think is that maybe we only have enough groundwater for seventy-five years. The valley's exploding with people moving in. I think that is a very short-sighted view. What does that mean? We have to be like the Anasazis and move because we don't have any water after 1975? I believe strongly in using all the surface water available before we get into the underground so heavily.

I believe that it takes thousands of years to replenish the underground system, and I think that eventually–I worked on Garrison Dam, and I know about Oahe Dam. Garrison Dam has a lake 200 miles long, Oahe Dam has a lake 250 miles long on the Missouri. That water may be used some day as we become better in our expertise for injection purposes to the underground water system. I think Reclamation still has a future, a heavy future, in that. We're just not going to dry up and go away. So I believe strongly in what I've been a part of and what the Bureau of Reclamation has accomplished. That's pretty much basically the way I feel about my job.

Storey: Why did you retire '83?

Leaving and Returning to Reclamation

Powell: Well, in 1983 I had worked with the government a long time and did a lot of survey, and my wife and I thought, well, we'd like to live in Prescott, Arizona. We've served a lot of time. We felt that we'd like to give that a try. That's a little town ninety miles from Phoenix northwest. So I was fifty-seven years old at the time, and I thought–by the way wrongly–I wish I hadn't retired at that time.

But then I went up–I had a real estate license and a couple other things, so when we moved to Prescott, sold out and moved to Prescott, and I retired, I had two part-time jobs. I sold real estate and consulting with the city fathers for an engineering firm. So I was busy at that.

We lived there for six years, and circumstances came about that we felt we had to come back to the valley because of my wife's health. Lo and behold, the same position I had opened up with the Bureau of Reclamation in March of 1990, and Bob Johnson, who was a construction engineer who I'd worked with for some time before I retired, wanted to know if I was interested in coming back, and I said yes. So I come back and work another five years to finish the project, and retired in April 1995. Now I'm getting a little too old. But my advice to anybody is don't retire until you can't work anymore. Retirement is a myth.

Storey: Now, is this the same Bob Johnson who's the Regional Director now?

Powell: No, it is not. It's a different Bob Johnson.

Storey: I didn't remember him talking about any construction engineers.

Powell: No, there's a different Bob Johnson.

Storey: Had there been any radical changes between your retirement in '83 and your coming back in '90, in terms of the project or the way work was done or anything?

Powell: No, not really. We did have a little more advancement in the G-P-S, Global Positioning System, a little more advancement on our Photogrammetric Section to be able to compute quantities from photos, which our Survey Section developed on our own through Kevin Black, who had worked with me at one time, then got away from the–didn't retire, but he quit the government and went to work for private industry, and then learned a lot of precise indexing methods, and then I kind of talked him into coming back to work for the Bureau so that we could upgrade our system, and Bob Johnson agreed with me. Bob Johnson was very observant about what it took to do good surveys.

So when Kevin come back, we made a couple of giant strides in our quantity surveying. We can survey the face of a dam, the face of a cliff, or anything, with photographs. That way we don't have to have people hanging on ropes in a dangerous situation all up and down cliffs. Anyway, it's a very intense, precise system now, that was developed to that perfection, mostly through this Survey Section and the Photogrammetry Section that we have here.

Storey: Good. I appreciate it very much. I'd like to ask you again whether or not information contained in these cassettes and the resulting transcripts can be used by researchers.

Powell: Yes, it can. I give you my permission.

Storey: Good. Thank you very much.

END SIDE 1, TAPE 3. MAY 20, 1996.
END OF INTERVIEWS.