THE PUQUIOS OF NASCA

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The puquios *of Nasca are a system of subterranean filtration galleries that provide water for irrigation and domestic uses in the middle portions of the Nasca, Taruga, and Las Trancas valleys of the Río Grande de Nasca drainage of the south coast of Peru. At present 36 puquios function in these three valleys; in the past their number may have exceeded 50. We discuss the formal characteristics and the construction of the puquios, and describe each of the extant puquios. The results of archaeological settlement surveys conducted in the three valleys indicate that the puquios did not yet exist in Early Nasca (Early Intermediate Period 2–4) times, but were almost certainly in use by the time of the Inka conquest of the region in the late fifteenth century. We suggest that the initial construction and use of the puquios may have occurred as early as Nasca 5 times, and probably not later than Late Nasca (Early Intermediate Period 6–7) times.*

Los puquios *de Nasca son un sistema de galerías subterráneas de filtracíon, ubicados en los valles de Nasca, Taruga, y Las Trancas, en la costa sur del Perú. Los puquios proveen agua para irrigación de los campos de cultivo y para uso doméstico en las porciones de los valles que carecen de agua superficial. A la fecha 36 puquios de los 50 que pudieron haber existido en tiempos pasados siguen funcionando. El presente trabajo describe las características formales y las técnicas constructívas, así como cada uno de los puquios que existen actualmente. Los resultados de diversas prospecciones arqueológicas realizadas en los tres valles indican que los puquios no existían en el período Nasca Temprano (Período Intermedio Temprano 2-4), pero sí funcionaron antes de la conquista de esta región por el imperio incaico, hacia fines del siglo XV. Sugerimos que la construcción inicial y uso de estas obras correspondería al período Nasca Tardío (Período Intermedio Temprano 6-7), pudiendo haberse iniciado en la época Nasca 5.*

In 1853 the young English traveler Clements Markham reached the Nasca Valley on his journey south from Lima. He marvelled at the verdant landscape and described it as "the most fertile and beautiful spot on the coast of Peru" (Markham 1991:50). He found it particularly notable because the Nasca Valley seemed to be one of the driest places he had seen. Not only is the Nasca region lacking in rainfall, as is typical of the Peruvian coast, but "all that nature has given it is a small watercourse, almost always dry" (Markham 1991:50).

It seems ironic that the portion of the valley with the broadest expanse of arable land, and in which the modern town was founded by the Spanish, is also the portion of the valley in which the river is most deficient of water. Anyone accustomed to judging the availability of water in a region by the amount of rainfall and/or the volume of water flowing in the rivers would certainly agree that the Nasca Valley is exceptionally dry, even by Peruvian coastal standards. Yet the Nasca Valley supports a substantial modern population and supported a perhaps even larger late prehistoric population. It was the locus of major Inka and Wari occupations, and was also the core region in which developed the well-known Nasca Culture. How can this be possible? In Markham's words,

> The fertility is due to the skill and industry of the ancient inhabitants. Under their care an arid wilderness was converted into a smiling paradise, and so it has continued. This was effected by cutting deep trenches along the whole length of the valley and so far up the mountains that the present inhabitants do not know the positions of their origin. High up the valley the main trenches

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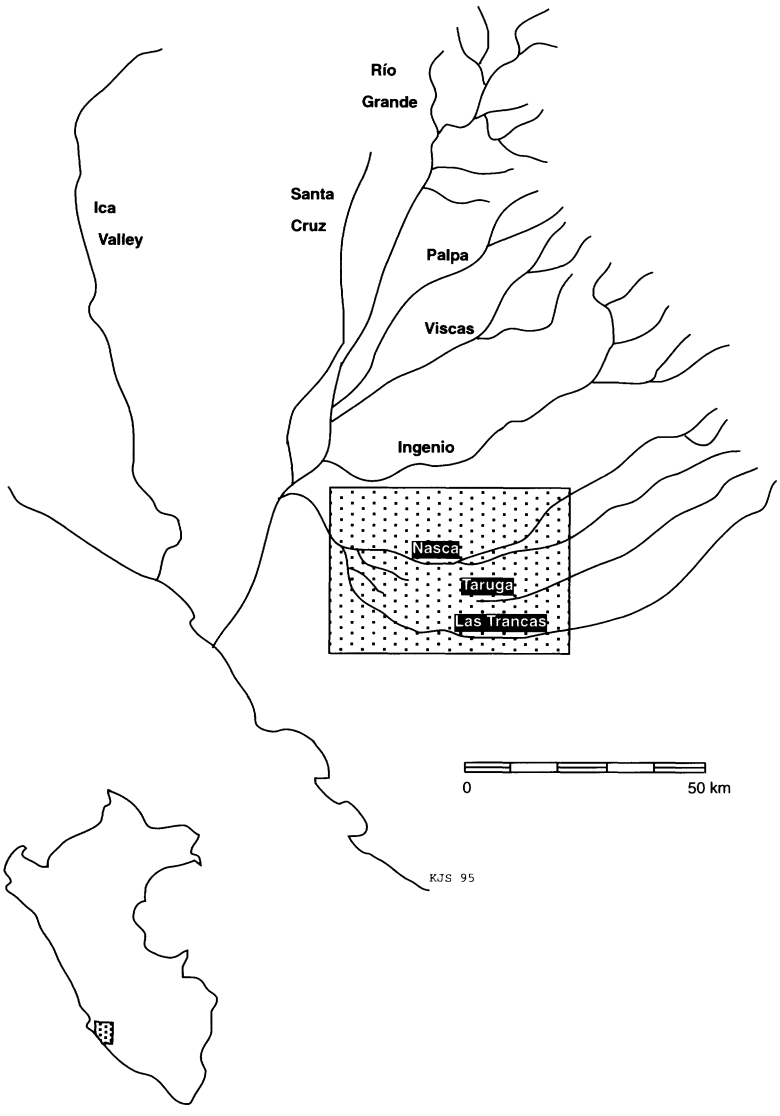

Figure 1. Map of the Río Grande de Nasca drainage of the south coast of Peru. The shaded area indicates the focus of the present study.

(*puquios*) appear, some four feet in height, roofed over and floored with stones and also with stone sides. Descending from the mountains, these covered channels separate into smaller conduits which ramify over the valley, supplying every hacienda with water all the year round and feeding the little streams which irrigate the fields and gardens. The larger *puquios* are many feet below the surface, and at intervals of about two hundred yards there are "eyes" (*ojos*) or manholes by which workmen can descend and clear away obstructions [Markham 1991:50].

Markham did not understand precisely how the puquios worked, but luckily their functions are still observable today.[1] Very simply, puquios are nearly horizontal trenches or galleries that tap underground water sources and act as conduits to transport the water to the gradually sloping surface. In this paper we discuss the puquios found on the south coast of Peru, in the three southern valleys of the Río Grande de Nasca drainage (Figure 1): the Nasca Valley proper, the Taruga Valley, and the Las Trancas Valley. The Nasca

puquios have been described by other writers, most notably González (1934), Mejía (1939), and Rossel (1942, 1977), and most treatments of Nasca at least refer to the puquios. Unfortunately, none of the published works is complete, and some contain serious errors. Our first goal is therefore to provide a more up-to-date and complete discussion of the puquios and to correct some of those earlier errors. In addition, the date of construction of the puquios has recently become a subject of some interest and disagreement (Barnes and Fleming 1991; Bray 1992; Clarkson and Dorn 1991, 1995; Dorn et al. 1992; Schreiber and Lancho 1988), and our second goal in this article is to present new archaeological data that shed light on this issue, and to put the puquios in their proper archaeological context.

Physiographic Setting

The Río Grande de Nasca drainage comprises some nine separate rivers that flow together and through a single pass in the coastal range of mountains. The drainage can be conveniently divided into a northern and a southern group of tributaries. The northern group includes the Santa Cruz, Grande, Palpa, Viscas, and Ingenio rivers; of these, the Santa Cruz flows only intermittently, whereas the Grande has the greatest volume of water. The southern group includes the Aja, Tierras Blancas, Taruga, and Las Trancas rivers; the Aja and Tierras Blancas join (via three separate channels) to form the Nasca Valley. The southern tributaries are substantially drier than the northern group, and all the rivers are deficient in water compared to other coastal valleys. The Aja River, which has the greatest volume of the four, has an average annual flow of only 30.27 million m^3 of water, compared to 198.05 million m^3 of water that flow down the Río Grande (ONERN 1971). These, in turn, pale in comparison to the Chicama Valley (839.43 million m^3) of the north coast (ONERN 1973).

Fed by seasonal precipitation in the Andes Mountains at elevations above about 2,000 m asl, the catchments of the southern tributaries are substantially smaller than those of the northern tributaries and very small in comparison to other coastal valleys; this accounts for the low initial river volume in the southern valleys. The southern tributaries flow down the western flanks of the Andes until they reach the deep alluvial valley bottom in the lower foothills. The valley alluvium has a moderate to high infiltration capacity that results in a substantial transmission loss in river volume, especially at elevations below 1,200 m asl. For this reason the rivers are what are termed "influent streams," which means that they flow partially on the surface, and for some stretches drop completely below the surface.

The initial point at which the rivers drop below the surface varies from valley to valley, depending on water volume, and varies within each valley seasonally and annually. For example, between 1989 and 1991, after one year of good rain and two years of drought, the Aja/Nasca River reached only elevations of 800 m asl, 900 m asl, and 1,050 m asl, respectively, in the month of September.

Local informants and our own observations indicate that the rivers are through-flowing only two years out of seven, on average, and hence in most years the middle portions of all of the valleys are devoid of surface water for the entire year.

At an elevation of 400 m asl, the Nasca River re-emerges and continues to flow on the surface. It appears that this location does not vary, either seasonally or with prolonged droughts. From this point on the stream is perennial for a distance of about 9 km; thence the stream variously appears and disappears on the surface until its confluence with the Río Grande. Maps and aerial photographs indicate that the Taruga and Las Trancas rivers also re-emerge at about 400 m asl.

For present purposes each valley can be divided into four sections, based on availability of surface water: 1) the upper valley, in which water is available year-round; 2) the zone of infiltration, in which water is available most years but may gradually dry up in years of prolonged drought; 3) the dry middle valley that is devoid of surface water except during times of flood; and 4) the lower valley, where the river re-emerges (Figure 2).

The distribution of surface water has two profound effects on human occupation. First, the rivers cannot be relied upon to provide irrigation water every year in the dry middle portion of the valley. Irrigation canals can be extended from higher up in the valley, but the volume of water is

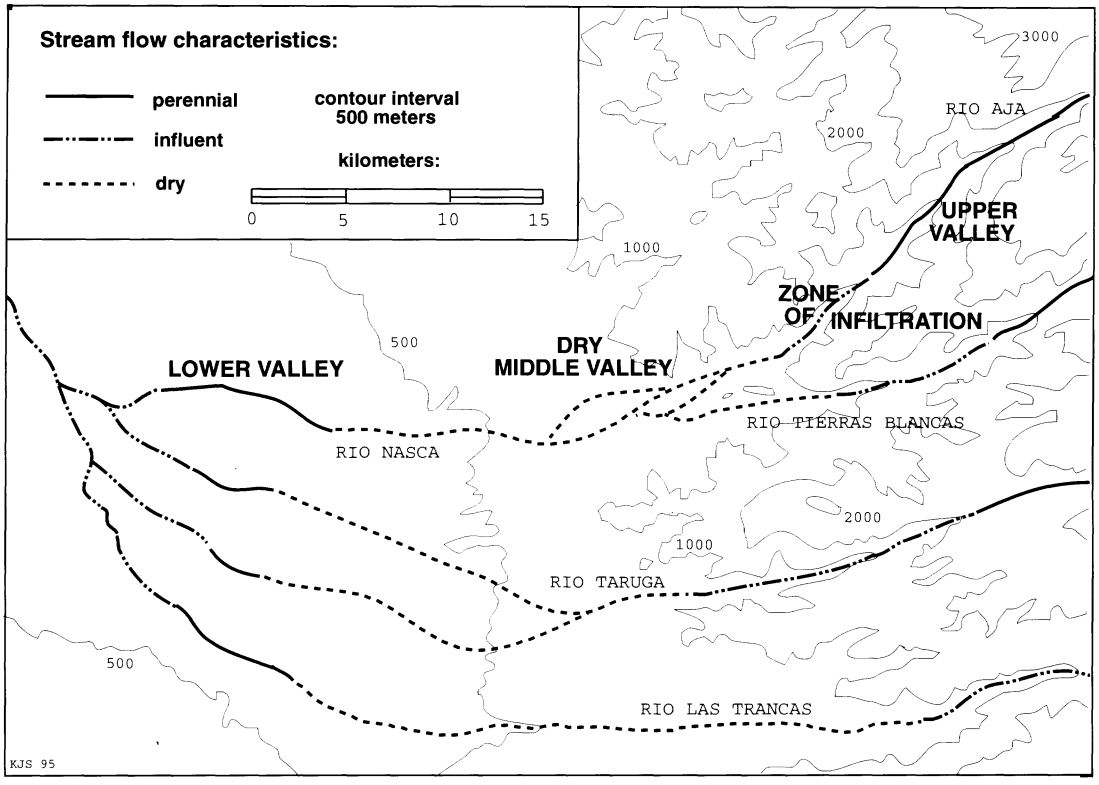

Figure 2. The southern tributaries of the Río Grande de Nasca drainage, indicating the availability of surface water: the upper valley with perennial flow, the zone of infiltration, the dry middle valley, and the lower valley where perennial flow resumes.

so low that they can only extend irrigation water a kilometer or two. The problem is further compounded by the fact that the lower reach of the rivers is constantly changing. As a result, large, long-distance canals do not occur in these valleys, and there is no evidence for their existence in the past. Agriculture in the middle valleys is therefore limited to years of flood, roughly two years out of seven. On the other hand, land in the upper and lower valleys is arable year-round thanks to perennial stream flow. Unfortunately, although the arable portion of the middle valley is generally 2–3 km wide, the lower valley narrows to less than 1 km and the upper valley is even narrower; hence most of the arable land in Nasca lies in the portion of the valley that normally lacks water.

Second, there is no water available for domestic purposes in the dry middle valley, and it is therefore not suitable for human habitation except during periods of flood. In the dry season, and during periods of drought, the aquifer is too deep (about 10 m deep in the central portion of the valley, from Nasca to Majoro) to be tapped conveniently by wells. However, at the upper and lower ends of the middle valley the aquifer is shallower, and domestic water can be drawn from shallow wells dug in the dry river bed. This is common practice in Nasca as well as in other valleys with influent streams; the wells we have observed are usually about 1 m deep. In contrast, the upper and lower valleys do have available year-round supplies of water for domestic purposes.

The inhabitants of the region overcame the lack of reliable water in the middle valley by developing the system of puquios to allow access to the subterranean aquifer—the underground flow of the rivers. A puquio is essentially a horizontal well, an open trench and/or a subterranean gallery that connects a point on the surface with subsurface water. The underground water filters into the puquio, flows through it, and empties into either a small reservoir (*kocha*) or directly into irrigation canals. Puquios provide not only a reliable source of irrigation water, but also a year-

round supply of domestic water. At present puquios water land between 675 and 450 m asl in the Nasca Valley, a horizontal distance of some 16 km; as we shall see, the prehistoric distribution of puquios was certainly greater.

History of Research

The first scientific mention of the puquios of which we are aware was made by Kroeber (1993) in 1926, who wrote in his field notes that he had been told of puquios in Taruga and Las Trancas. In 1927 Mejía Xesspe (1939) investigated several puquios; he provides a description of six puquios in the Las Trancas Valley and one in the Taruga Valley, and lists but does not describe eight in the Nasca Valley.

In 1934 the Consejo Superior de Aguas commissioned a study of the puquios by the engineer M. Francisco González García; the report, or at least part of it, was published that year by the Directorate of Waters and Irrigation (González 1934; reprinted 1978, text and diagrams unchanged, but with critical omissions on the location map). González's study is the most complete and accurate treatment of the puquios in the Nasca Valley, although he did miss at least two, and other writers have made direct use of his data, not always with attribution. His published report does not include descriptions of puquios in the Taruga or Las Trancas valleys, although we have reason to believe that he included the valleys in his study. He noted at the beginning of his report, "Disgracefully, not all of the puquios that they built have been preserved. There are many that have been destroyed and only vestiges are found of others" (González 1934:207).

Regal (1943) provides a table summarizing the descriptions and measurements of the puquios in the Nasca Valley. It is likely that most of his data were taken from González's article; nearly all measurements are exactly the same as those published by González, he uses precisely the same names, and he is missing the same two puquios. However, the fact that he provides some measurements that González did not indicates that he actually observed some puquios himself.

In 1942 Rossel Castro published an article on the puquios, which is reprinted in his 1977 book about the archaeology of the south coast of Peru, with only minor differences. His data are sometimes unreliable, but it is clear that he did examine many of the puquios, and is perhaps the only researcher who crawled through several of them; his observations are invaluable.

In 1960, a University of Tokyo expedition conducted a study of irrigation systems in coastal Peru; its report includes a discussion of the puquios in the Nasca Valley, and a reproduction of González's diagrams and the map that omits only minor details (Kobori 1960:83).

In 1986–1987 the Peruvian development agency CORDEICA (1987) sponsored a study of the puquios, which accomplished the cleaning of nine of them, and the detailed mapping of five.

Our ongoing collaboration in the study of the puquios began in 1985 (Schreiber and Lancho 1988). In 1986 Lancho conducted a survey of the puquios for the Consejo Nacional de Ciencia y Tecnología (Lancho 1986). That same year Schreiber undertook a project designed to document and map all the existing puquios, and began to look at the archaeological setting in which they occur (Schreiber 1987). The authors have made additional observations of the puquios between 1987 and the present. Since 1986 Schreiber has undertaken several seasons of systematic settlement survey in the Nasca, Taruga, and Las Trancas valleys that have provided data on sites directly associated with the puquios and evidence of shifts in settlement patterns correlated with the construction and use of the puquios. The data and interpretations presented here should be regarded as our most current assessments, and supercede all documents we have written or published in the past.

We have made extensive use of aerial photography in our studies. The earliest photos covering the entire region, available from the Peruvian Air Force National Air Photo Service, were taken in 1944. These photos enable us to corroborate (or correct) the articles written by Mejía, González, and Rossel. In addition, the 1944 photos provide invaluable data regarding puquios that have been destroyed or altered since that date, and they also provide clues to the existence of puquios that had already fallen out of use by 1944, but whose traces were still visible. The second set of Air Force aerial photos we used were taken in 1970; these provide a good contrast with the photos of 1944, and enable us to fix the time of certain alterations in the quarter century that separates those two dates.

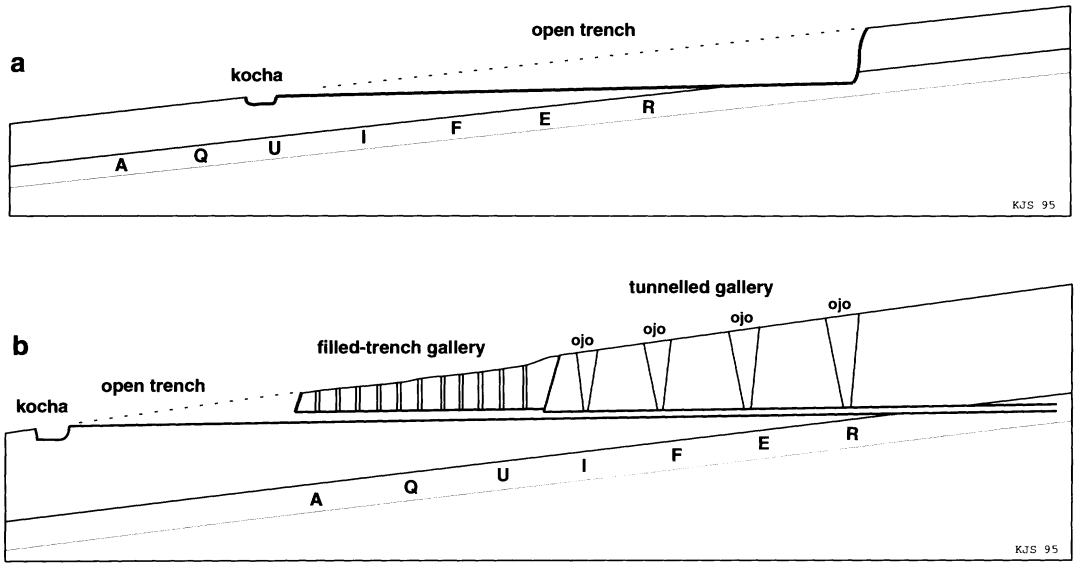

Figure 3. Cross sections of a trench-type puquio (top) and a gallery-type puquio, with both filled and tunneled sections (bottom).

In our descriptions of the puquios we frequently draw contrasts between conditions in 1944 and 1970, based on these two sets of photos.

Puquio Function and Construction

To the best of our knowledge, 36 puquios still function: 29 in the Nasca Valley, 2 in the Taruga Valley, and 5 in the Las Trancas Valley. All the existing puquios are named, usually for the land they water. About one-third have Spanish names; the rest carry indigenous names. Some puquios have been substantially altered during the last century, and numerous puquios have been abandoned or destroyed. At this point we cannot know the total number of puquios that once existed, but we estimate there were at least 41, probably as many as 44, and possibly more than 50 puquios in the past.

Puquios are one component of a dual-source irrigation system in Nasca. River water, as in other valleys, is conveyed in *acequias* (irrigation canals) directly to fields that are to be irrigated. Puquios tap ground water, and deliver the water either directly into irrigation canals or into small reservoirs. When the river flows, everyone has access to irrigation water; in years of drought, only those people who control puquios have irrigation water. Puquios are of two general types: open trenches, and combinations of trenches and subterranean galleries. This distinction corresponds to the one between puquios and *acueductos* made by González, although he was not always consistent in his use of the terms. Ten puquios, all located in the Nasca Valley, seem to be open trenches for their entire length (Figure 3a); this is typical of the shorter, shallower puquios. The base of the trench is usually only a meter or so wide, but trenches widen to 10 m or more at the surface. The sides of the trench are usually lined with river cobbles that form retaining walls that are stepped back, much like terraces. Some trench-type puquios have multiple branches.

Most puquios begin as tunnellike galleries, and then become open trenches at their lower end (Figure 3b); these gallery-type puquios often have multiple branches. The sides of the gallery are faced with river cobbles fitted together without mortar, and at the uppermost end the water filters between the stones into the gallery. The roof of the gallery is made either of dressed stone slabs or wood; because the wood does not survive for more than a few decades, it is often removed and replaced during the annual cleaning. We have never observed any sort of prepared surface along the base of a trench or gallery, although Rossel (1977:172) states that the base of a gallery might be lined with wood or stone to prevent erosion. According to González (1934:208), some galleries were excavated in hard conglomerate and had no need of facing stones along their sides; we, on the contrary, have never observed a gallery without

stone sides, and none has been reported by informants. The dimensions of the galleries vary according to the manner in which they were built.

Spaced along the galleries at varying intervals are *ojos*, holes dug from the ground surface down to the gallery (Figure 3b), which provide a means of access during the annual cleaning, and let in air and light. The forms and dimensions of the *ojos* also vary according to the manner of construction of the individual galleries. Our mapping of the puquios depends on the *ojos* to indicate the subterranean path of the gallery and any major branches. We have been told that some galleries have short side branches without *ojos*, but we cannot observe these branches from the surface. A comparison of our observations with those made by González (1934), and with aerial photos taken in 1944, indicates that there are many more *ojos* today than there were in the past. New *ojos* are typically built when a cave-in has blocked the flow of water through a gallery, because it is much safer to dig a new *ojo* than to clear the obstruction from inside the gallery.

Galleries apparently were constructed either by tunneling or by filling an open trench (Figure 3b). The deepest, uppermost portions of galleries were usually excavated as tunnels, generally less than 1 m in height and width. *Ojos* into tunneled galleries are generally very large and conical in profile, and spaced a few tens of meters apart. Some exceed 15 m in diameter at the surface, but narrow to less than 1 m at the junction with the gallery. Such *ojos* are usually closed at the bottom to prevent soil or other obstructions from falling into the galleries. We rarely found the *ojos* open, and many had a meter or more of accumulated soil and vegetation that made exact measurement of their depth impossible.

Other galleries were created by first digging an open trench, then constructing the gallery walls and roof at the bottom of the trench, and finally refilling the trench. Galleries built in this manner are sometimes of much greater height—up to 2 m in the case of El Pino, according to informants—than the tunneled galleries. The *ojos* are much smaller, usually less then a meter in width, with vertical sides. They are square in form, made of cribbed logs with cobbles in the interstices, and were built before the trench was filled in. In one case, Totoral, we were able to observe a section of the puquio where the fill had been washed away by a recent flood and the cribbed *ojo* structure was standing free. Sometimes the surface above a filled-trench gallery is slumped down a meter or so as a result of the gradual compaction of the fill.

We cannot know at this point whether a trench was filled at the time of the original construction of the puquio, or later. Local informants state that they were filled within the past century. Open-trench puquios are inconvenient barriers to the distribution of irrigation water on the surface, and they take up much potentially arable land, so there is good reason to fill them in. Unfortunately, although use of wood for the ceilings of the tunnels and the walls of the *ojos* might have been an expedient measure at the time of filling, within a few decades or so the wood deteriorates and must be replaced. Trees are a very limited resource at present, and the filled-trench sections of the puquios are therefore in the poorest state of preservation. It is impractical to replace the great quantities of wood they contain, and so as sections fall in they are left open. The most recent innovation in trench-filling can be seen in the cases of the Kopara and Chauchilla puquios of the Las Trancas Valley, and Santo Cristo in the Nasca Valley. In these cases cement tubes were laid as conduits for the water in the bottoms of the trenches, vertical cement tubes were spaced about every 50 meters, and the trenches were filled in, sometime after 1944. These puquios are visible on the surface only as a line of wells, each about 1 m in diameter.

The depth of a puquio is of course determined by the depth of the aquifer. Puquios are shallower at the upper and lower extent of their range, and deeper in the middle section. The length of a puquio is determined by the depth of the aquifer and the slope of the land: the deeper the water, the longer the puquio; the steeper the slope of the surface, the shorter the puquio. Puquios with relatively high output are located either immediately next to the riverbed, sometimes with galleries that extend under it, or else at the valley margin alongside impervious rock outcrops that extend into the valley. Puquios located in the valley bottom, away from either the riverbeds or the valley sides, have lower output.

Most puquios have small reservoirs, *kochas*, at their lower end from which waters are directed into irrigation canals, *acequias*. *Kochas* seem to

be in a constant state of renovation; outtakes are regularly replaced with cement slabs and wooden sluice gates, and some *kochas* have been enlarged and completely lined with cement.

There is a modern version of the puquio, called the *pozo-kocha*, that is still constructed in this region. In areas where the aquifer is not too deep, typically near the upper and lower ranges of the distribution of the puquios, a deep straight trench is excavated down to the aquifer with heavy machinery. Water filters into the *pozo-kocha*, and is then extracted with motor-driven pumps. Some puquios have been transformed into *pozo-kochas*, in which the lower end of the puquio is destroyed and just the uppermost end, where the puquio intersects the aquifer, is left open—an approach that serves to increase valuable arable land. Such alteration is most common in the Las Trancas Valley, where at least three puquios have been converted. At least one puquio in the Nasca Valley has also been converted into a *pozo-kocha*.

Description of Extant Puquios

In this section we provide a short discussion of each extant puquio in the Nasca, Taruga, and Las Trancas valleys. In each valley we proceed from east to west, upstream to downstream; in the mid-section of the Nasca Valley we first describe the puquios located north of the Tierras Blancas River, and then those to the south. Where previous reports have used different names, they are indicated in parentheses. Our measurements of the puquios are provided in Table 1.

Our studies of the puquios were conducted primarily from the ground surface. We have made plan-view maps of all of the extant puquios except Chauchilla and La Joya (of Nasca). Where possible, usually in the case of trench-type puquios, our measurements began exactly at the zone of filtration. In the case of galleries, we began our measurements at the uppermost *ojo*, which is seldom the true beginning of the puquio. Informants tell us that most galleries begin some distance before the first *ojo*, and our measurements of galleries should therefore be taken as minimums. It was only possible to measure the depth of the galleries below the surface when *ojos* were left open, which is rarely the case. With very few exceptions, which were made possible by the absence of water, we did not enter the subterranean galleries ourselves.

Nasca Valley

At present there are 29 puquios functioning in the Nasca Valley. They are distributed from east to west over a distance of 16 km, from Orcona to Soisonguito (Figures 4 and 5). González (1934) describes 27 of the 29, plus Soisongo, which has since been converted in a *pozo-kocha*; he does not mention Santo Cristo or La Joya. Rossel (1942, 1977) describes the same ones as González, and suggests the existence of Santo Cristo. Mejía (1939) lists eight puquios in the Nasca Valley, but does not describe any of them.

Existing puquios. The uppermost extant puquio, Orcona, begins as a gallery under the bed of the Aja River; a second branch begins at the bedrock outcrop called Cerro Orcona. After they join, the gallery passes under the riverbed and continues to the SSW until it opens into a trench. Because it lies at the upper end of the dry valley, Orcona is rather shallow; the aquifer lies at only 5 m below the surface. The course of the trench was altered in the late 1960s to follow along new field lines.

The next three puquios are all relatively small; each begins as a short gallery and becomes an open trench. In the case of Vijuna (Matara), informants report short side galleries, but there are few traces of them on the surface. The Vijuna *kocha*, which was functioning in 1944, has fallen out of use, but large mounds of earth indicate its location. The gallery portion of Cortez (El Cerco, Uchuya) was only recently discovered during cleaning efforts; it once had a short trench branch, still visible but not in use at the time of our study. González's length measurements are significantly greater than ours, and it may be that the newly discovered gallery is actually much longer than presently known. Both González and Rossel reported that the puquio Tejeje was in poor condition, and had multiple branches. At present it is in good condition and has only one branch visible from the surface. The *acequia* fed by the Tejeje puquio crosses the Quebrada de Belén and waters the lands of Belén.

The puquio Wachuka (Figure 6) has two major branches, both of which begin as galleries. The

Table 1. Puquio Measurements.

Puquio	Kocha	Trunk				Branches				End Point
		Trench	Gallery			Trench	Gallery			
			Filled	Tunnel	Indet.		Filled	Tunnel	Indet.	
Nasca Valley										
Orcona	yes	793.9	70.2	131.8				12.0		zf
								70.0		ojo
Vijuna	no	229.2			60.2					ojo
Cortez	yes	244.4			57.4					ojo
Tejeje	yes	368.8			151.5					ojo
Wachuka	yes	294.4				265.3	172.9			berm
						47.8	298.8		82.6	ojo
									150[a]	zf
Visambra	yes	209.0			870[a]					ojo
Aja Alto	yes	245.5								zf
Aja N	yes	487.7				82.65				zf
						169.6				zf
Aja S	yes	509.0			266.0					ojo
Cuncumayo	yes	536.5								zf
Curve	yes	541.0								zf
Anklia	yes	555.0	35.85	4.3						ojo
Achako N	yes	353.8				222.5				zf
						294.0				zf
Achako S	yes	1025.0								zf
Cantalloq	yes	101.7			104.1			70.8		ojo
								265.2		ojo
Santo Cristo	yes	301.3	219.7							ojo
Gobernadora	yes	180.4	123.5	372.2						ojo
Kayanal	no	80[a]			370[ab]					ojo
Pangaravi	yes	262.2				291.8	207.2			ojo
						256.0				zf
San Antonio	yes	488.1	22.4							berm
Wayrona	yes	493.7	43.7	304.0						ojo
Majorito	no	823.3								zf
Majoro	yes	907.2			95.9				81.6	ojo
									246.1	ojo
San Marcelo	no	336.8	96.3							ojo
Llicuas 2	yes	272.0			27.0				42.5	ojo
									172.9	ojo
Llicuas 1	yes	348.9	127.5					127.2		
								131.3		
La Joya	yes	260[a]								zf
Ocongalla	yes	592.0								zf
Agua Santa	yes	552.0								zf
Conventillo	yes	559.0								zf
Soisonguito	yes	597.0								zf
Taruga Valley										
Santa Maria	yes	218.7	168.8					23.2		ojo
								39.0	216.6	ojo
San Carlos	yes	65.6	140.7	183.6						ojo
Las Trancas Valley										
Totoral	yes	96.3	467.6		90.0					ojo
Pampón	no	279.9	630.5				536.1		41.4	ojo
							340[a]			berm
El Pino	yes	435.6	122.7				238.2		123.4	zf
							54.4			berm
Kopara	yes		828[b]							ojo
Chauchilla	yes		1280[a]							ojo

Notes: Measurements are in meters. For example, the puquio Orcona begins as two tunneled galleries, 12 and 70 m long, respectively. These flow together to form a single tunneled gallery 131.8 m long, which becomes a filled-trench gallery for 70.2 m, and then an open trench for 793.9 m; it terminates in a *kocha.*

Gallery types are filled = filled-trench gallery; tunnel = tunneled gallery; indet. = indeterminate gallery construction.

End points, the uppermost point measured on each puquio, are zf = zone of filtration, in cases of open trench puquio; ojo = first ojo, in case of gallery (puquio could be significantly longer); berm = end of berm from original trench construction, in case of filled-trench gallery.

[a]Measurement was taken from aerial photographs or CORDEICA maps.

[b]Puquio is considerably longer than what we were able to measure.

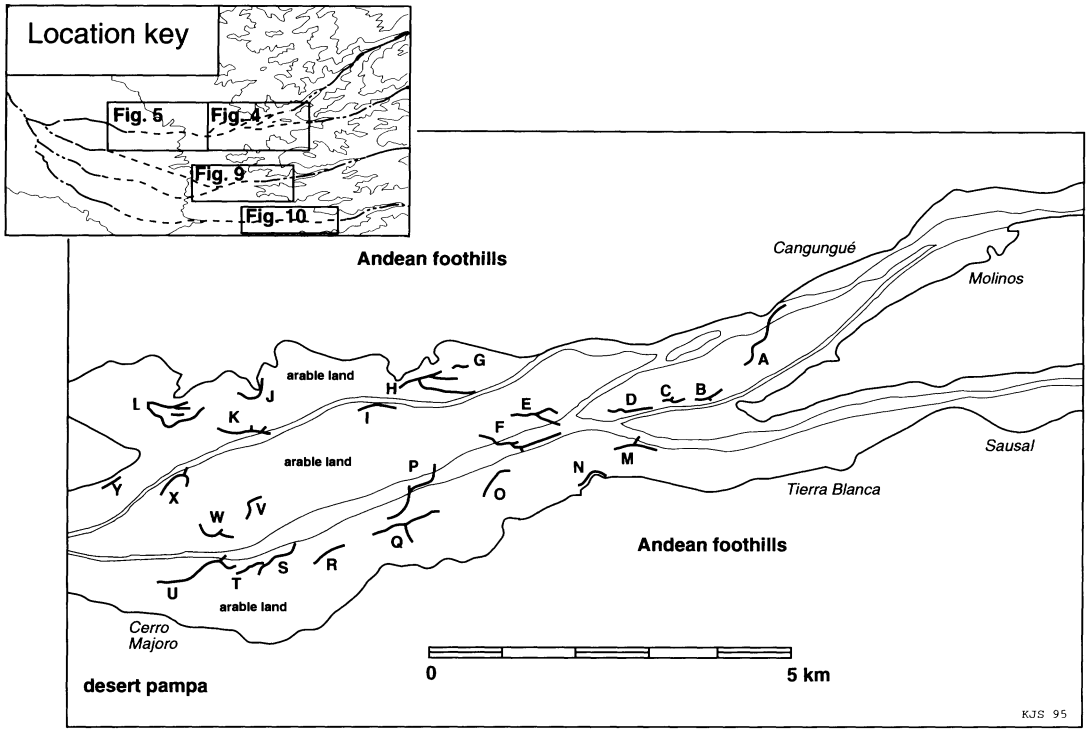

Figure 4. Map of the Nasca Valley showing limits of arable land, dry riverbeds, and locations of puquios from Orcona to La Joya: *A* Orcona; *B* Vijuna; *C* Cortez; *D* Tejeje; *E* Wachuka; *F* Visambra; *G* Aja Alto; *H* Aja; *I* Cuncumayo; *J* Curve; *K* Anklia; *L* Achaco; *M* Cantalloq; *N* Santo Cristo; *O* La Gobernadora; *P* Kayanal; *Q* Pangaraví; *R* San Antonio; *S* Wayrona; *T* Majorito; *U* Majoro; *V* San Marcelo; *W* Llicuas #2; *X* Llicuas #1; *Y* La Joya.

south branch is formed by the confluence of two galleries, one of which begins under the bed of the Tierras Blancas River. Cleaning of the puquio by CORDEICA in 1987 allowed the mapping of the portion under the riverbed. The large berms along most of the south branch and all of the north branch are remnants of the original trench construction; in these sections the gallery is of filled-trench type.

The puquio Visambra provides domestic water to the land on which the town of Nasca was established in the 1590s; it has the highest output of any puquio measured (González 1934:220). Visambra figures prominently in local beliefs about water. It is said that a person who drinks the water of Visambra will become enamored of Nasca, and should they ever leave Nasca they will always return.

Visambra begins as a gallery on the south side of the Tierras Blancas River and runs west parallel to the riverbed. Originally the gallery was located along the southern margin of the riverbed itself, but modern levees have reclaimed this land, which is now built up with houses. The gallery then bends to the northwest and crosses to the north side of the riverbed, and continues to the west under reclaimed land; the cleaning undertaken by CORDEICA revealed that three short branches join the main gallery in this stretch. The puquio then turns north, becomes an open trench, and flows west again to its *kocha*. The *kocha* has been modified several times, most recently in 1992 when it was enlarged and its cement sides raised; this has caused the submergence of the lowest section of the trench. The point at which the gallery opens into trench has also been changed as houses and streets have encroached on the puquio.

Aja Alto is a short trench-type puquio. Aja was originally two separate puquios that flowed west into the same *kocha*. Sometime between 1944 and 1970 the course of the southern puquio was altered so that it now veers north and joins the northern one. The northern puquio comprises two open trench branches. The southern puquio begins as tunneled gallery; our measurements begin at the first visible *ojo*, but informants report that the gallery actually begins under the adjacent bed of the Aja River.

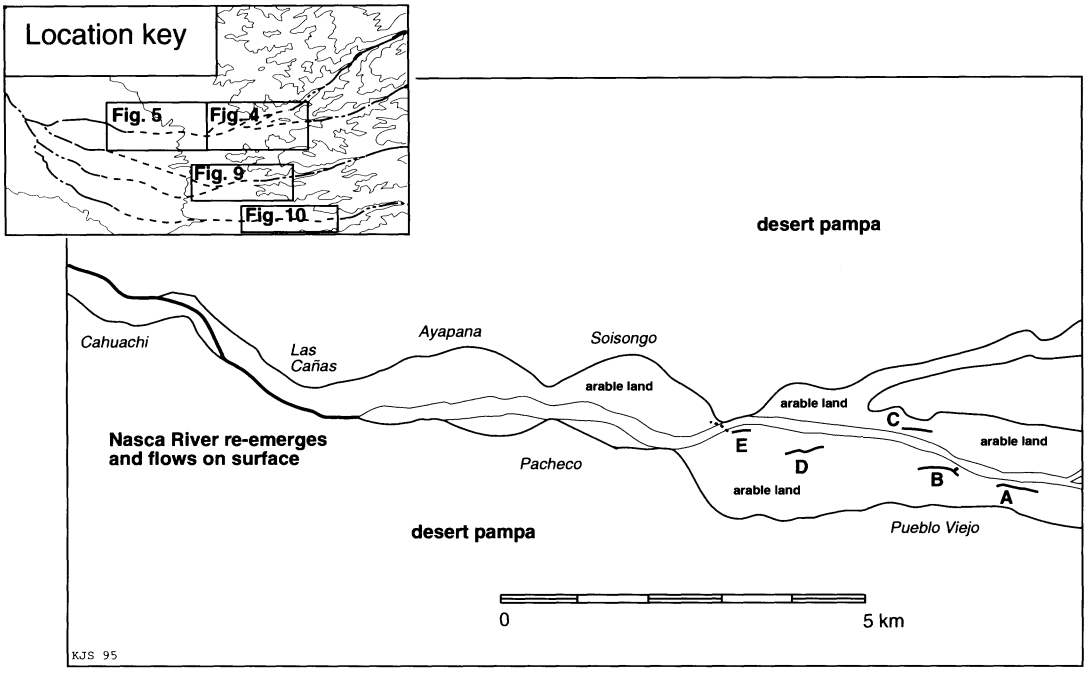

Figure 5. Map of the Nasca Valley showing locations of puquios from Ocongalla to Soisongo: *A* Ocongalla; *B* Agua Santa; *C* Conventillo; *D* Soisonguito; *E* Soisongo. Dashed lines, in this and the following figures, indicate a puquio that has been destroyed or converted; if the puquio today functions as a *pozo-kocha*, this portion of the feature is indicated with a solid line.

Cuncumayo is a trench-type puquio whose *kocha* seems to have fallen out of use several years before it was observed in 1986. The puquio Curve begins as a deep open trench alongside a bedrock outcropping that forms a ridge extending into the valley. The trench flows south, along the side of the ridge, then turns west to its *kocha*, which was enlarged and lined with cement in 1987. Anklia begins as a short section of tunneled gallery, said by informants to begin under the bed of the Aja River, followed by a long section of filled-trench gallery; one short branch enters from the north. The open trench flows to a very large cement-lined *kocha* that was occupied until recently by a penguin.

Achako (Figure 7) is actually a group of two and perhaps three puquios that share a single *kocha*. The northern puquio is formed by the confluence of two open trench branches, whereas the southern puquio is a single long open trench. The puquios flow separately to the *kocha*, much as Aja did originally. In the open land between the branches there is a short trench that now serves as a *pozo-kocha*, with a pumping station at its lower end.

On the south side of the Tierras Blancas River, the best known of all the puquios is Cantalloq. It was refurbished by CORDEICA in 1987, and some of the *ojos* were given spiral retaining walls so that tourists might more easily walk to the bottom and observe the water flowing through the gallery. Cantalloq has two major branches. The north branch is a tunneled gallery that begins at an unknown point and flows southwest under the Tierras Blancas riverbed. The southern branch parallels the riverbed and is also a tunneled gallery. At some time between 1970 and 1985, probably in 1978, two new *ojos* were excavated near the upper end of the branch. The stratigraphy exposed in the *ojos* reveals natural water-laid deposits, not artificial fill, and hence the gallery was without doubt built by tunneling. After the two branches join, a single gallery continues and then opens into a trench. The *kocha* is very large and cement-lined.

Cantalloq figures importantly in local legends about the puquios because of its proximity to Cerro Blanco, the enormous sand-covered sacred mountain that towers above the Nasca Valley. Local belief has it that the source of puquio water

Figure 6. Aerial photograph of the puquio Wachuka taken in March 1970. The *kocha* is visible in the upper left corner. The puquio comprises two main branches: the southern branch is actually formed by one branch visible on the surface, and a second that extends under the riverbed with no surface traces. In this, and the following photographs, the scale represents 500 m; the photos are oriented with north at the top.

is a subterranean lake inside Cerro Blanco, and each year offerings are made on its summit to ensure the rising of the water level in the puquios (Reinhard 1986:16–20).

On the south flank of the valley, just south of Cantalloq, is a small bedrock hill that extends into the valley. Santo Cristo (Kajuka) begins along the east flank of this hill, wraps around the hill, and follows the valley edge a short distance west to its large cement *kocha*. Motor-driven pumps also add water to the *kocha*. The puquio has been extensively modified, and *ojos* are now lined with cement tubes; the original construction is unclear. González did not record this puquio, and neither did the researchers who used his data to direct their own investigations. Rossel (1942) said that there must be a buried puquio at this location, as evidenced by a trench and the presence of plants normally found in humid locations. He suggested that the puquio passed under the Cantalloq *acequia* and went on 900 m to join the puquio La Gobernadora. His plan shows it connecting with both Visambra and La Gobernadora, and from the latter connecting to Pangaraví (Rossel 1942:198–199). We find no evidence of such interconnection among these or any other puquios.

La Gobernadora (Figure 8) is clear and functioning at present, but in 1934 González wrote that it was in the worst condition of all the puquios. The 1944 photos indicate that it had multiple branches, but all that is visible today is a single branch that begins as tunneled gallery, continues as filled-trench gallery and then open trench, and ends at a small, unimproved *kocha*.

The point of origin of Kayanal (Pangaraví No. 3) is unknown, but lies somewhere under the modern town of Nasca. It is said that it passes beneath the Plaza de Armas and then the Central Market, and thence under the bed of the Río Tierras Blancas where the river is crossed by the old iron bridge. From this point down, the puquio was cleaned by CORDEICA and its trajectory defined. The puquio more or less parallels the riverbed; originally, like Visambra, it flowed west under the southern margin of the riverbed. It then turns southwest and west again, opening up into a short open trench. Today the trench opens directly into irrigation canals; construction of the new

Figure 7. Aerial photograph of Achako taken in March 1970. Two large trenches join to form the northern puquio. The southern puquio is a very long trench that begins adjacent to the Pan American Highway; it is called "El Chico" because of its lower volume of water. Between the two is another trench that currently serves as a *pozo-kocha*; there are traces of a gallery that once connected it with the same *kocha* shared by the others. On the hillsides to the northeast are located settlements dating to the Late Intermediate Period.

bridge west of town and the new route of the Pan American Highway may have destroyed its original lower portion.

Pangaraví (Pangaraví No. 2) has two branches. The northern branch, flowing from east to west, begins as gallery and then becomes open trench. The southern branch is open trench and flows north to meet the other branch. The trench then flows west under the Pan American Highway to a unique double *kocha* made of cement. Located in the fields south of the river, San Antonio (Pangaraví No. 1) is mostly an open-trench type puquio, with possibly a very short gallery with one *ojo* at its upper end.

The puquio Wayrona begins along the southern edge of the river as tunneled gallery, flows southwest, and then bends west where it becomes filled-trench gallery. The lower open trench flows to a small *kocha*. Majorito (Majoro Chico) emerges from under the Wayrona puquio; it is an open trench that turns west and flows to a point where it enters irrigation canals directly. There are traces of a *kocha*, but it has not been used since before 1970. According to González (1934:218) the puquio was open trench and gallery, but the gallery was in poor condition. It appears that the gallery has been dug out since then and left open. The puquio Majoro (Majoro Grande) is much like Cantalloq in its layout. It has two branches, the northern of which begins at an unknown point and passes southwest under the bed of the Río Nasca; from this point on *ojos* mark its location until it joins with the southern branch. The southern gallery follows a path roughly east to west, joins with the northern branch, and continues until it becomes open trench. The trench flows west and enters the compound of the former hacienda house, where the blue cement-lined *kocha* served as a swimming pool.

San Marcelo begins as a short gallery and then opens up into trench. It has no *kocha*, but empties directly into irrigation canals. González reports a length of 790 m (compared to our measurement of 433.1 m), but because there is no *kocha* to define the lower end clearly, we may have defined its limits differently. Llicuas #2 begins as a gallery near the lower end of San Marcelo; a short branch enters from the north, and then the puquio becomes an

Figure 8. Aerial photograph of La Gobernadora taken in March 1970. The lower end of the puquio is open trench ending at a small *kocha*, visible near the lower left corner of the photograph. The middle section of the puquio is filled-trench gallery; portions have caved in and been left as open trench. The upper section of the puquio is tunneled gallery. Traces of an abandoned second branch can be seen just below the path that forms the field line running east–west to the right of the puquio.

open trench that winds west and then north to its *kocha* next to the Anklia-Majoro road. Llicuas #1 (Pikiman) has two branches: the northern branch is tunneled gallery that may extend under the riverbed; the southern branch is filled-trench gallery. After they join, the filled-trench gallery continues, becomes open trench, and reaches a small *kocha*. La Joya is a short, open-trench puquio not mentioned by any prior researcher. When we recorded it in March 1993, we were told that it had been dry for several decades and that it is the most meager of all the puquios.

At the lower end of the valley are four puquios, all with *kochas*. Ocongalla is an open trench for its entire length. The *kocha* today is small, but may have been larger and in a slightly different location in the past. Agua Santa is presently an open trench 552 m long, although local informants say it also had a gallery at one time. González (1934:211) reported that it was open trench for 240 m and then gallery, but said that the gallery was in poor condition. It appears that in the intervening years the gallery was dug out and left open. Conventillo is an open-trench type puquio with a large cement *kocha*. Soisonguito is the lowermost puquio still functioning, an open trench for its entire length.

Destroyed or Converted Puquio. The puquio Soisongo, described by González and Rossel, was modified between 1944 and 1970 and converted into a *pozo-kocha*. Originally it was an open trench parallel to the south side of the river, and then crossed to the north side of the riverbed and irrigated the lands of Soisongo. Given that the middle portion of the trench must have been destroyed each time the river flowed, it is understandable that it was not maintained once pump technology was available. Today on the north side of the river there is a large cement reservoir filled with water pumped out of the ground.

Probable Puquios. Above Orcona in the Aja Valley reliable informants report the existence of a buried gallery puquio at Cangungué. Just south of the Majoro puquio at Cerro Majoro are the remains of a trench following the valley edge along a series of low hills formed of impervious rock. We have received conflicting information from informants: some say it was definitely a puquio at one time; others say the ditch exists only to drain water off fields after they are irrigated. We lean toward the former interpretation.

Possible Puquios. One puquio is said to have been located at Molinos in the Aja Valley; there are ambiguous traces on the 1944 aerial photos near the impervious ridge at that location. The *acequia* that waters that region today did not exist until recently, and it is fed mostly with water pumped out of the ground. There are also reports of at least two shallow puquios located at Sausal and Tierra Blanca in the Tierras Blancas Valley, but the 1944 photos are ambiguous on this point. Below Soisongo at Ayapana Rossel describes a

puquio called Yapana. In 1942 he called it a lost puquio, but in 1977 he gave a description of it that sounds very much like Soisongo, which he omitted from the list (Rossel 1942:201, 1977:169). It is nevertheless possible that a puquio once existed at Ayapana. Today there is an enormous *pozo-kocha* at exactly the location of what, on the 1944 photos, look like traces of a puquio.

Taruga Valley

The Taruga Valley is the smallest of the three valleys, and has at present only two functioning puquios (Figure 9). In his 1926 field notes Kroeber (1993) wrote that, "It was said that 28 *puquios* [sic; he means *ojos*] had been located and cleaned out in the past year (1925) on hacienda Taruga, upstream from it." Mejía (1939:562–563) mentioned only one puquio in this valley, the Pukyo de Taruga. In 1942 Rossel said there were three puquios, one on the right (north), two on the left (south); in 1977 he said there were two galleries, but on his map he showed three, arranged as described in 1942 (Rossel 1942:202, 1977:171, 194).

The floor of the Taruga Valley begins to widen just below the zone of infiltration. In the other valleys, the aquifer drops to about 10 m in the middle valley and then rises again to intersect the surface. In the Taruga Valley, the water level drops gradually for about 5 km, but then drops off suddenly to depths of 30 m or more. Such depths seem to have been beyond the technical capabilities of the puquios' builders. As a result, only a short stretch of this valley is suitable for puquio construction and use, and the maximum area watered was only about 5 km long.

Existing puquios. Located on the north side of the valley at the former Taruga hacienda is the puquio today called Santa María. This is the Pukyo de Taruga described by Mejía (1939), and the series of 28 *ojos* mentioned by Kroeber in 1926. The main branch of the puquio begins as a tunneled gallery, and then is filled-trench gallery; a short filled-trench gallery joins it from the north. It continues as a filled-trench gallery, opens into an open trench, and empties into a large cement-walled reservoir.

On the south side of the valley is the puquio San Carlos, which begins as a tunneled gallery and then becomes a filled-trench gallery. In several areas the fill over the tunnel has been washed away, and the stone sides and roof of the tunnel are visible. A new *kocha* has been recently constructed alongside an older one. The *kocha* and the lower end of the puquio were dry when we mapped it in October 1986, but the water was 60 cm deep in the gallery at the upper end.

Destroyed or Converted Puquio. About 1 km west of the Santa María puquio, also on the north side of the valley, are the remains of a third puquio, Camotal, which is no longer functioning. There is no *kocha*, and 1944 air photos show the trench emptying directly into the irrigation system. At present there is a wide, open trench, with a sizeable berm at its upper end. Above this point the land is slightly depressed and saturated with standing water, which suggests the presence of a subterranean gallery in which an obstruction is now causing the water to back up.

Probable Puquio. In 1993 a reliable informant reported that a fourth puquio once existed upstream of the others at a place called Travesía, but that it was buried by the river.

Las Trancas Valley

Today there are five functioning puquios in the valley, two of which have been substantially modified in recent decades (Figure 10). In the past there may have been 11 or more. The Las Trancas Valley differs from the other two valleys in having a less steep gradient as the land drops in elevation from east to west. As a result, its puquios tend to be longer, on average, than those of the other valleys

In 1926 Kroeber wrote in his notes that, "Las Trancas is said to have a system of 80 [*ojos*], long in use" (Kroeber 1993). His investigations did not take him to Las Trancas, however, so he did not observe any of the puquios there. Mejía (1939) described and named six puquios that he observed in 1927, and provided a rough sketch map of the valley, but he indicated that some puquios had already been abandoned or destroyed. Mejía's data, although the most detailed of the published sources, are very difficult to interpret. The names he gives for the puquios are either mistaken or have changed. We have been able to identify with certainty only three of the six he described; for the remaining three we can only determine the general area in which each puquio was located, and each of those locations includes more than one puquio. Rossel wrote in 1942 that there were

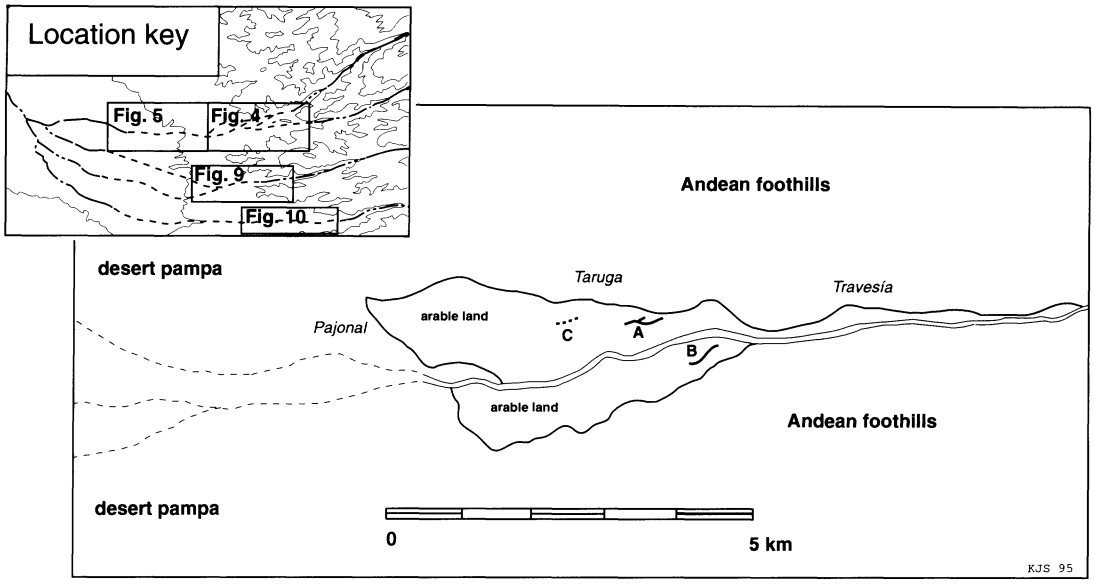

Figure 9. Map of the Taruga Valley showing limits of arable land, the dry riverbed, and locations of puquios: *A* Santa María; *B* San Carlos; *C* Camotal.

eight puquios functioning; in 1977 he described six, said there were seven, but noted eight on his sketch map (Rossel 1942:201, 1977:169, 171, 191–194). He described only one in detail.

Existing puquios. The three puquios that still function, and that maintain traditional construction, are located in the central portion of the dry middle valley. Situated on the south side of valley, the puquio Totoral (possibly Mejía's Pukyo B, La Marcha) comprises a gallery of indeterminate construction, then a filled-trench gallery. There are more *ojos* (more than 59) in this puquio than any other recorded. Below the gallery section a short open trench leads to the *kocha*.

The puquio Pampón (Mejía's Pukyo D, Totoral) is described in great detail by Rossel in both of his publications; he uses it as the "model" for the puquios of this valley, when in fact it is unique among them in several respects. It begins as two galleries, mostly of filled-trench construction, on the south side of the valley. Unlike other galleries recorded, Branch A of Pampón begins at a single abrupt point, a circular stone-lined pit into which the subsurface water filters. It then flows a few meters to a large subterranean chamber that measures some 4 m across and 3 m deep, according to our informant, the man charged with its annual cleaning. From this point the gallery flows west along the valley edge until it meets the riverbed; within this stretch a short branch enters from the south. Branch B begins at a natural cul-de-sac in the adjacent hillside, angles northwest toward Branch A, passes beneath it, and then parallels Branch A as they both approach the riverbed.

About one-fourth of the way across the riverbed, Branch B merges with Branch A. Rossel (1942:201; 1977:193) provides an eyewitness description of this confluence, and says that Branch B lies at a higher elevation than Branch A, and that the water cascades down a stone staircase where they join. On reaching the north bank of the river the puquio continues as a filled-trench gallery until it opens into a trench that in turn empties directly into the irrigation canal system. Because Pampón has no *kocha*, we defined its lower end as the point at which it crosses under the road running down the center of the valley and where it intersects several irrigation canals. From this point to the end of Branch A the distance is 1,488 m, the greatest we have recorded.

We find it especially interesting that, in his 1977 chapter, Rossel reproduces several of González's plans and profiles of the puquios, including one of Pampón. It is the Pampón profile that leads us to believe that González actually did study the puquios of the Las Trancas and Taruga valleys, but only published the data from Nasca.

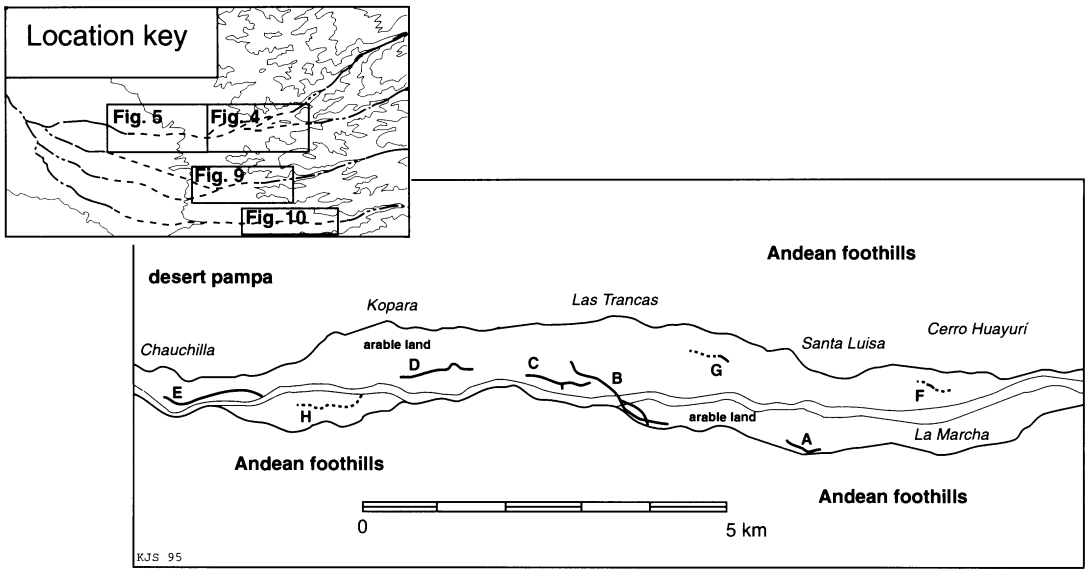

Figure 10. Map of the Las Trancas Valley showing limits of arable land, the dry riverbed, and locations of puquios: *A* Totoral; *B* Pampón; *C* El Pino; *D* Kopara; *E* Chauchilla; *F* Huayurí; *G* Huaquilla Chica; *H* La Joya.

Located just west of Pampón is the puquio called El Pino (Mejía's Pukyo E). The uppermost segment of the north branch of the puquio has been converted into a *pozo-kocha*; the remainder of the branch is filled-trench gallery. The south branch is visible on the surface as filled-trench gallery that flows north from the edge of the riverbed; informants say that most water comes from this branch. The puquio continues as filled-trench gallery, then as open trench; a large berm suggests the presence of another branch entering from the south, as described by Mejía, but it has apparently fallen out of use. The puquio ends at a small *kocha* of recent construction.

Moving west, we find two puquios that have been extensively modified. The puquio Kopara (possibly Mejía's Pukyo F) is clearly visible as a large open trench in 1944 photos. Sometime before 1970 the base of the trench was lined with cement tubes so that the water could continue to flow, and the puquio was buried. At least six cement *ojos* were created for access into the tube. The upper end, and hence the length, of this puquio is completely unknown; we were shown a well near El Pino and told it was an *ojo* of Kopara.

Farther downstream from Kopara is Chauchilla (also possibly Mejía's Pukyo F), which has also been entubed in cement. In the 1944 photo the puquio is visible as a large open trench, with a possible gallery at the upper end where it begins at the edge of the river. In the 1970 photo 24 cement tube "wells" are visible that follow exactly the trajectory of the old trench, and provide access to the now-buried puquio. There is a large cement reservoir at the lower end of the line of wells, approximately where the *kocha* of the old puquio was situated.

Destroyed or Converted Puquios. Three other puquios were clearly functioning in 1944; two have since been converted into *pozo-kochas*, and the third destroyed. One was located at the upper end of the middle valley on the north side, at the base of Cerro Huayurí. It is clearly visible in the 1944 photos, and was apparently functioning at that time. The upper portion was a gallery with at least four small square *ojos*, the lower portion was an open trench, and there was no *kocha*. This is very probably Mejía's (1939:560–561) Pukyo A, which he called the Pukyo Perdido, and Rossel's (1977:192) Wayurí. By 1970 it had been converted into a *pozo-kocha*, today called El Limón.

In the 1944 photos another puquio is clearly visible in the Las Trancas region; it was an open trench that began northeast of the mound called Huaquilla Chica. It followed along the northern perimeter of the mound, and emptied directly into irrigation canals to the west. Along the upper end there was a large mound of soil, probably excavated

from the trench. By 1970 the uppermost end had been converted into a *pozo-kocha*, and the rest, including the mounded soil, had been entirely obliterated. This is probably Mejía's Pukyo C, which he called El Pampón.

Another puquio, La Joya (also possibly Mejía's Pukyo F), existed near Kopara. Located just south of the river, it began as a gallery with six large conical *ojos* visible in the 1944 photo. It then opened into a trench that led to a small reservoir. There is no trace of this puquio on the ground today other than a higher-than-usual density of stone cobbles in a linear path through the modern fields. Informants said that La Joya was very deficient in water and was filled in sometime in the 1950s by the hacienda owner.

Possible Puquios. In addition to the three former puquios, others may have existed that are now destroyed or converted. At the upper end of valley on the south side at La Marcha, opposite the Huayurí puquio, there are traces of a possible destroyed puquio visible in the 1944 photo. Mejía's (1939:561) Pukyo B may refer to this puquio, or to Totoral. On the north side of the valley, near the small settlement at Santa Luisa, a short length of depressed land between two mounds is visible in the 1944 air photo and looks like the remnants of the upper end of a puquio. It appears that there was a square hole or well dug into the depression, which would support the notion that there was a filled-trench gallery below the surface. At present one of the mounds has been leveled, and the depression filled.

Below Chauchilla the valley floor narrows and there are no settlements, historic or prehistoric, for about 5 km. However, in the vicinity of Poroma there is a sizeable Late Intermediate Period occupation, and traces of old agricultural fields are visible in the 1944 photos. We suspect there may have been a puquio in this area as well.

The Puquios in Archaeological Context

Now that we have established the present condition and attributes of the puquios, the most intriguing question facing us is, "When were the puquios built?" Few people familiar with them lack an opinion on the subject. There is a strong local belief that they were built by the Nasca Culture of the Early Intermediate Period (Table 2), although some residents of Nasca maintain that it is more likely that they were built by the Inkas. Among the published sources that focus generally on Nasca or specifically on the puquios there is little agreement on the subject. González (1934) identifies them as Inkaic, whereas Regal (1942) and Rossel (1977:193–194) attribute their construction to the Nasca culture of the Early Intermediate Period. In a footnote to the reprinted version of González's article (González 1978:130), Ravines states that there is a general consensus that the puquios correspond to the Early Intermediate Period Nasca Culture. Peterson (1980:21) suggests that the system was begun in Middle Nasca (Nasca 5, in our terminology) times and finished in Late Nasca times. Barnes and Fleming (1991) argue that the puquios are not prehistoric at all, but rather were built by the Spanish in the Colonial period. Although many of these opinions are valid, given the bases upon which they were formed, none of the writers had access to the archaeological data that are now available as the result of the recent settlement surveys of the region. We attempt here to rectify this situation.

Historic Documents: Absence of Evidence vs. Evidence of Absence

One might logically begin with Spanish historic records, seeking mention of the puquios—references to their existence, if they were Prehispanic, or to their construction, if they were built by the Spanish. Barnes and Fleming (1991:57) have argued that the lack of mention of the puquios in early Spanish documents indicates that the puquios did not exist prior to the seventeenth century. But neither are there any descriptions of Spanish construction of puquios. The fact that puquios were not mentioned by Cieza de León (1984:221) is cited by Barnes and Fleming as strong evidence that the puquios did not exist in the mid-1500s. However, they fail to take into account the fact that Cieza never actually traveled along the coast of Peru south of Lima (Estrada 1987). He was never in Nasca and could not have had the opportunity to observe the puquios, so his oversight should not surprise us. Four of the other five sources cited by Barnes and Fleming (1991:57) do not refer specifically to Nasca at all; indeed, most refer to Chile. The fifth, that of Reginaldo Lizárraga (1909), merits closer attention. Written in 1605, it includes the earliest

description of the puquios of which we are presently aware.

Lizárraga traveled through much of South America, including the south coast of Peru. Like most Spaniards he was impressed with the dryness of the coast, and the general lack of water, and was careful to mention available water resources in each valley. He specifically noted where rivers were adequate or not, and in some cases gave details about irrigation. In specific cases he pointed out who built and/or used particular features, and distinguished between the Spanish, the Inkas, and the *indios* (natives), always noting that the latter were very few in number owing to the massive post-conquest depopulations. He has the following to say about water in Nasca:

> [The Nasca river] is lacking of water in the winter, which is the time that in the Sierra it does not rain, and here [on the coast] is the time of the *garúas*. But in the summer, which is the time of the rains in the sierra, it is a large and even dangerous river. . . . The Indians, in the dry season, make use of wells made by hand, at intervals, and in high places, as reservoirs of water from which they take *acequias* to begin the planting and to sustain themselves until the river comes [Lizárraga 1909:522; author's translation].

There are three points to be noted in this passage. First, Lizárraga points out the utter lack of water in the Nasca River during the dry season, and the apparent need to use groundwater when the river was dry; he says this about no other coastal valley. (He seems to assume that the river flows every wet season, which is not the case.) Second, he describes the alternative source of water as wells built at intervals on high ground. This is undoubtedly a description of the puquios: a sequence of *ojos* and/or *kochas*, on high ground above the level of the riverbed, providing water for irrigation. Third, he is specific that these were used by the Indians. He does not attribute them to the Inkas, as he does certain irrigation features in Cañete (Lizárraga 1909:519), or to the Spanish.

Although this source implies prehistoric puquio construction, in general we find the historic documents to be rather ambiguous for our purposes. Let us turn instead to the archaeological data and consider several lines of evidence that might be useful in estimating the date of construction of the puquios.

Table 2. Peruvian South Coast Chronology

Numerical Dates	Nasca Valley Chronology	Standard Chronology	Uncalibrated Dates
A.D. 1532			
	Late Horizon	Late Horizon	
A.D. 1476			
	Late Intermediate	Late Intermediate 1–10	
			A.D. 1000
		4	
	Middle Horizon	Middle 3	A.D. 800
		Horizon 2	
		1b	
			A.D. 650
		8	
A.D. 750			
	Late Nasca	7	
		Early 6	
	Nasca 5	Intermediate 5	
			A.D. 450
	Early Nasca	4	
A.D. 400		3	
		2	
A.D. 1			
	Montana Phase	1	100 B.C.
		10	
		Early 9	
	La Puntilla Phase	Horizon 8	
		7	
		6	

Absolute Dating, Stratigraphy, and Direct Associations

An obvious solution to the problem might be to obtain radiocarbon assays on the wooden beams that form the ceilings of the galleries. Unfortunately, because wood does not endure more than a few decades, the beams are regularly replaced, and hence dating them is not likely to indicate the date of construction of the puquio.

Wooden lintels from the Cantalloq and Majoro puquios collected by Hermann Trimborn yielded dates of 110 ± 100 B.P. and 140 ± 100 B.P. (see Scharpenseel and Pietig 1974). Another sample was collected from a beam of the puquio Visambra in 1986, during the CORDEICA-sponsored cleaning. The worker who retrieved the beam said it was the oldest piece of wood in the puquio, and that it was certainly put there by the Inkas when they built the puquio. However, like Trimborn's samples, the beam yielded a date of only 124 ± 65 B.P. (SMU 2237; wood; $^{13}C = -26.8$), somewhere in the mid-nineteenth century A.D. Either the sample was contaminated, or, more likely, the beam was a replacement, installed during a cleaning of the puquio in the last century.

A potentially more fruitful approach is that of Clarkson and Dorn (1991, 1995; Dorn et al. 1992). Dorn observed the formation of desert varnish on stone lintels inside the Cantalloq and Orcona puquios; microscopic analysis indicates that this type of varnish forms only in damp or wet environments. The AMS assays of the samples were Orcona: 1460 ± 50 B.P., cal A.D. 552–644 (1-sigma error); and Cantalloq: 1430 ± 60 B.P., cal A.D. 591–658 (1-sigma error) (Clarkson and Dorn 1995). These are minimum ages, because the varnish begins to form after the stones were cut. The results suggest, therefore, that the stones were cut in roughly the Early Intermediate Period.

Turning to stratigraphic associations, if puquio trenches were dug through existing (or abandoned) settlements, then the dates of those sites should provide a lower-limit date for puquio construction. Unfortunately, we have never observed evidence of archaeological remains in the side walls of puquio trenches or *ojos*. It is apparent that prehistoric people did not live on the arable valley bottom, and hence puquios were not excavated through extant sites.

Excavation of the puquios themselves (cf. Barnes 1992) is liable to yield little or, worse, misleading evidence. It is obviously not possible to excavate open trench segments or tunnels because they are excavations themselves. The only segments that might yield cultural remains are the filled-trench galleries. Artifacts in the fill should provide a lower-limit date for puquio construction if, and only if, the filling took place at the time of the initial construction. Unfortunately if, as we suspect, filling took place long after the puquios were built, possibly within the last century, then any artifacts found in trench fill might pertain to periods long after initial puquio construction.

A more productive line of investigation might be to consider archaeological sites in direct association with puquios. Although people did not live on the arable valley bottom, the excavation of puquio trenches created large elevated berms that were unsuitable for cultivation, but that might be suitable for limited habitation or other activities. Sites found on the berms must necessarily postdate puquio construction. Middle Horizon and Late Intermediate Period artifacts have been observed on the berms of the puquios Anklia, Achako, Agua Santa, Soisonguito, Pangaraví, and Santa María; and there is a scatter of Nasca phase 5 and Late Nasca artifacts at Pangaraví as well. While the presence of these artifacts might result from the excavation of a puquio trench through a pre-existing site, we sought but found no evidence of such sites. We suspect that numerous other small occupations may be located on puquio berms, but are concealed by modern houses.

The construction of puquios also created barriers to the distribution of irrigation water, and in the case of the puquio Totoral a small parcel of land was rendered unusable for agriculture. The fact that a Nasca 5 village was established on this parcel of land suggests that the puquio existed at that time.

In sum, sites directly associated with puquios are not uncommon, and the few cases noted indicate that the puquios probably existed in the Middle Horizon and the Late Intermediate Period, and may have existed as early as Nasca 5 of the Early Intermediate Period.

Settlement Patterns

Settlement-pattern data, specifically the distribution of habitation sites across the landscape, provide the most secure evidence presently available for dating the construction and use of the puquios. Recalling our earlier discussion of the availability of surface water in different parts of the valley (Figure 2), we make the following assumptions. Prior to the time of construction and use of the puquios, permanent habitation sites should be rare to nonexistent in the dry middle valleys. Although the land might be irrigated and cultivated during years in which the river

flowed, most years saw little water in this portion of the valleys, and certainly not a drop during the dry season. It is therefore extremely unlikely that permanent habitation sites were established in the dry portions of the valleys in the absence of puquios. This does not, of course, preclude the establishment of cemeteries in such areas. Perennial water is available in the lower and upper valleys, and usually in the zone of infiltration, and hence it is in those locations that we should expect to see permanent villages prior to puquio construction. The lower valley is rather inhospitable due to high temperatures and terrible wind storms, so we should anticipate finding most habitation in the zone of infiltration and in the upper valley.

After puquio construction, the middle valley was made habitable year-round, and we should therefore see a shift in site locations into this region correlated with the use of the puquios. In fact, given that there is much more arable land in the middle valley, and that puquios are more reliable than river water, we might expect to see movement of the majority of the population into the middle valley as the use of the puquios increased.

Archaeological survey (Figure 11) was directed by Schreiber and conducted on foot by a crew of three to four persons. The region comprises four zones: valley edges, ridges and hilltops, valley bottoms, and desert *pampa*. Because nearly all sites are located on the valley edges, immediately adjacent to the arable valley bottom, these areas were surveyed completely. Ridges and hill tops were surveyed only in the lowest portion of the Andean foothills, up to 250 m above the valley floor. Sites in the valley bottom are located only on low rises of land where irrigation water cannot reach; these include natural and man-made mounds and puquio berms. All such areas were surveyed except where modern settlements (i.e., the dogs at them) caused us to skirt some pieces of land. In addition to these parcels, we surveyed up to 50 percent of the valley bottom in each valley, but thus far we have not located any prehistoric settlements on potentially arable land. Survey of the valley bottom did allow us to define the limits of arable land established by traditional technology; the use of motor-driven pumps has expanded cultivation significantly in some parts of the valleys. Survey did not extend away from the valleys onto the desert plain or up alluvial fans of side valleys; these areas are covered with geoglyphs, and it is prohibited to walk on or near them without special permission. Because the geoglyphs were not a primary focus of our study, we did not seek such permission.

We have completed systematic survey in the Aja and Tierras Blancas valleys, beginning at an elevation of 1,200 m asl in each, and continuing down through the Nasca Valley to an elevation of 275 m asl, a distance of about 50 km. The survey area includes all four hydrologic sectors: upper valley, zone of infiltration, and middle and lower valley. We have also extended limited reconnaissance up to 1,600 m asl in the Tierras Blancas Valley. In the Taruga and Las Trancas valleys we have completed systematic survey only in and around the dry middle portions of the valleys, with some reconnaissance of areas above and below, and the survey has not yet been extended through the valleys' upper and lower reaches. Thus, the Nasca Valley and its tributaries should provide both the expected "before" and "after" patterns, if they exist. The Taruga and Las Trancas valleys should show evidence of the "after" pattern, but we must await further research to provide the "before" picture.

When we compare settlement patterns of the Early Nasca period with those of the Late Intermediate Period in the Nasca Valley (Figures 12 and 13), we clearly see our expected "before" and "after" patterns. In Early Nasca times sites were distributed in the lower valley, and in the zone of filtration and the upper valley. In the lower valley Cahuachi, a major ceremonial center (Silverman 1993), occurs along with numerous cemeteries (Ogburn 1993). It is no surprise to us that the region was sacred to the prehistoric inhabitants; the emergence of the river at Las Cañas, in the midst of some of the driest territory on the coast of Peru, must have had great religious significance. Permanent habitation sites seem to have been lacking in the lower valley in Early Nasca times, probably owing to the heat and wind.

In contrast, numerous habitation sites, mostly small villages, were located in the zones of infiltration and upper portions of the Aja and Tierras Blancas valleys. The extensive occupation of the zone of infiltration suggests that water was relatively plentiful in Early Nasca times, and that

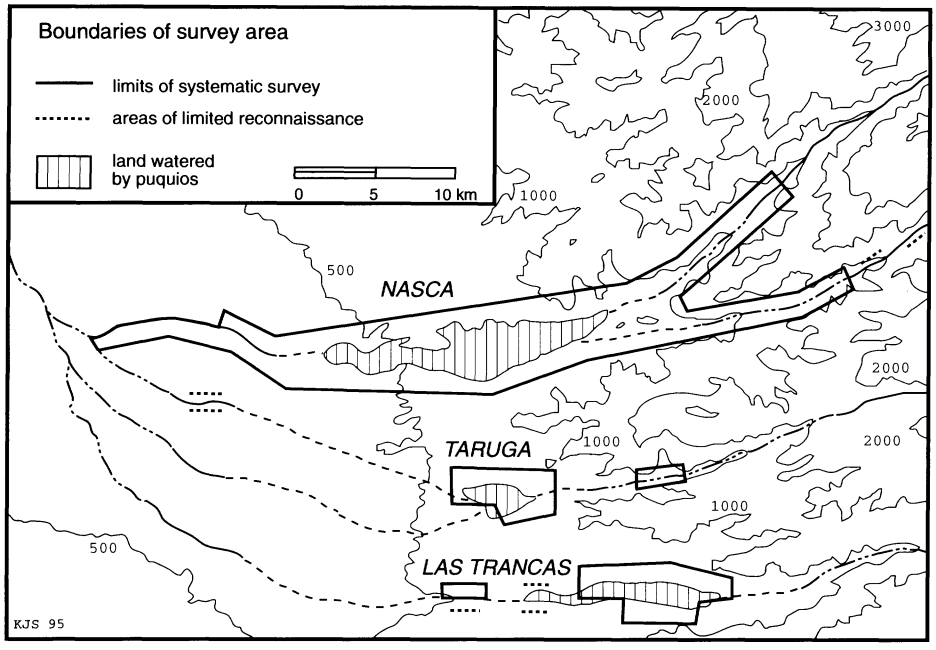

Figure 11. Boundaries of the areas systematically surveyed, 1986–1994.

there were no extended periods of drought that would cause people to move to higher elevations. Not a single habitation site is found in the dry middle valley, although numerous cemeteries and two small ceremonial centers (Pueblo Viejo and Cantalloq) are present. Likewise, in the Taruga and Las Trancas valleys, no habitation sites are found in the middle valleys.

In sum, settlement patterns of the Early Nasca period match our expectations regarding patterns prior to the construction of the puquios. The lack of permanent occupation of the middle valleys indicates to us that the puquios were not yet in use.

This pattern changed completely by the Late Intermediate Period. In the Nasca Valley settlements are found throughout the dry middle valley. The sites in the zone of infiltration and upper valley are smaller and fewer in number than those in the middle valley, an indication that the majority of the population lived in the middle valley. In both the Taruga and Las Trancas valleys there are likewise major settlements in the middle valley in the Late Intermediate Period. These data indicate to us that puquios were in use by the Late Intermediate Period and long before the arrival of the Spanish. Furthermore, in the Late Horizon immediately after, the Inkas established a major center at Paredones, in the heart of the dry zone (Figure 13). Water must have been available at or near the site; at present the land in front of Paredones is watered by the La Gobernadora puquio, and the Pangaraví puquio is nearby. It is probably no accident that the Spanish also chose this portion of the valley for their town; in fact, they located Nasca on a tract of land watered by the most productive puquio of all, Visambra.

The differences in settlement distribution demonstrate to us that the puquios were built after roughly A.D. 450, but well before the Inka arrival in A.D. 1476. Can we be any more precise regarding the period of construction within that millennium? We should be able to determine the period of initial use by identifying the period in which people first established major permanent settlements in the dry middle valley. The data from all three valleys suggest that initial use of puquios began by Nasca 5 (Figure 14). In the Nasca Valley, settlements were first established in the middle valley in Nasca 5. The middle Taruga Valley includes a very large Nasca 5 site, and several major Nasca 5 sites were established in the middle Las Trancas Valley as well. These data suggest an initial period of use of at least some of the puquios in Nasca 5 times. The association of Nasca 5 sites with the Pangaraví and Totoral puquios also supports this interpretation.

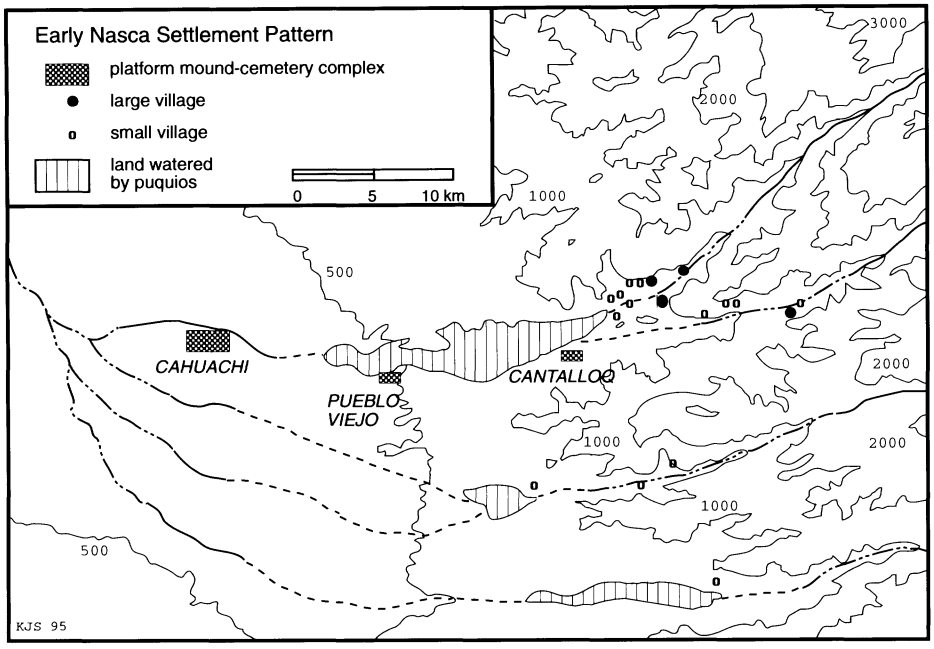

Figure 12. Settlement patterns of the Early Nasca period. Habitation sites are located in the upper valley where peren-

It is interesting that while people were moving down into the middle valley, others were moving farther up-valley in Nasca 5. New and larger settlements were established at elevations above 1,050 m asl in the Aja Valley, and above 1,150 m asl in the Tierras Blancas Valley. Movement out of the zone of infiltration and into the upper valley is exactly the expected pattern during periods of prolonged drought, which might also account for the need to develop new sources of water, such as puquios. Prehistoric precipitation in the south highlands of Peru has been documented through the study of ice cores by Thompson et al. (1985). The data do not yet extend to periods prior to A.D. 470, but they do indicate a prolonged drought between A.D. 540 and 560, and an especially severe drought between A.D. 570 and 610. There is evidence in the puquio constructions themselves that suggests they were built in times of severe drought; the fact that the galleries are longer than they need to be today and are no longer cleaned to their original end suggests that the aquifer is slightly higher today than it was at the time of puquio construction.

The shift in settlement locations is even clearer by Late Nasca times (Figure 15). There was a complete change from the pattern of numerous small villages seen in Early Nasca times to a pattern characterized by a limited number of very large towns. In the middle Nasca Valley there is a cluster of one large and two small sites; in the upper Tierras Blancas there is a similar cluster. In the middle Taruga Valley growth of the large Nasca 5 site to cover some 16 hectares made it the largest site in the region in Late Nasca times. In the middle Las Trancas Valley several large villages were occupied in the Late Nasca period. Our data indicate that the Late Nasca period was a time of population aggregation and increased sociopolitical complexity. More to the point, the location of major sites in the dry middle valleys indicates very strongly a reliance on puquios in Late Nasca times.

Conclusion

Today the puquios provide the people of the Nasca, Taruga, and Las Trancas valleys with water year-round for both irrigation and domestic use. We have attempted to provide a brief, updated description of the system of puquios, a discussion of how they function and how they were built, and the condition of each one of them today. We have considered the archaeological data that suggest a prehistoric date of construction,

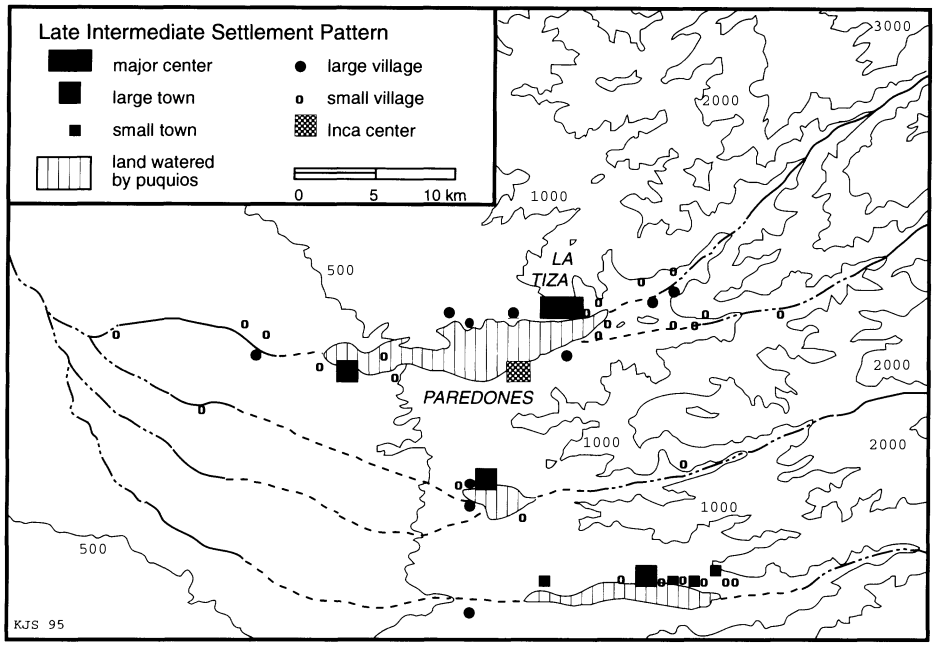

Figure 13. Settlement patterns of the Late Intermediate Period. The majority of the population lived adjacent to lands watered by puquios, which suggests that the puquios existed at this time. The location of the Inka site, Paredones, which was established at the beginning of the Late Horizon, is also noted.

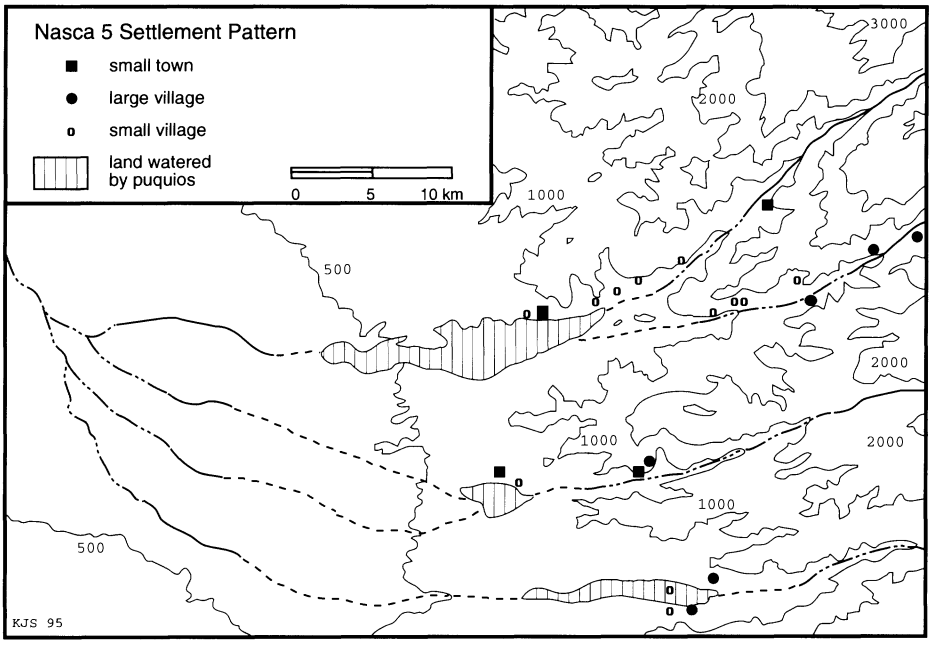

Figure 14. Settlement patterns of Nasca 5. Habitation sites are located at higher elevations than in Early Nasca, suggesting drought conditions. For the first time sites are located adjacent to lands watered by puquios, which suggests that the puquios were first used at this time.

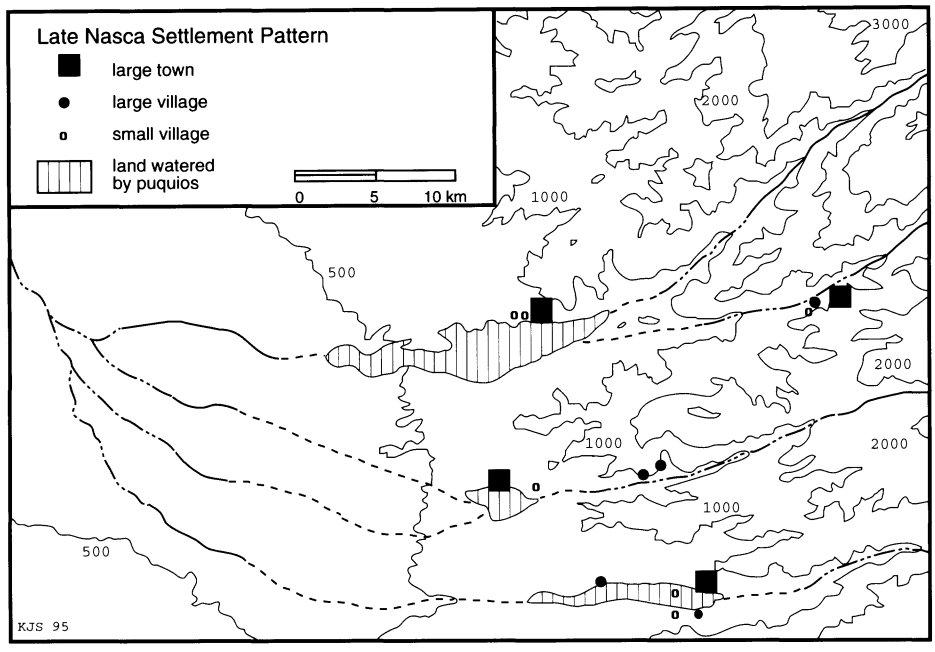

Figure 15. Settlement patterns of the Late Nasca period. Population aggregation into a small number of very large sites suggests changes in sociopolitical organization. The presence of large sites adjacent to lands watered by puquios suggests that puquios were in use at this time.

and our best estimate for the date of initial construction and use of the puquios is Nasca 5, the transitional period between the Early and Late Nasca phases of the Early Intermediate Period.

This is not to say that all the puquios were built in Nasca 5 times. It is not unlikely that puquio construction and modification continued over the centuries, as population grew, and the need for water grew ever greater. It is also clear that puquios are constantly undergoing structural modifications even now. It is quite likely that modifications in the centuries since the Spanish conquest have increasingly caused them to resemble the *qanats* of the Old World, and have given rise to some confusion regarding their authorship.

The archaeological evidence indicates that the "smiling paradise" so charmingly described by Markham was created well over a millennium ago by the Nasca people of the Early Intermediate Period. The puquios are perhaps the most enduring legacy of the ancient Nasca Culture.

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Note

1. The word *puquio* is Quechua, and it usually refers to a natural spring. However, its meaning can also be quite broad and may refer to natural water sources modified by human action (Zuidema 1986:199 [endnote 5]). In Nasca the term *acueducto* has received increasing usage in recent decades, in part to attract tourists to see what the local people consider to be some of their greatest prehistoric accomplishments, and in part because European terms are seen to be of higher status than indigenous ones. However, because the term used most widely in Nasca by the people who actually use this irrigation system is puquio, we use it herein.

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