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UNITED STATES

NUCLEAR REGULATORY COMMISSION

REGION IV

URANIUM RECOVERY FIELD OFFICE
BOX 25325
DENVER, COLORADO 80225

JAN 22 1991

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Docket No. 40-8907

MEMORANDUM FOR: Docket File 40-8907

FROM: Joel P. Grimm, Project Manager

SUBJECT: REVIEW OF GEOLOGIC AND GEOMORPHIC ASPECTS OF THE UNC-CHURCH ROCK RECLAMATION PLAN

BACKGROUND

10 CFR 40, Appendix A, requires uranium mill operators to provide a disposal site and tailings stabilization design to prevent the release of tailings for 1000 years, to the extent reasonably achievable, and, in any case, for at least 200 years. This correspondence provides partial results of reviews of the reclamation plan submitted by United Nuclear Corporation (UNC) for the uranium mill and tailings pile at Church Rock, New Mexico. Included in the plan were design features to protect the tailings pile from erosive processes in the neighboring Pipeline Arroyo. The purpose of this report is to provide a review of geologic aspects of the site and form a basis for amending the license approving the reclamation plan.

Traditionally, the design basis used to meet the long-term stability requirement in 10 CFR Part 40 is protection of a tailings pile from extreme events known as Probable Maximum Precipitation (PMP) and the Probable Maximum Flood (PMF). Accordingly, UNC submitted a design including artificial excavation of Pipeline Arroyo to dimensions capable of containing and passing a PMF event without flood flows along the tailings embankment.

Geomorphic Setting of the Site

Pipeline Arroyo and UNC's site occur in an area underlain by Cretaceous sandstones and shales. The rocks dip north-northeast about 3 degrees, forming elongated sandstone cuestas and intervening valleys underlain by intervening mudstones. The Pipeline Arroyo drainage basin is elongated parallel to the cuestas and valleys, converging on and cutting through a narrow bedrock constriction (fig. 1), draining south two miles to the Rio Puerco. In the tailings area, the valley includes a flat valley floor 380 to 500 meters wide. The drainage channel is found at the far western side of the valley. The tailings occupy the greater part of the valley's floor to the eastern hillslopes.

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Pipeline Arroyo is a channel incised in excess of 10 meters adjacent to the pile (fig. 2). The arroyo's vertical banks are subject to mass wasting and erosion, as revealed by aerial photographs and field observations. The channel gradient in the deeply incised area is approximately 0.018. The arroyo has headcut upstream from the Rio Puerco. Approximately one-third of the way northward along the tailings pile, Pipeline Arroyo encounters resistant sandstone bedrock in its channel. The channel rises steeply in a short distance, resulting in a nickpoint that comes to nearly the same elevation as the valley floor. The arroyo no longer occurs upstream, and the channel is unincised on a wide valley floor (fig. 2). The unincised area is a sediment storage area, maintaining a very low channel gradient of only 0.002 (Table 1).

Originally Proposed Design

The applicant's goal is stabilization of the pile for the required 1000 years, using a PMF as the design basis. The applicant originally proposed to excavate through the nickpoint, creating one continuous, straight, and deep channel from the northern property boundary (fig. 2) to beyond the southern end of the tailings pile. The design included lowering the channel in excess of 8 meters at the nickpoint, creating 2:1 sideslopes in the bedrock reach, knocking down the vertical gully walls in alluvial reaches to 3:1 sidelopes, and steepening the channel gradient upstream to about 0.008, and downstream up to 0.025. The goal of this design was to contain the PMF within the excavated channel, preventing high-velocity flow along the tailings embankment. The entire reach of Pipeline Arroyo along the tailings and up-valley would be channelized, and would mostly occur in alluvium. Most importantly, the tailings embankment is adjacent to the channel for a distance exceeding 400 meters, with no intervening buffer area.

DISCUSSION

Current Geomorphic Processes in Pipeline Arroyo

The conditions and processes observed in Pipeline Arroyo are known as rejuvenation, and occur in response to base-level lowering. For several decades, geological and engineering field studies and laboratory simulations have been employed to determine the processes of basin rejuvenation. Base-level lowering creates a nickpoint where the tributary meets the main channel, and the nickpoint begins to migrate up the tributary channel, creating a gully. Once a nickpoint is formed, headcutting in the arroyo is quite rapid, proceeding through a basin in time scales measured in years or decades (Schumm and Hadley, 1957). Typically, the same depth of channel degradation occurs throughout the channel length, with the main impact felt early near the mouth (Begin and others, 1980). The rate of gully growth at any station is initially high, then slowly decreases.

Channels experiencing gullying display unstable conditions downstream of the migrating nickpoint, evidenced by bank failures and high sediment loads (Schumm and others, 1984; Meyer, 1989). Sediment is typically transported downstream as bed load. The applicant has demonstrated that alluvium in this valley is mostly sand sized. In arroyos with sandy bank material, bed load occurs as braided bars and the active channel occupies the entire arroyo floor (Meyer, 1989). Both arroyo walls are nearly vertical, and the arroyo experiences large amounts of widening by bank failure and erosion (fig. 3). These findings resemble existing conditions in Pipeline Arroyo. Unstable conditions continue for extended periods of time, and stability is not achieved until large volumes of sediment are removed, and sediment production upstream abates (Meyer, 1989).

Effects of Channelization

Channelization causes artificial straightening and shortening of a channel, thus steepening its gradient. The steeper and concentrated flow results in increased stream power, leading to channel incision and bank erosion as the channel readjusts to the steeper gradient (Emerson, 1971).

Meyer (1989) summarizes numerous studies of the effect of channelization:

> Channelized or straightened stream channels commonly respond like gullies. Vertical incision results from concentration of flow that formerly spread over the valley floor. After or accompanying downcutting, channel side walls erode, usually by lateral channel erosion and mass wasting of vertical banks. In channelized streams, ten-fold increases in channel area are common, which are attributed to both downcutting and bank-top widening (Meyer, 1989; p. 3-4).

The result of channelization, therefore, is the same as arroyo formation by nickpoint migration. All channel reaches downstream of the uppermost channel modifications are likely to display unstable conditions leading to channel incision, arroyo widening by bank failures, and associated high sediment loads in the channels.

Review of the Originally Proposed Design

All the typical unstable conditions associated with basin rejuvenation are observed in Pipeline Arroyo, and are due to base-level lowering in Rio Puerco. This area is probably in an early stage of basin rejuvenation which became widespread beginning in the late nineteenth century (Cooke and Reeves, 1976). Migration of Pipeline Arroyo's nickpoint, however, has halted on account of encountering resistant bedrock in the channel.

Considering the site characteristics and geomorphic concepts discussed above, it is concluded that geomorphic conditions downstream of the nickpoint are unstable, and the southern one-third of the tailings pile is in jeopardy of becoming involved in arroyo widening. In addition, removal of the nickpoint and channelization of the northern area will result in destabilization of that area, including the area where no buffer area occurs between the embankment and channel. Specifically, the unincised area's valley gradient is probably as steep as is stable. If a gradient steeper than 0.002 were stable, excess sediment would have be deposited upstream to raise valley slope. Thus, the northern part of the site will become susceptible to basin rejuvenation if altered. Without considerable engineered enhancements to this design, it is concluded that the proposal is not likely to provide stabilization of the tailings pile for the time period required in 10 CFR Part 40. These findings were summarized in NRC correspondence dated June 29 and August 16, 1990.

Latest Design Modifications

UNC's submittal of December 4, 1990, provided significant design modifications in consideration of the geomorphic concepts described above. The changes consist of:

1) Changing the proposal to excavate the northern channel. Instead, the existing channel will be altered only to provide a low-flow channel 30 feet wide from the northern property line to the nickpoint. Erosion of the tailings embankment during extreme events will be minimized by construction of an erosion resistant berm along the embankment interceptor ditch at the calculated level of the PMF.

2) Abandoning the proposal to remove the nickpoint by excavation. Instead, the nickpoint will be reinforced with a buried riprap jetty from the exposed bedrock, through the subsurface, to the tailings embankment. This proposal will provide stable base level for the drainage basin north of the nickpoint.

3) Leaving the arroyo south of the nickpoint relatively unaltered. The area known as the sacrificial slope will be regraded to promote sheet flow of direct runoff. In addition, the base of the tailings embankment will be ringed by an interceptor ditch, and runoff from the embankment will be diverted to a controlled structure.

Relying on the long-term stability of the nickpoint and its reinforcement by the buried jetty, it is concluded that geomorphic stability north of the nickpoint is reasonably assured for the required performance period of the remedial action. This assurance is contingent upon the suitability of the erosion resistant berm at the base of the embankment, and the buried rock jetty in the channel.

Stability of the area downstream of the nickpoint is more difficult to assure. Based on the concepts discussed above, it is concluded that the incised arroyo is geomorphically unstable. Erosion and arroyo widening there seems likely to continue, perhaps for decades or centuries, until the arroyo is sufficiently wide to contain a stable channel (Meyer, 1989). Even formidable engineered enhancements to the channel are likely to be undercut or sidecut by continued arroyo growth. The rate of arroyo growth is unpredictable. The tailings embankment now lies 130 to 150 meters from the arroyo. In larger drainage basins, arroyos commonly display width-depth ratios up to 100 (Meyer, personal communication). Experimental evidence suggests smaller basins may stabilize when the ratio is 10. Assuming all arroyo widening occurs eastward, the sacrificial slope is perhaps suitably wide to protect the tailings embankment. The design, however, does not allow for a deeper arroyo, nor for a shift in the arroyo's position in the valley.

In order to add assurance that the sacrificial slope will remain sufficient throughout the performance period, the applicant proposes the following enhancements:

1) The slope of the sacrificial area will be decreased to nearly zero percent near the embankment. Therefore eroded gullies forming on the slope will be unable to headcut to the embankment.

2) The area will be graded to promote sheet flow. Even though the slope is relatively steep (2 to 9 percent), drainage area is small and gully erosion will be limited.

3) Runoff from the embankment will be diverted at a basal interceptor ditch. This runoff will not contribute to erosion of the sacrificial slope.

CONCLUSIONS

Pipeline Arroyo is an example of an unstable drainage basin undergoing rejuvenation. While landscape stability and protection of the tailings is difficult to assure, base level provided by a resistant nickpoint in the arroyo helps assure stability along the northern two-thirds of the tailings embankment. The applicant's design to augment the nickpoint from the channel to the embankment provides reasonable assurance that the northern part of the tailings cell will not be affected by channel processes upstream of the nickpoint.

Meanwhile, there appears to be no reasonable method to prevent geomorphic changes in the deeply incised arroyo downstream of the nickpoint. Given enough time, erosive processes associated with base-level lowering in the Rio Puerco will run their course and remove much of the sediment currently stored in the valley which contains Pipeline Arroyo. The rate and extent of erosion is difficult to predict. The applicant, however, has provided information to conclude that the arroyo will not experience widening exceeding the sacrificial area.

It is concluded that the proposed design and modifications will prevent tailings instability to the extent reasonably achievable.

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Attachment:
As stated

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LFMB
PDR/DCS
URFO r/f
ABBeach, RIV
LLO Branch, LLWM
OB:IMNS:NMSS
JPGrimm
ROGonzales
PJGarcia
BGarcia, RCPD, NM
EMontoya, NM
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REFERENCES CITED

Begin, Z.B., Meyer, D.F., and Schumm, S.A., 1981, Development of longitudinal profiles of alluvial channels in response to base-level lowering: Earth Surface Process and Landforms: v. 6, p. 49-68.

Cooke, R.U. and Reeves, R.W., 1976, Arroyos and environmental change in the American southwest: Oxford, Clarendoc Press, 213 p.

Emerson, J.W., 1971, Channelization: a case study: Science, v. 173, p. 325-326.

Meyer, D.F. 1989, The significance of sediment transport in arroyo development: U.S. Geological Survey Water-Supply Paper 2349, 61 p.

Schumm, S.A. and Hadley, R.F., 1957, Arroyos and the semi-arid cycle of erosion: American Journal of Science, v.255, p. 161-174.

Schumm, S.A., Harvey, M.D., and Watson, C.C., 1984, Incised channels: morphology, dynamics, and control: Littleton, Colorado, Water Resource Publications, 200 p.

Table 1: Comparison of Physical Characteristics of Pipeline Arroyo and its Channel Upstream and Downstream of the Nickpoint Position

	Upstream	Downstream
Gradient	0.002	0.018
Bank Height	approximately 1 meter	up to 10 meters
Channel Form	braided-sinuous	braided

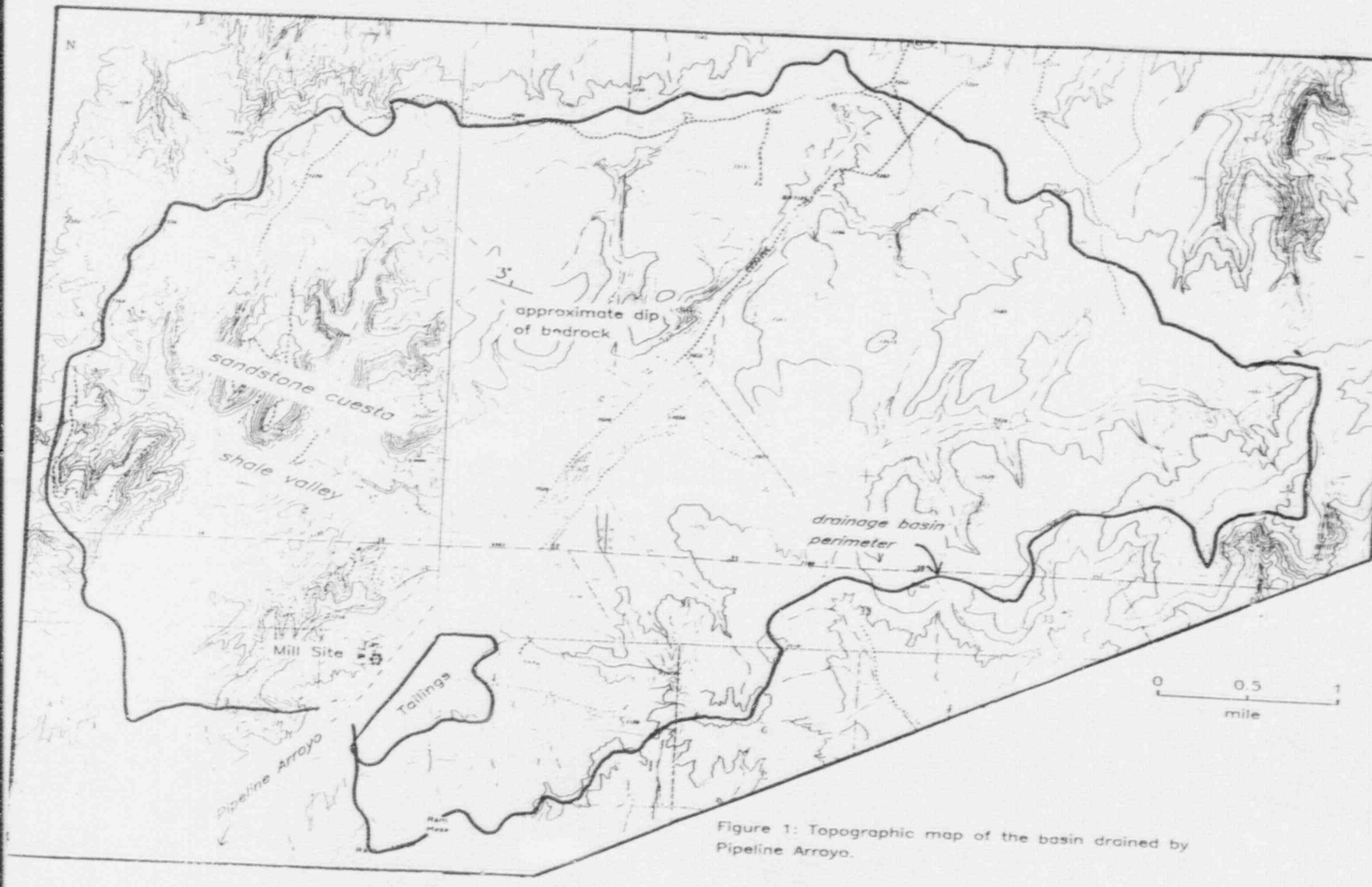

Figure 1: Topographic map of the basin drained by Pipeline Arroyo.

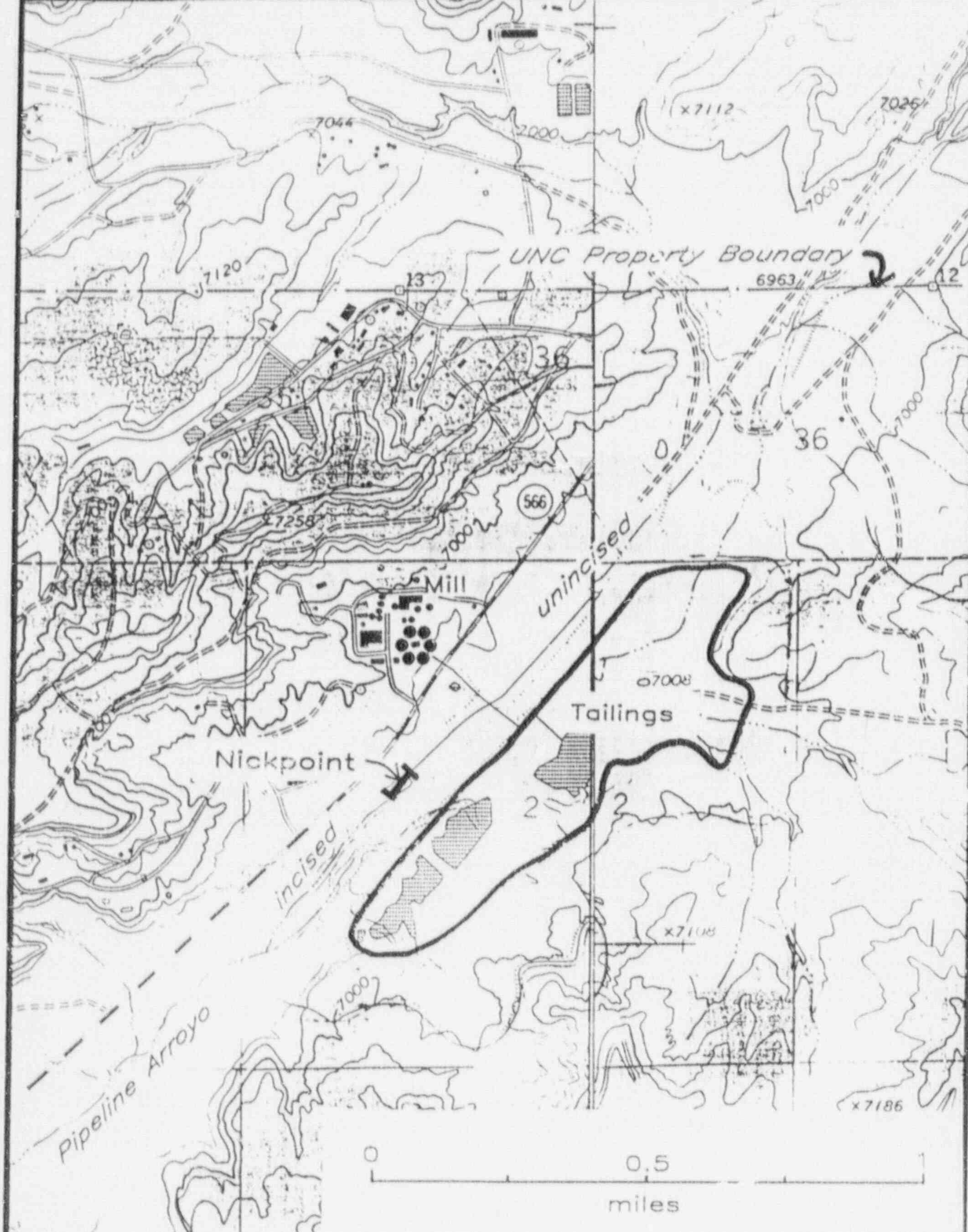

Figure 2: Detailed topographic map of the approximate tailings disposal area and its relationship to Pipeline Arroyo.

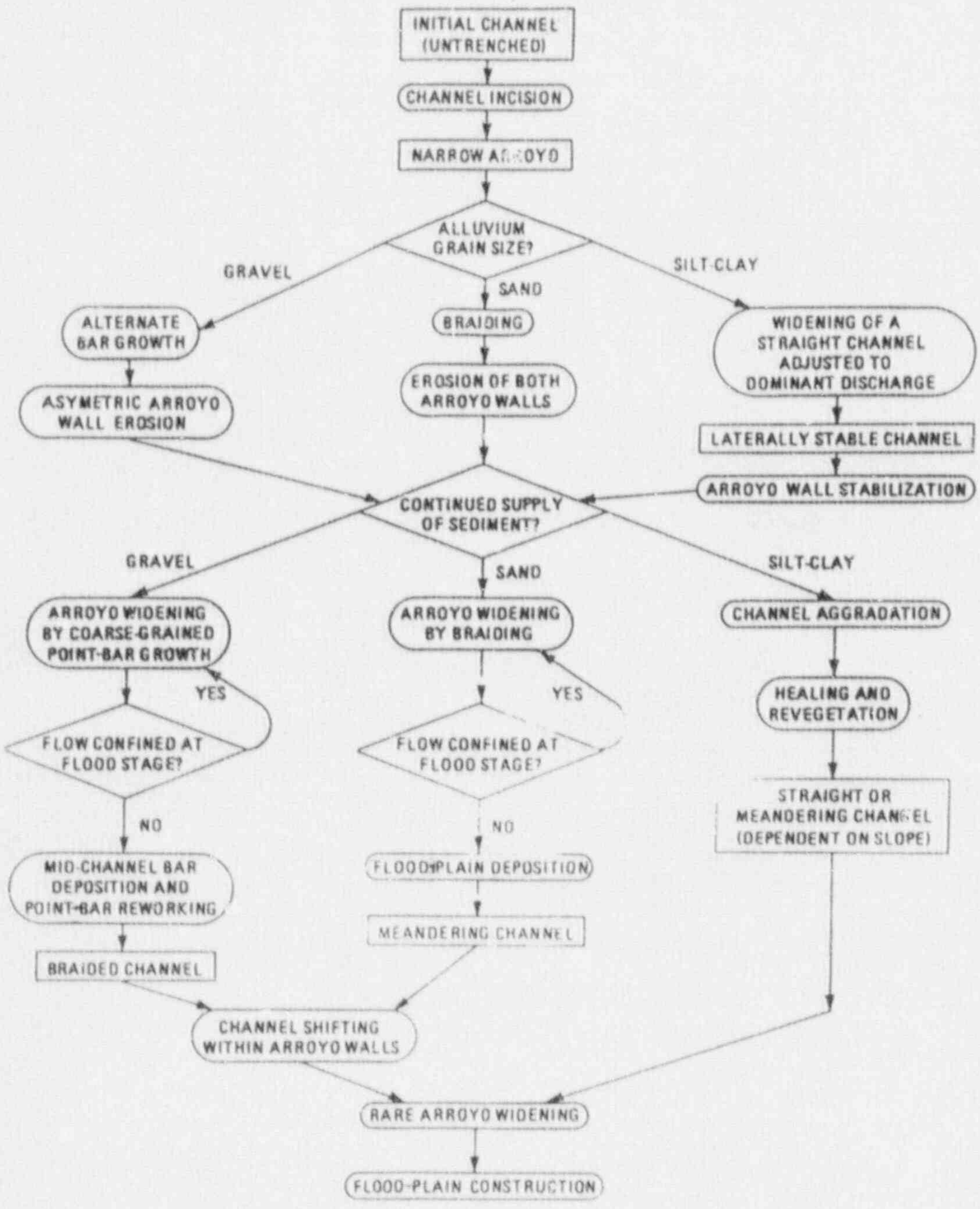

Figure 3: Model of arroyo development in different sediment, based on field studies and laboratory simulations. Pipeline Arroyo conditions are similar to those in the central column (from Meyer, 1989; Figure 37).