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The Nuclear Sea-Level Canal Engineering Feasibility Field Studies and Epistemic Risk in the Darién, 1965–1970

▼ **SPECIAL ISSUE** in *Knowledge and Power: Projecting the Modern World*

▼ **ABSTRACT** What kind of knowledge is needed to blast a seaway across the Central American isthmus with buried thermonuclear bombs? That question pervaded an ambitious Atomic Age project: the proposal to renegotiate the inequitable 1903 treaty between Panama and the United States and to replace the aging, US-controlled Panama Canal and its colony-like enclave with a streamlined waterway. While Cold War-era projects employing the "peaceful atom" may now appear bizarre or geopolitically symbolic at best, the nuclear canal engineering feasibility studies in the Darién had tangible environmental, epistemological, and diplomatic effects. Moreover, despite the futuristic aspirations of the "Panatomic Canal," the investigations perpetuated colonial values. While the field directors learned to respect the region's Indigenous populations and recognized that their landscapes were unamenable to nuclear conquest, the Washington commissioners included tropes in their final report about "primitive" people in "primeval" jungles resisting modernity, and expressed confidence that nuclear excavation technology would still proceed "someday." Examining social and epistemic practices of the isthmian canal field studies, as revealed in public and private records, illuminates problematic continuities in the history of world-building projects by researchers working in transimperial contexts.

▼ **KEYWORDS** peaceful nuclear explosives; fieldwork; Panama Canal; Darién; megaprojects

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BREPOLS

The dream of voyaging across Central America via an interoceanic canal, rather than navigating 8,000 miles around Cape Horn, occupied explorers, engineers, and officials from the moment of European contact in 1513. Colonization, surveying, and excavation attempts ensued over the next 400 years by multiple entities, whom the authors of this special issue deem "projectors"—historian Vera Keller's term for opportunistic, risk-embracing, capitalistic planners of the early modern era.[1] By deploying technoscientific and managerial expertise, the US government completed the Panama Canal in 1914. By raising ships 85 feet through massive locks, the waterway transformed maritime history and signified a triumphal conquest of nature.

Yet within a generation, the canal started to obsolesce. The largest warships could no longer squeeze through its locks, prompting calls to widen it or build a new waterway with a much simpler design—at sea level. The argument for excavating such an enormous amount of earth gained strength after the emergence of nuclear weapons. Why not harness such astounding power to create public works projects via "peaceful nuclear explosives" (PNEs)? This was the rationale of the US Project Plowshare program, one of several Cold War-era initiatives to mobilize nuclear technology for non-military objectives. Plowshare aimed to minimize the cost and risks of constructing infrastructural megaprojects by detonating thermonuclear bombs buried at precise depths.[2]

Today, popular press coverage of Plowshare uses words such as "crazy" and "bizarre"—harking back to the satirical critiques of early modern projects discussed by Keller, Kelly Whitmer, and Ted McCormick in this issue's introduction.[3] Employing more nuance, some Cold War scholars assert the political fictiveness of programs promoting the "peaceful atom," arguing that US officials used them to serve geopolitical and ideological purposes.[4] In this sense, such authorities paralleled early modern projectors who used "grand designs" to serve hidden ends.[5] However, overemphasizing the cynicism underlying state visions of the peaceful atom obscures important real-world epistemic dimensions of these projects. Participants in civilian nuclear demonstration projects and feasibility studies of the 1950s and 1960s produced place-based ecological, geological, and anthropological knowledge, providing precedents for the now-ubiquitous environmental impact statements of modern infrastructural projects.[6]

In this vein, this essay focuses on the "Panatomic Canal," the project to use PNEs to replace the Panama Canal and the surrounding Canal Zone, a 553-square-mile enclave housing thousands of US workers and soldiers, with

1 Keller, *The Interlopers*.
2 Kirsch, *Proving Grounds*; Kaufman, *Project Plowshare*.
3 See, for example, Madrigal, "7 (Crazy) Uses."
4 Hamblin, *Wretched Atom*; Lawrence, "Exception."
5 Keller, *The Interlopers*.
6 See, for example, Coates, "Project Chariot"; O'Neill, *Firecracker Boys*; Keiner, *Deep Cut*; Kirsch, *Proving Grounds*.

a more efficient sea-level channel. To determine the feasibility of excavating a nuclear route across the remote Darién landscape of either eastern Panama or western Colombia, around 900 workers collected geological, hydrological, meteorological, biological, ecological, and medical data from 1966 to 1968. They generated masses of information, including geological evidence of extensive clay shale soils that would not hold up to nuclear excavation. As the canal study commissioners announced in 1970, despite their confidence that "someday nuclear explosions will be used in a wide variety of massive earth-moving projects," that time was not now.[7]

Like the grandiose projects of the early modern period discussed by other authors in this issue, the nuclear sea-level canal studies featured the mobilization of state power, macro-inventions, and assumptions about using new knowledge of supposedly empty spaces to render natural environments maximally productive. Moreover, the nuclear canal feasibility studies speak to the issue's themes of risk, violence, agency, and situated knowledge. Plowshare planners risked irradiating bodies and food chains, as well as violating sovereignty and alienating fragile Cold War relationships, by releasing radiation from nuclear tests across national borders. The field studies inflicted a form of violence against people and environments of the isthmus by clearing forested areas growing sustenance crops.

"Agency" is also a palpable theme, as the project underscored the domination of the United States in Panama dating to the nation's founding. US officials negotiated the nuclear waterway in conjunction with a new diplomatic agreement that would abrogate the inequitable Hay-Bunau-Varilla treaty of 1903, which allowed the United States to operate its own colony-like zone surrounding the waterway. Yet when it came to conducting the engineering feasibility studies, they often overlooked the agency of the Indigenous residents who resisted both Panamanian and US encroachment on their lands.

Finally, this study highlights the theme of "situation" with respect to place-based specialized knowledge. Engineers had envisioned a sea-level waterway across the mountainous isthmus for centuries, but the excavation technology did not materialize until the eras of high modernism and atomic power. While harboring hubristic assumptions about the minimal effects of radioactivity, even die-hard proponents of the nuclear canal recognized the need to acquire site-specific data. However, the knowledge production process faced many problems, including arduous weather, limited funding amid the escalating Vietnam War, disagreement about the kinds of data needed, and opposition from residents of the proposed Darién route of eastern Panama, an area spanning 5,280 square miles and home to around 30,000 people, just over half of them Indigenous.

7 APICSC, *Interoceanic Canal Studies*, 1.

The Panatomic Canal has been explored by several scholars, including me.[8] This article focuses on the land-based engineering feasibility investigations in the Darién of eastern Panama. Employing the lenses of epistemic risk, violence, agency, and situated knowledge illuminates conflicts on the ground between US, Panamanian, and Indigenous workers and residents, as well as moments of the co-creation of knowledge by these tenuous allies. This approach draws inspiration from the editorial vision of this issue, and from recent scholarship in two areas: infrastructural megaprojects as sites of knowledge production, including the generation of data that can be used to delegitimize the projects in question; and "parachute science," the practice whereby researchers from developed nations extract knowledge from Global South field sites without collaborating with local communities.[9] In turn, these critiques, and a tip from historian Roger Turner, led me to a new set of archival records, which I hope will attract other scholars, especially historians of fieldwork.[10]

The Engineering Feasibility Studies and Epistemic Risk-Taking

Project Plowshare began in 1957, with a focus on building a harbor in Alaska with five buried thermonuclear explosives.[11] Despite intense resistance against the Alaska project from both locals and distant environmentalists, the Central American nuclear canal proposal received an unexpected boost in 1964. Violent demonstrations erupted in Panama against the US occupation of the Canal Zone. President Lyndon Johnson responded to the Flag Riots by announcing plans to renegotiate the unequal treaty between Panama and the United States. Not only would the United States reconsider its dominion over the Canal Zone, it would investigate the feasibility of building a new sea-level waterway, which would obviate the need for a large labor force of despised Yankees.[12]

The US Congress appropriated $17.5 million (the equivalent of $172 million today) for the Atlantic-Pacific Canal Study Commission later in 1964. Composed of five citizens with engineering and political expertise, and headed by former treasury secretary Robert B. Anderson—who also led the treaty renegotiations—the commission had the enormous job of determining the best site for a sea-level canal, including "the practicability of nuclear canal excavation."[13] One set of challenges entailed conducting experiments at the Nevada Test Site in ways that would not violate the Limited Nuclear Test Ban Treaty

8 Keiner, *Deep Cut*; Keiner, "Two-Ocean Bouillabaisse."

9 Heine and Meiske, *Beyond the Lab*; Graef et al., "How Is the World Shaped"; Stefanoudis et al., "Turning the Tide."

10 For recent overviews, see Brinitzer and Benson, "Introduction"; Vetter, "History of Fieldwork."

11 O'Neill, *Firecracker Boys*; Kirsch, *Proving Grounds*; Kaufman, *Project Plowshare*.

12 Keiner, *Deep Cut*, chapter 2.

13 APICSC, *Interoceanic Canal Studies*, 1.

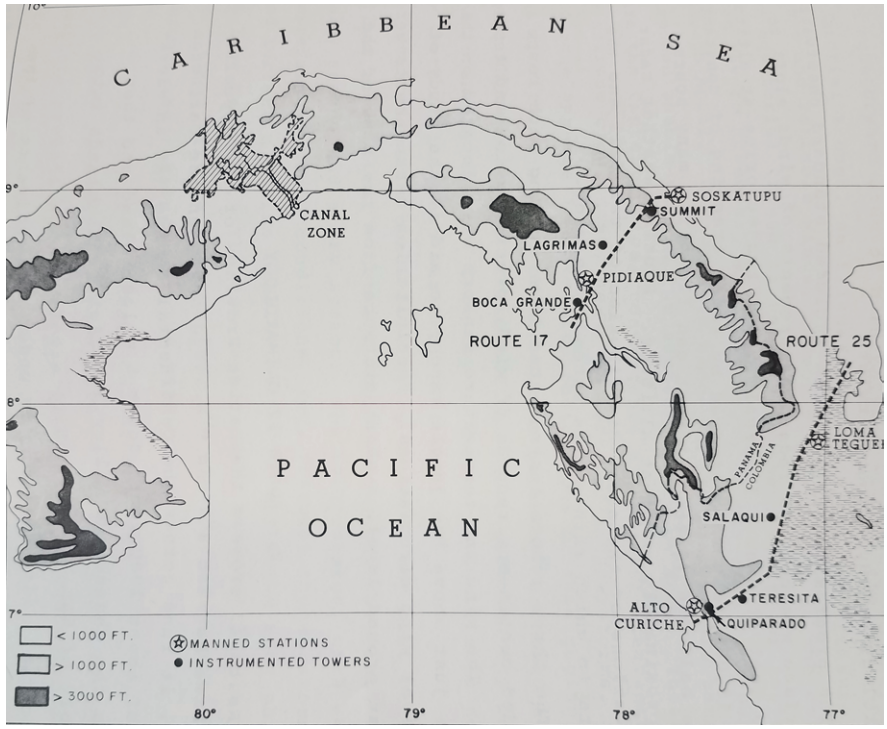

Figure 1. Location of weather stations along Route 17, and other relevant features of the isthmus. Source: List et al., *Meteorological Data Summary*, 3, National Archives and Records Administration.

of 1963; another regarded the coordination of comprehensive field studies of two potential paths: Route 17 in Panama (105 miles east of the original canal) and Route 25 in the Atrato-Truando region of western Colombia. The former encompassed densely forested, swampy river valleys of the Darién isthmus, the 310-mile "gap" of the 19,000-mile Pan-American Highway [**Fig. 1**].[14]

To predict the effects of blasting out a 1,000-foot-wide channel across the Darién, the Anderson Commission relied upon the conclusions of an earlier team, the US Army Engineer Nuclear Cratering Group, that the feasibility studies would need to prioritize geology, hydrology, topography, meteorology, and seismic effects, as well as radiation and human ecology. After much debate, the commission also reluctantly funded studies on the potential for a sea-level canal to facilitate marine bioinvasions.[15] Another contested bioenvironmental issue involved the health hazards facing the field personnel and future construction workforce.[16] Malaria and yellow fever had killed over 20,000 laborers during the aborted French excavations of the 1880s, and it was only by

14 Velásquez Runk, "Creating Wild Darien."
15 Keiner, "Two-Ocean Bouillabaisse."
16 APICSC, Technical Steering Committee, 12.

investigating and destroying insect vectors that US construction proceeded in 1904.[17] Expressing concern about new tropical disease threats, the Surgeon General's office agreed to sponsor "medico-ecology" studies that aimed to update the legendary research of Colonel William Gorgas during the original construction era.[18]

The feasibility fieldwork required not only multiple kinds of expertise, equipment, and funding, but also diplomatic clearance. Except for experiments conducted at military installations in the United States and the Canal Zone, the site studies required permission from the governments of the lands in question. However, securing Panamanian and Colombian consent took much longer than anticipated due to disagreements over labor and equipment contracts, and distrust among the two nations being used as leverage against each other.[19]

In the meantime, the newly appointed Field Director of the Office of Interoceanic Canal Studies (OICS) arrived in the Canal Zone in January 1965, a month into Panama's short dry season. Working from the turn-of-the-century Gorgas hospital complex, Colonel Alexander Sutton began networking with fellow members of the Army Corps of Engineers, the agency that built the original waterway, and other US governmental groups to figure out how to manage the massive data collection program. One of his first jobs involved a reconnaissance trip to Route 17 to scout locations for weather stations and base camps. The trip provided a wake-up call that the nuclear canal feasibility fieldwork might not end as triumphantly for the United States as the Panama Canal project of fifty years earlier.

Knowledge and Power on Route 17

Extending 46 miles from Caledonia Bay on the Caribbean side of the isthmus to the Gulf of San Miguel on the Pacific side, Route 17 intersected the continental divide ten miles from the Caribbean coast. To blast out its maximum elevation—1,100 feet above sea level—the Nuclear Cratering Group had proposed firing 294 nuclear explosives in fourteen separate detonations, yielding an aggregate of 166.4 megatons (for context, the most powerful nuclear weapon ever tested, the 1961 planet-shaking Soviet "Tsar Bomba" blast, yielded around 57 megatons).[20] To avoid the radioactivity, air blasts, and ground shocks, approximately 30,000 people would have to be evacuated "and resettled in adjacent frontier areas," but the Plowshare planners assumed that from such a distance "the possible hazards are not severe, and the outlook

17 Sutter, "A Subversive Bonanza."
18 Stacy et al., "Survey."
19 Keiner, *Deep Cut*, 79.
20 Dowling, "Monster Atomic Bomb."

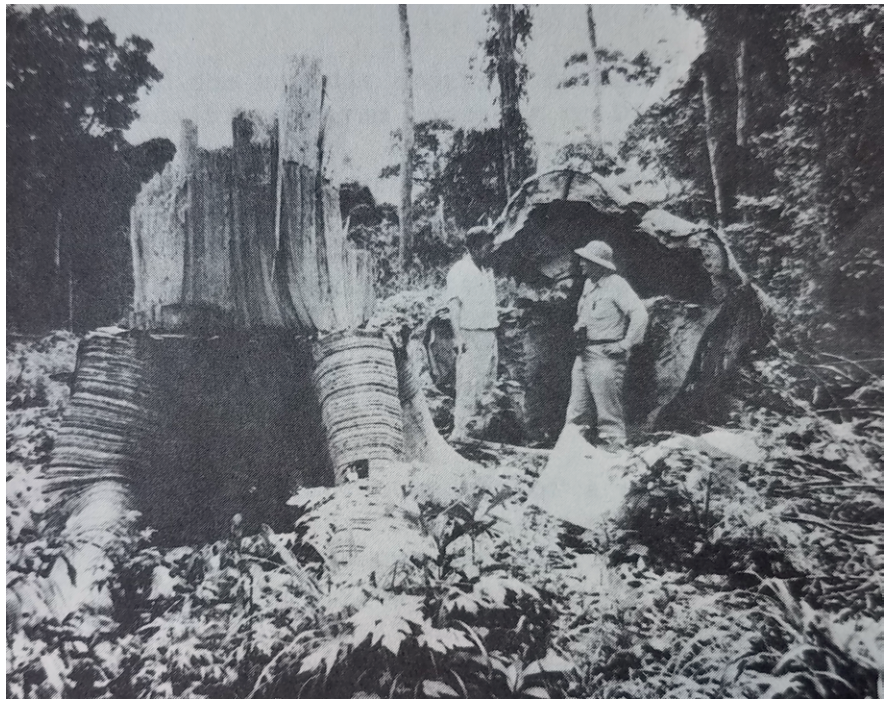

Figure 2. "Site Clearing on Route 17. Note size of Cuipo Tree." Source: Sutton, *Engineering Feasibility Studies*, 29, National Archives and Records Administration.

for control is promising."[21] The Canal Study Commissioners later described the "nuclear exclusion area" of Route 17 as "one of the most primeval and sparsely populated in Central America," containing around 43,000 people, "mainly tribal Indians and others living in small settlements or as migrants."[22] Consistent with other historical acts of projecting, as discussed in this issue's introduction, nuclear seaway planners saw the Darién as an empty space in need of development, rather than one that was already full, of both human and non-human organisms [**Fig. 2**].[23]

In the mid-1960s, the Darién remained so difficult to access that only a few scientific-military teams had surveyed it during the previous century. Inhabited by migrants, mestizo and Black populations, and Indigenous agriculturalists and fishers, including the semi-autonomous Guna (known previously as the Kuna or Cuna), who had a long history of resisting Spanish, Panamanian, and US colonizers, the region featured thick forests and tidal rivers.[24] The lack of roads made it impossible to travel without canoe-like cayucos, planes, and

21 AEC et al., *Isthmian Canal Studies—1964*, 3.
22 APICSC, *Interoceanic Canal Studies*, I-28.
23 Keller et al., "Introduction." See also Velásquez Runk, "Creating Wild Darién," 142.
24 Howe, *A People*; Lindsay-Poland, *Emperors*, 95–96, 101.

helicopters, which remained in short supply due to the Vietnam War. Moreover, the humid eight-month rainy season compounded the difficulties of traveling and surveying. Accordingly, the nuclear canal planners relied on topographical and geological data dating back to the late nineteenth century, along with a few postwar maps.[25]

Sutton made his first reconnaissance trip in 1965 to the Guna village of Morti Abajo, where he planned to arrange with the local chief to hire guides to take his party through the mountain pass to Mulatupo, the Caribbean/Atlantic terminus of the route. Accompanying him were three employees of the Panama Canal Company, including a lieutenant colonel, a guide, a Chocó Indigenous man, and Simon Quirós Guardia, a US-trained Panamanian nuclear physicist who served as the official Panamanian representative for the canal studies. The trip involved flying from Panama City to La Palma, the capital of Darién Province, where about 1,500 people lived near the Gulf of San Miguel, proceeding upstream on the Sabana River in cayucos, hiking through thick forests, and sleeping in hammocks. The cold night air surprised Sutton, as did the swift tidal currents miles inland from the Pacific Ocean, and the disorienting environment: "With no paths, with the jungle appearing exactly the same everywhere, and with having to hack our way with machetes, we were fairly well exhausted after only a few hours." Having finally arrived at Morti Abajo, a village of 130 Guna, he was stunned that his party had to wait while the Indigenous leaders argued in a tent for an hour. A young man who spoke fluent Spanish finally emerged. As Sutton detailed in a long report about the person whom he dubbed "No. 4 Chief,"

> First of all, he objected to our being on their land. We told him that we had permission from the Panamanian Government to pass through but that we had stopped at his village to request his concurrence as well. He informed us that permission from the Panamanian Government was meaningless, as the land belonged to them and was subject only to their laws. He then began to tell us what these 'laws' were—which all involved payments of money from us.

After going back and forth, Sutton and Quirós relented the next day, handing over $75 (the current equivalent of around $725) and saying they would return later to negotiate again after consulting with US and Panamanian authorities. "While they had not threatened us with physical harm," Sutton wrote to his supervisor, he expressed the fear that departing might not be straightforward. Reflecting from the comfort of the Canal Zone, he concluded, "It is difficult to realize that a matter of an hour or so separates the most primitive existence in the jungle from our civilization."[26]

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25 APICSC, *Interoceanic Canal Studies*, V-37.

26 Sutton, "Memo: Trip Report," January 28, 1965, 5, 7.

The experience also led Sutton to issue prescient warnings to the canal study commissioners in Washington about the difficulties of conducting research in the isthmian environment. He called for more powerful radio transmitters and more supply points for the surveying parties, especially fresh water during the dry season, and for building and maintaining helicopter landing sites, roads, and bridges. Moreover, due to the "tremendous Cuipo trees" and the rough, swampy terrain, he anticipated difficulties with the geological studies, and questioned the need for an extremely accurate center-line survey [**Fig. 3**]. Having witnessed several Guna children with serious insect bites, he also recommended collecting comprehensive data on medical, entomological, and environmental conditions. Finally, he wrote, "Permission and cooperation of the Indians—which may reluctantly and greedily be given—will be essential. We must make the necessary agreements through channels, with the top Chiefs—or someone who cannot be overruled."[27]

The following month, in February 1965, Sutton made another trip, this time to the Caribbean San Blas (now known as the Guna Yala) islands of Soskatupu and Mulatupo, with a group of eleven, including Quirós, a physician, and representatives of the US Weather Bureau, AEC, and the Panama Canal Company, to negotiate the development of a meteorological station. The week before, Sutton had made a preliminary visit to ask the local Guna leadership for permission to bring in the large group, which led to better results. As Sutton reported:

> Our reception was so different from that experienced with the village in the interior that it was difficult to believe that both were of the same tribe. Señor Yabiliquina received me graciously, and made a speech of welcome saying that he understood our purpose, held the United States of America in highest regard, and I did him honor to visit him. I replied appropriately, and…he asked to discuss the proposed canal. Specifically, he wanted to be reassured that his people would be taken care of if the canal were built at this site. I informed him that my own role was only that of an engineer engaged in certain preliminary reconaissances, but that I was sure he could consider the history and foreign policies of my country, with which he was familiar, to be promise enough.

To Sutton's surprise, President Yabiliquina then announced that the Guna nation had already planned a congress for the next month, with an expected attendance of 400–500 delegates, to discuss the proposed canal and their concerns.[28] Moreover, they had invited the presidents of Colombia, Panama, and Venezuela, the Panamanian secretary of state and foreign minister, and

27 Ibid.
28 Sutton, "Memorandum re: Visit of AEC," March 9, 1965.

Figure 3. A section of the cleared Route 17 centerline trail through the Chucunaque Valley. Source: Atlantic-Pacific Interoceanic Canal Study Commission, *Interoceanic Canal Studies 1970*, 38.

the Canal Zone governor, and expected representatives of those officials to attend.[29]

Other US members of the visiting team expressed surprise that the tribe owned a radio transmitter and receiver, and that one of its leaders had spent the past three months conducting his own counter-study. As Vaughn Rockney of the Weather Bureau recorded, Chief Estanislao Lopez informed the group that he had been "conducting a census of all Cunas who would be displaced, and their property, number of pigs, chickens, coconut trees, etc. so that if they are forced to move, he has facts on which to base an equitable settlement."[30] Lopez reported that he had counted 4,433 Guna living in San Blas Province in the proposed area for the canal, and estimated that a total of about 20,000 Guna lived in the San Blas Province—a much larger number than in the interior Darién Province.[31] While newspaper and official accounts of census initiatives associated with the canal studies emphasized developing the area's labor and consumption potentials, for Lopez and his people, quantifying their population and resources constituted a vital safeguard against dispossession.

Like Sutton, Rockney recognized that operating a weather station on Soskatupu Island to gain data for the seaway project would require maintaining good relations with the Guna. Rockney wrote that the meeting reminded him of "the Indian negotiations by our Army in the days of the Old West," and that he gave away around 100 Polaroid picture portraits, which the community appreciated. While explaining that the Americans needed to "explain the purpose of our visit in such a way that the leaders of the Cuna Indians would accede to our proposal," he acknowledged their agency: "After all, it is rather presumptuous of the United States to propose to disturb the tranquility of their life, to uproot some of their coconut trees, and, if a canal is dug through the area by nuclear explosives, to relocate 4500 of them to a different place."[32] To minimize the disruptions that the station would cause, he recommended piping in fresh water for the village to relieve the women of having to paddle to the mainland every day to fill gourds with river water, and to abate the skin problems plaguing many of the children.[33] Providing medical assistance likewise struck the US visitors as an important goodwill measure; the physician who attended "was deluged with patients and various cases of sickness, particularly children," and prescribed medicines that Sutton arranged to bring the next time.[34] Finally, Rockney emphasized the importance of forbidding the station employees from pursuing relationships with Guna women.[35] Another member of the trip used implicit language to this effect, stressing that the

29 Steuer, "Interoceanic…Trip Report."
30 Rockney, "Travel Report."
31 Steuer, "Interoceanic…Trip Report."
32 Rockney, "Travel Report."
33 Ibid.
34 Sutton, "Memorandum re: Visit of AEC," March 9, 1965.
35 Rockney, "Travel Report."

proposed island site for the meteorological complex would likely mitigate "the morale problem" by offering "a pleasant place for the men to work," with palm trees and crystal-clear ocean views.[36] The March 1965 visit with the Guna of Mulatupo Island ended with a festive farewell ceremony that appeared to resolve the tensions underlying the fieldwork.

Negotiating the Field

However, a year later the Darién studies still had not officially begun due to delays in obtaining surveying equipment, funding, and land access rights from Panamanian and Guna authorities. In the spring of 1966, Sutton reported the results of another series of site visits to finalize the construction of the multiple hydrology stations along Route 17. This time he brought a different representative of the Panamanian government, the anthropologist Reina Torres de Araúz. She had conducted extensive research on the Guna and Chocó (now known as the Emberá and Wounaan), leading to her role as "the Panamanian equivalent of the Minister of Indian Affairs,"[37] and had participated in a famous four-month expedition attempting to drive across the Darién. More recently, she had received an AEC contract to research the human ecology of Indigenous communities along Route 17.[38] Today Torres de Araúz is remembered for her significant works documenting Indigenous cultures and establishing museums in Panama.[39] More research on her career is needed, and the archival records of the nuclear canal engineering studies provide new insights into her role as an academic and governmental intermediary between Panamanian and Indigenous groups during the 1960s, a pivotal period of infrastructural development in Panama.[40]

In his reports to his supervisors, Colonel Sutton praised Torres de Araúz for smoothing the way in the interior Guna territories where he had encountered hostility the previous year. In response to a request from Chief Iguaihuinape to negotiate payments for conducting the fieldwork on their lands, Sutton and his team visited the villages of Uala and Morti in late April. The two communities each asked for an annual rent of $500 (the current equivalent of $4,700). However, as Sutton reported:

> Dra. Arauz proceeded with a rare combination of diplomacy and firmness to advise the Indian Council that she represented the Government of Panama, and that she had come both to inform them that the engineering studies were to take place and insure their cooperation in the project.

36 Steuer, "Interoceanic…Trip Report."
37 Sherzer, "Moments," 341.
38 Torres de Araúz, *Human Ecology*; Keiner, *Deep Cut*, 82–84.
39 See, for example, Strochlic, "These Women"; Acosta, "Torres de Araúz."
40 Wali, *Kilowatts and Crisis*.

> She explained that the studies were a joint project of the Governments of Panama and the United States, and that Panama had agreed to make the government lands available for that purpose, to the Office of Interoceanic Canal Studies as represented by Colonel Sutton.

In both Uala and Morti, when leaders pressed for payment for the use of their lands, Torres de Araúz replied that the lands belonged to Panama, which had "no intention whatsoever of making any payments for the use of its own lands." She emphasized "that there would be full cooperation and no interference with the study personnel." To Sutton's amazement, she secured written agreements from the Indigenous chief and secretary of each village affirming their understanding of "her terms."[41]

At the same time, Guna members of the Uala community mounted a counter-negotiation by presenting governmental maps and letters outlining their right to hunt and fish on the lands in question. The documents led Torres de Araúz to assure them that in exchange for their cooperation with the fieldwork, her committee would attempt to gain future recognition of their claims. She and Sutton also negotiated several specific requests from the two village leaders regarding the participation of locals. They agreed to hire only native people at the rate of $3 per day for unskilled labor (and to restrict such hirings "in the Uala area to Uala Indians and in the Morti area to Morti Indians"), to pay each village chief a lump sum "as if he were a labor contractor," to buy fruits and vegetables from locals, and to obtain boots for the workers. To show respect and maintain good relations, they also agreed to keep the US and Panamanian fieldworkers away from the Indigenous settlements, wear badges to show they were not loggers, and avoid "killing game or exploiting certain trees and herbs on which the Indians depend for their livelihood."[42] Sutton's office also provided fresh water to the community by drilling a well.[43] In late May 1966, Sutton expressed relief that he had obtained all the needed permissions to proceed with the engineering studies along Route 17, noting, "Dra. Arauz is to be congratulated upon her ability, knowledge of the Indians and how to deal with them, and above all, upon achieving the results desired in so short a time."[44] Torres de Araúz also helped resolve a major break in trust a few months later between the US fieldworkers and the island Guna, after the former cut down trees without permission during construction of the weather station, leading to a compensation ceremony featuring photos of Sutton paying Yabiliquina a stack of bills.[45]

Sutton's colleague, Glenn Stallard of the Weather Bureau, also traveled with Torres de Araúz to the aforementioned islands in May to finalize the plans

41 Sutton, "Memorandum: Trip Report of Route 17," May 27, 1966.
42 Ibid.
43 Sutton, "Advance Party Construction."
44 Sutton, "Memorandum: Trip Report of Route 17," May 27, 1966.
45 For some of the photos, see Keiner, *Deep Cut*, 83–84; Lindsay-Poland, *Emperors*, 95.

for the meteorological station complex. He reported that upon arriving, his party stood on the airstrip while "Dr. Arauz and her group visited the Indian Chiefs on Mulatupu Island to confirm that our party was granted permission to perform reconnaissance on Soskantupo [sic] Island." About an hour later she returned with two Guna guides and announced that Stallard's team members were free to explore. To his astonishment, within minutes of embarking upon their expedition, one of the guides motioned for everyone to stop, and calmly decapitated a palm viper hiding along the trail. "This experience, although not at all frightening," wrote Stallard, "makes me well aware that snake-bite kits must be an essential part of our medical supplies at all site stations."[46] It was a wise warning about heeding the knowledge and agency of locals in such a perilous place.

Danger, Datafication, and Demobilization in the Darién

Work finally proceeded during the 1966 rainy season, with almost 300 US, Panamanian, and Indigenous people conducting the Route 17 studies.[47] Most of the work involved the tedious, and often hazardous, collection of data. Technicians dodged snakes and slogged through the tropical heat drilling for soil samples, launching balloons and rockets to conduct high-altitude air studies, triangulating landscape features, and measuring streamflow, rainfall, temperature, and other variables along the route and at the weather stations they built. Other workers counted village members and interviewed them about their diets and sustenance practices. By recording millions of data points in logs archived by the OICS, the project analysts sought to elucidate the region's subsurface geology, drainage areas, coastlines, seafloor, climatic patterns, and food chains. This new knowledge would in turn provide the foundation for predicting radioactive fallout patterns and otherwise assess the opportunities and risks of nuclear excavation technology. In conveying these taxpayer-funded activities in reports to the Washington-based commission, Sutton included photos of some of the Indigenous field and lab assistants [**Fig. 4**]. However, the captions did not usually include their names, and thus we do not know what became of these "invisible technicians"—an all-too-common theme in the history of science.[48]

Fieldworkers faced multiple risks, from machete fights and helicopter crashes to bat bites and disease-causing microbes. Before entering the field, all non-Indigenous personnel had to provide blood samples.[49] The first round of blood tests, surveying 965 individuals in Panama and Colombia, revealed

46 Stallard to Sutton, May 23, 1966.

47 US Army Corps of Engineers, IOCS Memorandum, 1.

48 Shapin, "Invisible Technician"; Doel and Henson, "Reading Photographs." See also Dent, "Whose Home."

49 Eldridge et al., "Survey."

Figure 4. "Work in Medico-Ecology Laboratory, Route 17. Native Choco Indians were trained as technicians." Source: Sutton, *Engineering Feasibility Studies*, 34, National Archives and Records Administration.

antibodies for at least eight arboviruses, "some of which might be potential health hazards for non-immune or large populations moved into the two route areas for construction of the proposed Interoceanic canal."[50] The medico-ecology studies also required 274 personnel working on Route 17 to provide stool samples to investigate diarrhea; technicians then prepared the samples to be flown for analysis at the Gorgas Memorial Laboratory in Panama City.[51] Although the medical researchers sought to conduct repeat bleedings, the low incidence of follow-ups suggests resistance to such invasive procedures.[52] Researchers also trapped 528 animals, including rats, opossums, bats, and birds, and killed them with chloroform to analyze the presence of entereobacterial infections.[53]

50 Srihongse et al., "Survey."
51 Kourany and Vásquez, "Survey" [VI].
52 Stacy et al., "Survey."
53 Kourany and Vásquez, "Survey" [VIII].

To prepare for the dangers in the field, the fieldwork leaders had access to a 1963 booklet titled *Survival Manual: Pacific Panama* by ethnobotanist James A. Duke. Like Torres de Araúz, Duke received a contract to conduct research of relevance to radiation ecology along Route 17; his work focused on isthmian plant communities and relied on extracting knowledge and 8,000 botanical specimens from local people and environments. His resulting "Darien Ethnobotanical Dictionary" listed the colloquial and scientific names and uses of hundreds of plants. One of the OICS publications included Duke's claim that hiring Indigenous workers had led many to convert "from an agricultural to a commercial or semi-commercial existence," and that his team had taught "the Indians many new uses and previously unknown facts about their own native plants and animals."[54] Duke went on to an illustrious career, publishing guidebooks as well as digital databases still maintained in his name by the US Department of Agriculture.[55] But like many Global North scientists who have conducted research in the tropics, he did not share co-authorship credit with his Indigenous informants.[56]

In addition to overseeing the logistical details, Sutton's OICS team endeavored to generate good publicity, especially by working with journalists to emphasize the economic value of the research, and the sharing of it with Panama officials. Sutton commended Torres de Araúz in one such article in the *Panama American*, which included photos of him, her, and her husband with the survey team.[57] Another newspaper noted, "The investigations going on in Darien, a jungle covered area virtually unexplored in detail until now, hold the promise of opening up a new frontier" regarding the area's mineral resources, hydroelectric power potentialities, and a precise census.[58] As in the early modern era of projecting, convincing skeptical stakeholders to buy into a grandiose endeavor often relied not only on its benefits *per se*, but also on its ability to generate valuable spin-offs.[59]

The Route 17 field studies ended in 1968 when the money ran out, and Congress refused to appropriate further funds or to extend the final report deadline, having already done so once. Sutton's focus shifted to shutting down the programs and infrastructure. The San Blas meteorological complex that had entailed so much negotiation was one of the first to go; although the United States gave it to the community, "the Indian Chief advised the Field Director that he intended to demolish all of the structures at Soskatupu and to utilize the materials within the villages."[60]

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54 US Army Corps of Engineers, IOCS Memorandum, 11.
55 USDA, "Dr. Duke's Phytochemical."
56 See, for example, Duke, *Isthmian Ethnobotanical Dictionary*.
57 Sarmiento, "What's Happening."
58 "US, Panamanian Scientists."
59 I thank Keith Pluymers for emphasizing this point.
60 Sutton, *Engineering Feasibility Studies*, 47.

The demobilization process also entailed analyzing the mass of data collected. The Anderson Canal Study Commission focused its final report on the nuclear excavation feasibility question, including previously classified revelations about the poor performance of PNEs in wet tropical clays, which undermined the entire rationale of the nuclear project.[61] On the other hand, Sutton's final OICS report emphasized the mechanics of running a smooth field operation in the event that the canal studies resumed with conventional methods. While noting the project's limitations, he included some defensive justifications, attributing the one fatality, of a Colombian contract employee who drowned in the Truando River when his cayuco capsized, "in part to the difficulty of enforcing safety regulations (i.e. wearing a life preserver) by small, isolated, native parties under a native supervisor."[62]

Regarding the interactions with Indigenous communities, Sutton concluded, "among the lessons learned (the hard way) was the fact that the primitive Indian tribes would object to any penetration of their lands, and that action to reach an agreement with these Indians would also be a prerequisite to operating within their 'reservations.'"[63] In addition, without naming her, he commended Torres de Araúz: "Through the exercise of diplomacy and assistance of a Panamanian expert in Indian relations, and perhaps most importantly the provision of medical assistance, a working relationship was established with the three major Indian Chieftains which permitted the studies to proceed." If a future project led to the evacuation of Indigenous isthmian communities, warned Sutton, authorities must consider their physical well-being as well as their culture, which included holding certain birds, animals, and rocks sacred. Finally, in an implicit nod to the media-savvy Guna, he noted the importance of public relations: "Advance preparation with these people by understanding and sympathetic representatives should be made in order to avoid a major problem and much adverse publicity."[64]

Yet the official final report of the Canal Study Commissioners in Washington, *Interoceanic Canal Studies 1970*, described the Indigenous population in offensive ways that seemed more redolent of 1870:

> The Panamanian government has a special agency to deal with the San Blas Cunas, whose culture has been thoroughly studied. The interior Cunas avoid strangers and relatively little is known about their culture and tribal organization. Hostility to the white man has been passed from generation to generation since the time of the conquistadores. Both the San Blas and interior Cunas could be expected to resist any efforts to move them in order

61 Keiner, *Deep Cut*, 107; Coulombe, "Searching for Stability."
62 Sutton, *Engineering Feasibility Studies*, 53.
63 Ibid., 11.
64 Ibid., 12, 53.

> to permit canal construction. The Choco Indians might be more amenable to such a shift.[65]

The question of Indigenous resistance to displacement, while expressed in demeaning ways that undermined their agency, was not abstract, and it demonstrated what was at stake for isthmian groups facing proposed megaprojects by outsiders.

In 1968, General Omar Torrijos seized control of the Panamanian government via a military coup. Seeking to modernize the nation, he accelerated plans for a different development project in eastern Panama, the Bayano hydroelectric dam. Despite the recommendations of Torres de Araúz and other Panamanian anthropologists that the affected Guna and Emberá communities should have a say in their relocation following the flooding of their lands, the government's resettlement process generated intense dissent among the 4,000 displaced people. Recognizing the risks of bad publicity, Torrijos visited a Guna village in 1974 with two of his World Bank backers to assure them of his respect. However, insufficient compensation following the dam's completion in 1976 led the Bayano Guna to organize Pan-American Highway blockades and other dramatic protests during the mid-1970s and 1980s.[66] Since then, despite a façade of support, Panamanian neoliberal policies have further weakened Indigenous land rights.[67] Perhaps for Torrijos and his successors, the Route 17 nuclear project functioned as a powerful impetus to develop other aspects of the Darién, no matter the opposition. As geographer Jonathan Peyton argues, unrealized projects can generate capacities and "conditions of possibility" for envisioning new plans for resource-rich landscapes, and the means of mobilizing state and corporate power to implement them, despite high risks and past failures.[68]

Conclusion

The nuclear seaway proposal might appear to have been a mere quirk of the Cold War that epitomizes the hubris of nuclear physicists and their political allies, a bizarre megaproject destined to be defeated by the rising power of environmentalism. However, the sea-level canal feasibility studies show how even unrealized projects can have epistemic, material, and social effects that ripple out over time.[69]

By deploying hundreds of workers to collect geophysical and medical data, the nuclear canal fieldwork generated new scientific information about

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65 APICSC, *Interoceanic Canal Studies*, V-43.
66 Wali, *Kilowatts and Crisis*.
67 Velásquez Runk, "Indigenous Land."
68 Peyton, *Unbuilt Environments*, 11.
69 See also Covich, "Projects"; Carse and Kneas, "Unbuilt and Unfinished."

a part of the world that had long remained elusive to colonizers, the Darién. The studies generated numerous peer-reviewed articles, gray literature, and opportunities for advancement among at least some of the participants.[70] Moreover, building weather and hydrology stations, campsites, helicopter landing pads, and other infrastructure had environmental impacts that affected relationships with the Indigenous residents of Route 17. By negotiating these mini-infrastructural projects, US and Panamanian engineers on the ground learned to respect the agency and expertise of Indigenous authorities, rather than dismissing them as uncivilized. They also learned that even the most violent technology in the world, the thermonuclear bomb, was not suitable for digging massive ditches in the wet clay shales of the Panamanian isthmus.

Even so, the Washington-based commissioners remained spellbound by the promise of PNEs, and recommended that Congress continue to support Project Plowshare "until definitive answers are obtained," which might take another twenty years.[71] Mounting criticism and budget deficits led to Plowshare's demise in 1977. That same year, the United States and Panama ratified a new treaty that relinquished US control of the Panama Canal and Zone in 1999, but which also included an option for a non-nuclear sea-level canal.[72]

In recent decades, Panama and other developing nations seeking to modernize seemingly unproductive landscapes through massive infrastructure projects have replicated some of the violent entanglements of knowledge and power examined in the studies of this special issue. At the same time, local communities in tropical nations have called for greater acknowledgement and participation in projects extracting knowledge from their environments.[73] Despite increasing historiographical attention to the ways in which Western scientific endeavors in the Global South facilitated inequitable, transimperial connections between scientific, political, and economic missions,[74] most scientists did not begin to address this problematic history until 2020, when the COVID-19 pandemic lockdowns prevented Global North scientists from traveling to the tropics to conduct research. Since then, criticisms of "parachute science" have intensified in the scientific literature.[75] When metropole researchers conduct short-term studies at biodiverse-rich sites without building collaborations with locals, they perpetuate the structural disadvantages afflicting scientists in the developing world. When they perform such research for infrastructure projects, as in the case of pre-development environmental impact statements, they perpetuate even greater harm if they fail to include local scientists and resource users in analyses of alternatives.

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70 Covich, "Projects"; Keiner, *Deep Cut*, 88.
71 APICSC, *Interoceanic Canal Studies 1970*, 41.
72 Keiner, *Deep Cut*, chapters 7–8.
73 See, for example, Alper, "Smithsonian."
74 See, for example, Raby, *American Tropics*.
75 Stefanoudis et al., "Turning the Tide"; Asase et al., "Replacing 'Parachute Science.'"

Cognizance of these damaging legacies, both past and present, should be part of the scientist's toolkit. The long history of projects and their entangled knowledge practices, from the early modern period to the Atomic Age and beyond, offers a means of envisioning more just futures for all inhabitants of the planet.

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