Mirror Macro-Imagineering Water Supply Megaprojects: Pipedream Chile-California Complementarity?

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Abstract: Two tractable New World west-coast Mediterranean climate zones, burdened with increasing urbanized populations, must each be transformed by humans because of inherent North-South variances of natural precipitation. In other words, each politically-defined landscapes must technically devise its own anthropogenic dimension for future prosperity induced by the prospect of a plentiful freshwater supply. Both the nation of Chile, as well as the State of California (USA), have investigated the hypothetical use of gigantic offshore buoyant freshwater pipelines to serve their coastal and inland population's needs. This report is meant to inspire and engage the next generation of Macro-Imagineering experts.

Key words: Submarine pipeline, freshwater transport, Chile, State of California, geographical similarities.

Resumo: Duas zonas de clima Mediterrâneo na costa oeste do Novo Mundo, sobrecarregadas com o aumento das populações urbanizadas, devem ser transformadas por seres humanos devido às variações inerentes de precipitação natural entre o Norte e o Sul. Em outras palavras, cada cenário politicamente definido deve tecnicamente conceber sua própria dimensão antropogênica para a prosperidade futura, induzida pela perspectiva de um suprimento abundante de água doce. Tanto o Chile como o Estado da Califórnia (EUA) investigaram o uso hipotético de dutos de água doce flutuantes (*offshore*) gigantescos para atender às necessidades de suas populações costeiras e interiores. Este relatório tem como objetivo inspirar e engajar a próxima geração de especialistas em *Macro-Imagineering*.

Palavras-chave: Aqueduto submarino, transporte de água doce, Chile, Estado da Califórnia, semelhanças geográficas.

1. Introduction

Earth's principal watershed separates the drainage regions of the Atlantic, Pacific and Indian oceans; in the New World the watershed follows the Cordilleran Belt, which includes the Southern Hemisphere's Andes Mountains, as mapped by the indefatigable Russian geographer A.A. Tillo (1839-1899) by 1887 AD. Numerical model experiments show that both coastal Chile, extending latitudinally 4,200 km between latitudes 170 30' South and 560 00' South, and the USA's State of California located in the Northern Hemisphere would become more arid climatically if our Earth actually spun in a retrograde rotation [1]; in other words, even with an Earth spinning backwards, their thirst-beset, needful populaces would still have to technically overcome significant urban and agricultural freshwater supply macro-problems for all human

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inhabitants! Ultimately, the definition of "fresh-water" is a function of the actual end-use of water — human consumption, river release and industrial applications/municipal uses [2-3]. Homo sapiens' working real-world collaboration with our Earth-biosphere's total water mass means that, from our multiple regionalized human outlooks, major parts of our world's natural hydrologic cycle is rapidly becoming properly named the "hydro-social cycle" [4]. Well before the World Wide Web's advent, agriculture, mining and cities are humankind's longest-running examples of "open-source" megaprojects.

The northernmost part of Chile is likely our planet's driest region while the southernmost part of Chile is probably the wettest extra-Tropical Zone region of our Earth-biosphere. Chile's physiography stimulates the divergence of expert opinions about the comprehensive management of its natural freshwater resources — ~928 km^3, 7.9% of all South America runoff [5]. The UNO, as well as other concerned organizations, hold the threshold value internationally considered minimum for sustainable development is ~2,000 m^3/person/year; from Chile's capital, Santiago, to the far-north desert, the average freshwater availability is only ~800 m^3/person/year whilst, by marked hydro-social contrast, from Santiago to the far-south freshwater availability exceeds 10,000 m^3person/year! The rain-shadow effect of the Andes Mountains maintains the hyper-arid conditions of the Atacama Desert in northern Chile and the South Pacific Ocean's cold northward flowing Humboldt Current paralleling Chile's shoreline further contributes to the south-north latitudinal desiccation landscape geography. A Mediterranean-type climate occupies a narrow ocean-adjacent landscape zone from 300-360 South latitude. However, all 21st Century climate regimes are changing and this evident and appreciable alteration has come just as freshwater availability is increasingly vital to intensifying industrialization and mining of Chile's northernmost landscape. The aquifers (groundwater) of Chile's northern and central landscapes suffer overexploitation as well as natural and anthropogenic pollution! Freshwater pollution in northern Chile is mainly the naturally mineral-rich soils formed by ancient and modern-day erosion of rock formations bearing contaminants such as copper, molybdenum, boron, aluminum and arsenic whereas in Chile's central Mediterranean climate zone most of the apprehensive freshwater pollution seems to originate from cities and modern agriculture's use of artificial chemicals. In the past, anthropogenic freshwater supply management systems were typically designed and operated under the assumption of stationarity; this normal operational assumption is nowadays invalid under increasingly sophisticated and perfected global and regional climate change modelling scenarios [6-7]. Coordinated management of the total natural flowing freshwater resources of Chile's northern, central and southern regions, perhaps to most embellish its coastal Mediterranean climate zone where most of the nation's human population dwells and works, is of paramount national importance to forestall or prevent freshwater insecurity (stimulated by meteorological droughts, desperate user competition, over-allocation of available freshwater and freshwater supply infrastructure damaged or destroyed by commonly world-renowned earthquakes accompanied sometimes by major tsunamis) [8].

2. Submarine Pipeline, Chile

Long-distance freshwater transport by can be accomplished by the emplacement of a system of pipes forming a continuous pipeline carrying that chemically stable substance, so vital to human prosperity and comfort, to wherever it has been deemed to be needed. Team Geographos visualizes submarine pipelines as reserve supply tanks, a kind of elongated storage "bottle" which ought to be complemented by carefully built back-ups on land since freshwater dependency is

not desirable. Chiles' Minister of Public Works first sent a letter of interest to Via-Marina, focused on its Subma-River (submarine river) concept, during June 2009; Via-Marina's freshwater-carrying flexible undersea pipeline — dubbed Subma-Flex — is secured by the European Patent Office publication EP 2,788,643 B1 as a proprietary protected technology. Via-Marina emphasizes the pipeline's structural flexibility because the well-known natural occurrence of major seismic events in Chile arouses skepticism amongst a few potential design and construction partners and ordinary financial investors. The quite recent Maule region earthquake, with its epicenter near Chile's second largest city, Concepcion, stalled temporarily governmental consideration of this proposed 2,500 km-long megaproject transporting freshwater abstracted from the Bio-Bio River and then inexpensively pumped to northward to Arica situated near the Chile-Peru border. The most recent news-media provided status report of related organizational activity dates from late-2017 AD. Patent holder Mr. Felix Bogliolo, presently listed as a Founding Partner and the acting Chief Executive Officer of Via-Marina, when contacted on 11 October 2018 through the business entity's Via-Marina website (http://www.via-marina.com), declined to provide any "sensitive", generally enlightening or substantial information whatsoever. However, according to data provided in various documents derived from a thorough search of the Internet, in the Chile setting and instance, Via-Marina offered to convey 2.6 million m3/day of freshwater moving at 30 m^3/second, shifted geographically at a basic energy cost of ~0.9 kWh/m^3 from the Bio-Bio River, situated adjacent to but south of earthquake devastated Maule, to the Arica coastal segment of northern Chile. The Mean Annual Runoff difference between these two places could not be more startling: a ~335 m^3/second flow for the Bio-Bio River versus ~0.3 m^3/second outflow at Arica — that is, ~1116 times more freshwater river runoff per second! A submarine pipeline would be a difficult target for petty or major freshwater thefts, nuisance vandalism, industrial sabotage and even some inadequately strategized terrorist-schemed onslaughts on Chileans. Figure 1, prominent base image of South America, illustrates the maximum possible extended length of a national Subma-Flex pipeline that is geopolitically conceivable as of late-2018 AD. (As mentioned earlier in this Section 2, Mr. Felix Bogliolo declined to offer publicly a location-precise map of Via-Marina's proposed offshore undersea route.)

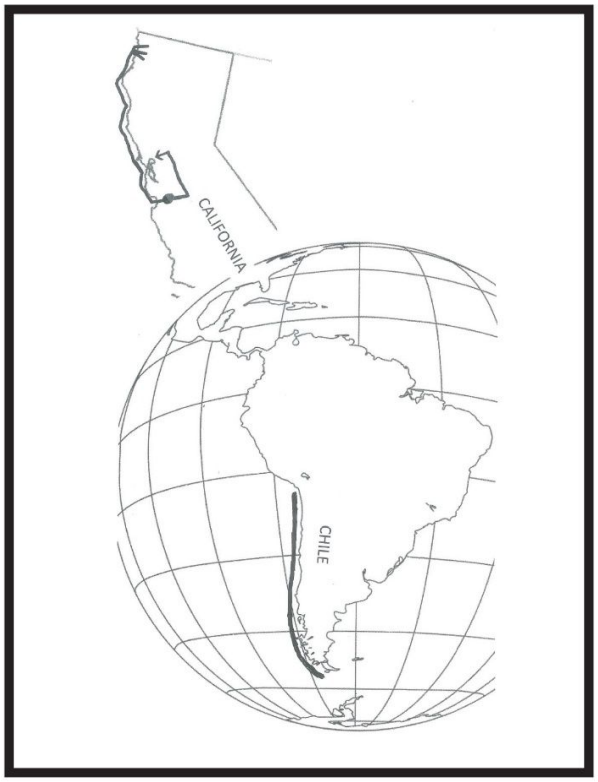

Figure 1. The maximum possible extended length of a national Subma-Flex pipeline in Chile.

As is the case of Subma-River, publicly available information on any macroproject is usually imperfect, rarely complete, and often lacking in absolute revealed clarity. Team Geographos, surely characterizable as upstarts in the offshore infrastructure business, here boldly suggests several possible improvements for the Subma-River concept as it is here applied to Chile's coastline. First noticed elsewhere during the mid-1960s

[9], beach-sited groundwater springs supported pre-historic human populations living on the distant island of Rapa Nui, Chile [10]. Though known coastal aquifers are present in the northernmost region of Chile, most known to exist in the Atacama are located in fluvial valleys on land, none yet known to be offshore. Yet, at Surquillo, Peru, freshwater is currently pumped from beach-located wells which is subsequently distributed by ordinary commercial tanker-trucks [11] and meteoric-origin freshwater exists in quantity within the marine sediments near Callao, Peru's biggest international seaport [12]. In the context of northern Chile, tanker-trucks might in future be assisted in especially hilly landscapes by dedicated funicular railways using freshwater-transporting pods than can be rolled horizontally from trucks to railway flatbed wagons where they would be latched to assure immobility during transit. Perhaps intensive 21st Century exploration of Chile's offshore continental shelf ought to be done to develop supplemental or emergency resources for the Subma-River mega-project? Furthermore, a reflective Team Geographos recommends Beryle D. Brister's US Patent 4,220,012, "Apparatus for freezing a slug of liquid in a section of large diameter fluid transmission line", awarded on 2 September 1980, as a potentially worthwhile and economical means for controlling the Subma-Flex freshwater inflows and outflows at important places along the submarine route. Since the undersea pipeline is necessarily affixed to the seafloor with numerous anchor moorings, why not utilize its obligatory structural fixity for useful and profitable macro-planned structural add-ons, such as associated aquaculture installations (fish-farming, seaweed farming)? Even when moored, inhabited artificial islands afloat on the ocean's surface above the invisible South-North flowing freshwater pipeline does not seem too ridiculous as a viable Macro-Imagineering proposition! Such installations are possible as the submarine pipe, filled with freshwater, naturally floats because of a density difference with seawater; consequently, the submarine freshwater pipeline will bend upward slightly between its vertical anchors, some of which could be perhaps intentionally spaced more widely at desirable geographical ocean-surface sites. Under the influence of seawater currents, the flexing submarine pipeline can be monitored by attached remote-reporting devices powered by piezoelectric patches attached to the constantly vibrating pipeline. Nothing ambiguous is deemed impossible, just so long as Macro-Engineering can make it happen eventually whenever afterwards the real-world economic cost appears to be reasonable; a corollary rule of commerce is that every situationally non-recurrent — that is truly unique — macroproject must also be constructed by closely associated and cooperative public event-managers, news-media consultants, website-masters, region marketers, brand-name formulators and politicians. In its present-day formulation, Chile's serious and sober-minded announced investigations of a seemingly feasible real-world civilian submarine freshwater pipeline megaproject cannot be compared to any distasteful, illegal drug-induced human pipedream!

3. Submarine freshwater pipeline, State of California (USA)

In the USA, the State of California's coastline extends from 32^0 30' to 42^0 North latitude, a shoreline of ~1,350 km. Like Chile, the disparity of coastal zone river runoff regimes is remarkable: the State's North Coast has an annual runoff of ~35.6 km^3 while the Sacramento River (27.6 km^3) and San Joaquin River (9.7 km^3) finally debauch into the Delta Region and thence into San Francisco Bay. In contrast, the South Coast has a runoff of merely ~1.5 km^3 yearly — in other words, ~48 times less than the North Coast alone! "California's [fresh-] water landscape has been reengineered so that roughly 75 percent of the *demand* for water originates south of Sacramento, although 75 percent of the water *supply* in the state comes from

north of the capital city" [13]. The key fact relevant to *Team Geographos*' proposal in Section 3 is that, because of persistent long-term farming and some established industrial use, the only freshwater entering the Delta Region since World War II issues from the Friant Dam Reservoir with some enhancement by selenium-infused farm return drainage and urban sewage! In other words, like today's repugnant Salton Sea located in Imperial County in Southern California, the lower reaches of the San Joaquin River is a perennially polluted human-designated "sump sacrifice region" that contributes to the further degradation of beloved San Francisco Bay ecosystems. Since the San Joaquin River deposits little or no sediment into the Delta Region, the puny marshlands partly surrounding San Francisco Bay are dwindling spatially through normal erosion event-processes. Supercomputer climate modelling implies a future Pacific Ocean sea-level rise that, inevitably, will push tidal seawater into the already ecologically-distressed Delta Region [14]. Realizing the societal gravity of this worrisome mismatch of regionalized river freshwater runoff data and the macro-problems nowadays endemic to environmentally beleaguered San Francisco Bay, *Team Geographos* will here offer a new Macro-Imagineering solution for a very difficult hydro-social cycle intellectual "knot" of ecologic and general political discord amongst extant Californians. **Figure 1**, upper incomplete image of the State of California, with small dot that indicate site of San Luis Reservoir mentioned in the text.

It is immensely instructive that a 107 km-long, 1.6 m-diameter freshwater pipeline already horizontally extends 80.15 km beneath the Mediterranean Sea's surface linking the reservoir of Alakopru Dam on Turkey's Anamur River (draining the Taurus Mountains) to the reservoir backed by the Gecitkoy Dam on north Cypress. The satisfactorily serving submarine pipeline, operational since 29 October 2015 AD, is immersed ~250 m below the seawater's surface — deep enough to avoid ships from striking and sundering the underwater high-density polyethylene tube — and is held in place by 132 plastic buoys. Therefrom, 0.075 km^3 of freshwater can be distributed annually to northern Cypress farms and homes as well as other connected and served establishments. The concept of buoyant, anchored structures is proposed by *Team Geographos* as having many unique advantages over existing conventional seafloor-resting, load-bearing marine structures usually emplaced in the ocean. The particular case of a submerged, buoyant pipeline, anchored safely below the tumultuous Pacific Ocean's notable surface energy effects for the purpose of transporting freshwater by gravity flow from California's North Coast to near Moss Landing on the shore of Monterey Bay, thence ~40 km inland to the San Luis Reservoir and beyond, ultimately to merge with the San Joaquin River south of the seaport City of Stockton is rudimentarily technically and economically evaluated. (Electric power for pumping delivered fluid from Moss Landing uphill to San Luis Reservoir may most easily be provided were Vistra Energy's natural gas-fired Moss Landing Power Plant, now idled, were brought on-line again.) We have dubbed this proposed infrastructure the "*California Umbilical Cord*". In effect, it continues an 11-page preliminary technology assessment effort instigated 14 August 1991; by January 1992 the Congress of the United States, Office of Technology Assessment, issued its summarizing report ***Alaska Water for California? The Subsea Pipeline Option — Background Paper, OTA-BP-O-92***. Freshwater was to be subtracted from rivers in Alaska at a withdrawal site upstream of the river mouth and then entering an intake sited somewhere near Prince Rupert Sound, conveyed by submarine pipeline to a landfall place east of the Pacific Ocean, but exactly west of Shasta Lake, a reservoir impounded by Shasta Dam, which usually contributes to the overall seasonal regulated flow of

northern California's Sacramento River. From the near-seashore outfall, the freshwater was intended to be pumped, at considerable energy and monetary cost, to far-distant Shasta Lake. Such a scheme is hereby determined to be economically infeasible as well as unsightly infrastructure if carelessly emplaced in that mostly wild, pastoral and rural landscape! Like Chile, the State of California cannot ever actually be under-resourced in terms of its freshwater so long as much of its freshwater runs off into the Pacific Ocean; conversely, like Chile the State will have a naturally-limited freshwater resource so long as its coastal rivers continue to flow unimpeded into the Pacific Ocean, without anthropogenic infrastructure intervention whatsoever.

The "*California Umbilical Cord*" megaproject fostered by *Team Geographos* contains some very attractive elements in its operation if it is realized and materialized! Like Chile's potential undersea aqueduct, these systems operate gravitationally and energy is needed chiefly to pump the delivered freshwater into established major canal distribution systems on land; this feature allows a speculation—that a volumetrically enlarged San Luis Reservoir, today used jointly by the State Water Project and the Central Valley Project could, in an emergency (such as cave-in or blockage of the twin tunnels bored under the Delta Region west of Stockton connecting from south of Sacramento to Clifton Court Forebay), serve as a substitute freshwater deliver mechanism. As of 2018 AD, barely 2% of all State of California energy consumption is applied to pumping freshwater — extraction, conveyance, potability treatment and waste disposal. Massive freshwater redistribution within the State of California using relatively short ocean routes is desirable from a hydro-social cycle managerial viewpoint. However, we cannot honestly claim origination of the basic hydro-social cycle idea because the outlining vision was originally proposed by partners of the (now corporately defunct) National Engineering Science Company of Pasadena, California [15-17]. During the late-1960s and early-1970s, legislators at the capital in Sacramento helped to shift profoundly California's general outlook on supply management of freshwater to greater consideration of managing demands by improving efficiency to cause freshwater cost reductions, or at least to retard the increase in freshwater supply costs paid by the public. The proposed Macro-Engineering-styled megaprojects, such as vastly increasing the lake area of San Luis Reservoir could act to create anomalous regional moisture and/or heat sources (or sinks) the effects of which may, in theory, propagate eastwards via atmospheric dynamics [18]. *The main goal for our* "*California Umbilical Cord*" *must be the essential restoration of the San Joaquin River's pre-World War II volume of freshwater flow into the overstressed Delta Region and San Francisco Bay by using its watery augmentation through North Coast freshwater importation via submarine pipeline and connected overland pipeline to San Luis Reservoir.* Coincident with this singular environmental maintenance goal must be the reformation or reorganization of the Eel River [19-21], Russian River and Rogue River; the documented response of North Coast residents and their representatives, in the past, has been hostile to development plans affecting these California rivers. On 18 July 2018, California's Supreme Court removed Proposition 9 from the General [State-wide] Election Ballot slated for 6 November 2018. Proposition 9, sometimes referred to as the "Three State Initiative", would have sought the citizenry's voted advice on a proposal to divide the State's existing counties into three new USA states. Monterey County, Santa Clara County and San Benito County were suggestively mapped as included in one of the three new USA states, "Coastal California". Were this political separation to occur it would be fortunate that these strategically nodal counties be joined in

freshwater supply management since the rock-mass volume beneath the 417 m-high Pacheco Pass (37^0 3' 59" North latitude by 121^0 13' 7" West longitude) and surrounding the extant San Luis Reservoir currently is being excavated in places and reshaped for enlarged reservoir capacity by massive earthmoving megaprojects: the California High-Speed Rail System tunnels penetrating the difficult Franciscan mélange formation of the Coast Range into the Central Valley and the rebuilding of the B.F. Fisk Dam (first closed 1963) prior to some unpredictable future seismic dam-failure event initiated by the dangerously nearby 66 km-long north-northwest-striking, right-lateral strike-slip Ortigalita Fault [22]. Shortly after the sudden release of 2.518 km^3 of that mass of deliberately stored off-stream freshwater, the B.F. Fisk Dam's failure could cause flooding of the western outskirts of the City of Stockton and certainly disrupt ocean-going shipping schedules at its port! Still uncertain, is whether the Delta Region's yet-t-be-dug twin tunnels under the Sacramento-San Joaquin rivers could be damaged by strong temblors. (By comparison, California's famed Lake Tahoe contains only 0.903 km^3 of freshwater.) Both intrusive megaprojects are multi-billion USA dollar governmental investments, funding for which remains open, uncertain and legally disputable (see Figure 2).

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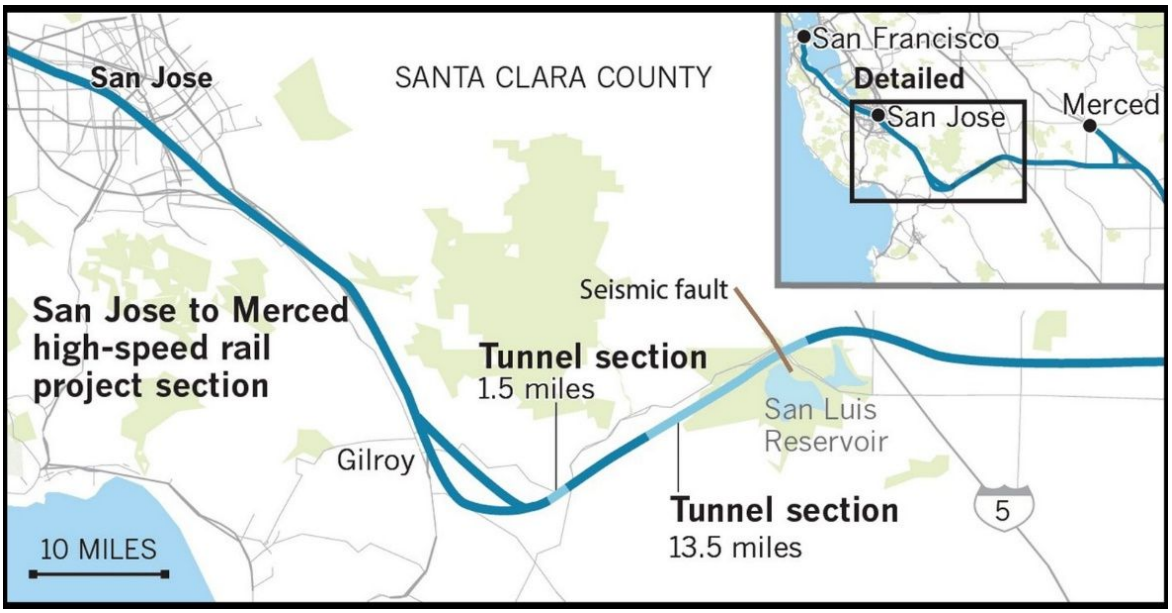

Figure 2. All Californians' standard of living depends on access to abundant and low-cost freshwater. Might a "*California Umbilical Cord"* imitate Chile's potential ***Subma-River*** before 2030 AD?