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StudyTank Report (April 1, 2021-August 15, 2022)

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Introduction	2-3
The Project	4-13
The Interface of Drought/Water Rights	14-16
The Cluster	17
Water Rights notes	18-21
Questions	22-23
Addendum +Literature Search PDF (attached) +Consequences of Drought (diagrams) +Map	24-31

Introduction



The Wright-Ingraham Institute's mission is, in part, to identify and further comprehend complex interfaces between cultural, technological, and ecological systems, with the understanding that the concept of "interface" is, itself, contingent on what is being brought together. The Institute's early focus on integrated studies was grounded in the idea that students participating in its Field Station program were the primary "integrators" of the diverse disciplines and points of view presented in the curriculum. Students' individual and collective discoveries and articulations of relationships between different disciplinary approaches to understanding a specific ecosystem (e.g. from the point of view of paleontology, hydrology, economics and so forth) was, and still is, a crucial part of the Field Station program.

StudyTank (ST) is being developed by Catherine Ingraham and Frank Miller, in concert with the Institute's executive director, Lea Rekow, as the first research branch of the Institute's programs. While ST will periodically collaborate with Field Stations program, as a research initiative it is forming a different relation to integrated studies and the study of complex interfaces. Interdisciplinary research is now common in scientific and academic graduate studies and there are numerous new disciplines emerging in response to urgent new problems. However, integrated approaches are also still contending with the difficulty of crossing disciplinary lines, which requires, among other things, altering entrenched nomenclatures and methodologies while keeping the integrity of each field of study intact. Our observation, which is not unique, is that many of the problems we are facing today in relation to cultural, technological, and ecological interactions will need new forms of collaboration and, potentially, new disciplines.[1] Our reliance on data also requires new interpretations and visualizations that, in turn, can produce new ways of stating complex problems. Thus, underlying our specific investigation into drought during the past eighteen months is our further interest in gathering an expert and diverse cluster of respondents to evaluate this preliminary research from their respective disciplinary points of view.

[1] New hybrid disciplines have emerged throughout the history of science. The manner in which cybernetics emerged in the 1950's out of cross-pollinations between multiple established disciplines–e.g. conventional mathematics, anthropology, biology, and mechanical engineering–is a particularly striking instance of how this might work. Geo-hydrology is another.

The Project

The StudyTank project, "What is Drought," concerns the Colorado River system in relation to the severe drought now threatening the American West. At first glance, the answer seems obvious. We all know what drought is. It is a scarcity of water, a "prolonged shortage of water supply" or "a prolonged time with less than average precipitation."[2] And yet within these common definitions further questions present themselves: For example, how prolonged does a shortage need to be to qualify as a drought? Or which measure of average precipitation are we using?[3] The perpetuation of a shortage depends on the character of the landscape or ecosystem that is suffering from the dry period. Average precipitation varies widely depending on whether you are in an arid, mountainous, polar, coastal, or some other region. Complex ground water systems also underlie land systems but while these are currently being taken into account due to the severity of water shortage, ground water has normally been added to surface water metrics. The concept of "shortage" alone is highly relative. It is subjective.[4] Shortage for whom or what? For farmers, animals, and plants? For electrical utility companies, mining operations? For those who use ground water, irrigation, and/or acequias? For the maintenance of hydrological power systems in reservoirs? For tribes dependent on hydrological electricity? For those with swimming pools, horticultural businesses, plumbing systems, recreational facilities, casinos?

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[2] "Understand Drought and Know How to Respond," *https:/www.weather.gov* ; "Drought," *en.wikipedia.org*. Both citations were taken at 11:17am, August 10, 2022

[3] See a "Self-Calibrating Palmer Drought Severity Index," by Nathan Wells, Steve Goddard, Michael J. Hayes, June 15, 2004 in the *Journal of Climate*. The Palmer Drought Severity Index has been used for 30 years to quantify the severity of meteorological drought. However its spatial comparisons between different locations has been inconsistent making spatial comparability of diverse climatological regions. Current work on amending this deficiency includes replaced the "empirically derived climatic characteristic and duration factors...with values automatically calculated based upon the historical climatic data of a location."

[4] Thanks to Dr. Troy Hartely, a political scientist who helped launch StudyTank in early 2021. He noted immediately the subjectivity of our subject matter and was also extremely helpful in formatting our first field trip to the Colorado River.

As we began to search the literature on drought, of which there is a great deal, it gradually became quite clear that prolonged drought, historically, has significantly impacted animal, plant, and human cultures, resulting in large migrations of humans and animals, socio-political upheavals, and the desertification of land among other environmental and ecological changes. Humans have often tried to explain droughts as either a natural disaster, a misuse of resources, the result of supernatural forces (in mythical terms), or, more currently, a result of climate change. It is among the earliest documentation of climate events, notable in the *Epic of Gilgamesh* and, in western cultures, "tied to the Biblical story of Joseph's arrival in and the later Exodus from ancient Egypt." "Hunter-gatherer migrations in 9,500 BC Chile have been linked to drought, as has the exodus of early humans out of Africa about 135,000 years ago." [5]

This report, which covers the past eighteen months of study, is organized around a set of questions that were derived from StudyTank's observations and studies during that period and are frameworks for further analysis.

1. How can the global context of drought help us understand the current conditions in the southwest?
    a. The North American drought is not a geographically isolated event and is best understood in the context of global climate.
    b. Hoerling and Kumar (2003), in an influential paper entitled 'The Perfect Ocean for Drought', were the first to point out that the North American drought during the last 20 years fitted into a zonally symmetric pattern of mid-latitude dryness that dynamically linked the droughts in North America, the Mediterranean and Central Asia.

If we approach drought from the perspective of specific settlements dependent to some degree on the Green and Colorado River watersheds for water and energy, we would need to

[5] "Drought," *en.wikipedia.org*, citations taken at 11:25am, August 10, 2022

understand the complex historical and current relation of both rivers and land to those settlements. Regional evaluations of the severity of drought and the tier systems of dams that track the loss of water are effective but the perpetuation of drought is difficult to predict. The water rights system (which we have been studying more closely) that governs who currently has the right to existing surface water is also an historical structure that is now under scrutiny by federal, state, and tribal agencies.

States and tribes in the west who are currently facing water shortages are: Wyoming, Colorado, New Mexico, Utah, Arizona, Nevada and California, the Chemehuevi Tribe (a branch of the Southern Paiute people), Cocopah Tribe, Colorado River Tribe (Arizona), Colorado River Tribe (California), Ft. Mohave Tribe (Arizona). Ft. Mohave Tribe (Nevada), Ft. Mohave Tribe (California), Ft. Yuma/Quechan Tribe (California), Ft. Yuma/Quechan Tribe (Arizona), Jicarilla Apache Nation, Ft. MacDowell/Yavapai Tribe, Gila River Indian Community/Pima and Maricopa, Pascua Yaqui Tribe, Salt River Pima-Maricopa Tribe, San Carlos Apache Tribe, Tohono O'Odham Tribe, Tonto Apache Tribe , White Mountain Apache, Yavapai-Apache, Yavapai-Prescott Tribe, Southern Ute Indian Tribe, Ute Mountain Ute Tribe, Ute Indian Tribe of the Uintah and Ouray Reservation, and the Navajo Nation.

Alternatively, we would take a different path if we approach drought as a large climate event that is connected to global climatological changes, particularly the climate patterns of El Niño warming/La Niña cooling of ocean water in the eastern equatorial Pacific Ocean that influence the position and dynamics of the jet stream and directly affect weather in the Southwestern United States. As Hoerlineg and Kumar (2003) indicate (in the above question) drought in North America over the past twenty years fits into zonally symmetric patterns of

"mid-latitude dryness" in the Mediterranean and Central Asia,.[6] Such patterns and forces in climate data refer to dissipative weather systems that are also unpredictable but can be analyzed through stochastics: It is possible to ascertain, for example, "random probability distributions or patterns that may be analyzed statistically but may not be predicted precisely."[7] While our ST research is not, at this juncture, pursuing the *cause* of drought in relation to climate change, it necessarily takes account of the epistemological, ontological, and scalar discrepancies between the local analysis of water scarcity and global climate scenarios. These different scales of observation and interpretation dovetail from time to time–specifically in the assessment of variability in agricultural production– but the rapidity of the loss of water in the Colorado River dams is now increasingly localizing water scarcity analysis in the American West. While global events attributed to climate change are clearly impacting forests, cities, and communities, world-wide, the severity of the ongoing drought in the west is seen less as a climate event than as increasingly consequential regional and local event that could affect economies (food production), geo-political policies, federal laws and legislations, energy production (hydroelectric, solar and wind), beyond the western states and tribal communities suffering from the drought.

2. How does our inadequate understanding of the physical environment impair our assumptions regarding drought?
    a. Flawed assumptions regarding water quantity and availability [i.e., 1922 Colorado River Compact assumed wet years were normal]:
    b. Inadequate long-term baseline data prevented a historical context.
    c. Micro (local, regional) perspectives prevailed within the unknown macro (global) context.
    d. Poorly understood relationship between surface water and groundwater existed.

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[6] Hoerling and Kumar (2003) report on ocean and drought, National Geographic definition of El Nino.
[7] Oxford English dictionary definition of how stochastics work. Complexity theory, in physics, which emerged in the 1970s with Ilya Prigogine's work on non-linear dynamical systems, has been seminal to the alteration of evaluations of weather. The Santa Fe Institute was created to advance complexity theory mathematics and physics in studying multiple problems.

In the United States common law system, water is a public resource that is governed by federal and state agencies. It was in anticipation of expanding populations (particularly in California) and a potential scarcity of water vis a vis overuse and drought that water rights came to be allocated. Legislative allocation of water rights in the American West, which began in 1922 with *The Colorado River Compact*, was drafted during an unusually wet period. (See **Water Notes**,18-21). The *Compact* was somewhat amended to address different problems in subsequent years, but, in general, the lack of historical data and a misreading of the variability of water ecosystems resulted in an underestimation of the possibility of drought. Evidence of this underestimation is the fact that water rights have continued, into the present time, to be allocated in hard numbers that quantify the amount of acre-feet of water available to right-holders for an undefined future rather than allocating a percentage of the available water at any given time. This de-temporalizing of the river now appears to have been not only naive but also reckless. States procured water rights as a form of insurance against drought and yet its allocations, in the *Compact*, ignored not only the variability of rivers but also the variability of climate.

A note about climate: *The Compact*, which the federal government has recently put back on the table for urgent renegotiation, is still seen as a keystone contract for numerous subsequent water rights actions. It could be seen as an historical document that reflects a particular point of view, Newtonian in character, that regarded cosmic systems as relatively stable. Climate, as such, certainly was present in 1922 but its complexity as a system was both anecdotally and scientifically unclear. This is relevant to our current, stochastic, understanding of climate and bears on future constructions of water rights law and conceptions of drought in relation to this law. The articulation of thermodynamic forces, in the latter part of the twentieth century, which began to define climate systems as complex far-from-equilibrium systems and rivers as dissipative

systems, is everywhere missing not only in the *Compact*, which is understandable, but also in current federal and state reactions to the pressure the drought is now placing on water availability in the west. Climate variability is, and has been, self-evident in every culture for centuries but the meaning of this variability has shifted radically over time. The concept of a river as a dynamic environment, and the ability to anticipate, statistically, the likelihood of a significant change in its flows, was, in the 1920's, based on short-term historical documents. Contemporary scenario planning that is used widely to assess dynamic systems is, nevertheless, still considered as a relatively innovative approach. And yet the latent necessity of the idea of drought–a climate event that has been recorded in diverse ways since antiquity–in the assignment of water rights is significant. Drought as a future threat allows for an somewhat orderly distribution of rights, but as a present threat it can throw both the concept and value of water rights into chaos. The potential of drought in the *Colorado River Compact*, in spite of the relative ignorance about ecological systems, was weighty enough to make water rights seem necessary and practical, but not weighty enough to include a future plan for adjusting water rights should they become unstable due to prolonged drought. Economically, water rights are now increasing in value for obvious reasons. When water was plentiful and the dams were full, one acre-foot of a water right sold for approximately two hundred and fifty dollars. Now, in 2022, one water right can cost as much as two to five thousand dollars. Long-standing agreements have also been thrown into jeopardy as stake-holders try to find ways to break the Law of the River contracts.

How might we further describe this "inadequate understanding of physical environments"? One of the early goals of the ST project, as mentioned earlier, was to identify dynamic interfaces between different systems (cultural/technological/natural) that act as porous divisions or a point where two systems meet and interact. Focusing the question "What is Drought" specifically in the region encompassed by the Upper and Lower Basin of the Colorado

River watershed, the ST team visited and gathered data about the three major dams that control the Green River and Colorado River system–Hoover Dam on the border of Nevada and Arizona, Glen Canyon Dam in Arizona, and Flaming Gorge Dam in Wyoming. Following the Green river from Flaming Gorge in the Upper Basin to the Colorado river (the Green joins the Colorado river in Canyonlands National Park, Utah) and Glen Canyon Dam, periodic and superficial evidence of drought was observable: dried grasslands, reduced water in streams, evidence of forest fires, and a few dust storms. The Flaming Gorge Dam is now being asked to release additional water to help fill lower dams (dropping its reservoir from 87% full to 74% full). Anecdotally, one of the personnel in the Flaming Gorge Dam shop, which sells maps, key chains, among brochures about the region, said the release of this additional water was primarily meant to assist with the Green River's annual fish hatching process. This poses the question of how local communities in the Upper Basin who are dependent on the river are being informed, or informing themselves, about a Lower Basin draw on Flaming Gorge's stored water. There is a real possibility now that, lower down the river, Glen Canyon Dam will be decomissioned and Lake Powell drained of its water in order to "Fill Lake Mead first," which is needed to maintain Hoover Dam's hydrological energy system. The question of fish hatching versus a drought crisis is not meant to discredit the person in the Flaming Gorge Shop; only to note that "micro perspectives" of all kinds, including those of our team, necessarily blur macro perspectives. Another example was a conversation with expert rafters in Moab who know intimately alarge part of the Colorado River that flows through Moab. From their standpoint, the river was understood to be normal. Full. And, indeed, it looked full. So where does the drought begin? It begins, in hydrological terms, in the Rocky Mountains where snowfall has diminished and when snow does fall is melts faster due to dust (particulate matter in the atmosphere created by drought). Drought creates more drought. Faster melting snow means the water flushes through

the rivers faster and its duration through subsequent spring and summer months is less. Casual or narrowed observations, which is the way most of us observe landscapes, suggest that our perception of drought is also, not surprisingly, based generally on hazy understandings of how weather systems and river ecosystems work. The Colorado River's relation to networks of tributaries small and large, its geological interactions with soil and rock and runoff (beneficial and toxic) that are flushed into it, its hydrological changes related to watersheds, forests (and forest fires that erode mountains), as well as its relation to snowfall, solar and atmospheric forces, the multiplicity of plants and animals it supports and is, to some degree, supported by, its seasonal behavior, and the scope of its flow from headwaters to Mexico, among many other aspects, are largely left out by the lay observer.[8] Moving from Flaming Gorge's green forests to Lake Powell's extremely arid land is also a significant drop in elevation. And yet even this metric is deceptive. The aridity that surrounds Glen Canyon Dam is desert land that has been there from the beginning of the dam's construction. Evaporation of water from Lake Powell has always been substantial because of the aridity of its location. Evaporation now, however, as the lake has receded and dropped below benchmarked levels that signal severe losses of water, becomes a new factor. Its cost, in the amount of acre-feet of water evaporating, is larger than the income from Glen Canyon's hydroelectric dam, which suggests that the dam-reservoir system is no longer sustainable.

[8] Marcy Rockman, an anthropologist who has studied cutting edge climate data, noted in an essay concerning the settlement of Jamestown in ____ that the settlers did not understand the climate they had moved into. Her hypothesis is that most people have many stories about weather events but they do not generally understand climate as a system and, accordingly, climate change (the concept and the data) means very little to the average person.





Lake Powell (Glen Canyon Dam) and, after Grand Canyon, Lake Mead (Hoover Dam), now have deep perceivable drops in water levels. Marinas no longer connect with the land, land between resorts along the river are now very far from the river, bodies and cars that had sunk in the lakes are now being revealed, rock formations that have not been seen since the dam construction began are now visible. Unlike landscapes and streams, dams and reservoirs are constructed technological systems that have clear purposes: they store water for future usage, help with flood control (which make downstream settlements less vulnerable), provide lakes and boating marinas, and, in the case of Glen Canyon and Hoover dam, produce hydroelectricity. We know how to read these infrastructures. In some sense, the clearest evidence of drought as a climate event resides in these dams, which gather the loss of water, so to speak, in a calculable place.

The perceptual distinction (and scale) between understanding drought through calculable local measurement provided by technologies versus understanding drought through large ecosystems such as climate or river systems, offered ST a preliminary interface: The calculability and visualization of stored water in the dam/the calculability and visualization of water and land

systems.[9] This interface, which remains interesting, nevertheless led to another interface that included various relations of dam to river but added in the legal system of water rights. Dams bank water that stake-holders, who possess water rights, draw on. "Water banking," is a metaphor used by California and other states that does not mean having the money (water) and saving it. It means spending less and getting a credit for the less that is then banked for later use. [ICS (2007 agreement) about Banking water–Banked water is credited to the user that created it.][10] This interface could be described, also in a preliminary way, as the structural relation (intersection) of drought with the Colorado River water rights system.

[9] In the lower basin we discovered that the degree of control of the river by the dam was absolute. During the day the river flows, during the night the Hoover Dam faucet is turned off and there is no river.

[10] Cf. "Amid Drought Billionaires Control A Critical California Water Bank," Chloe Sorvino, Forbes Magazine, September 20, 2021, online.

The Interface Between Drought and Rights

Note: There are a number of questions associated with the development of this interface between drought and rights that are potential frameworks for StudyTank's continuing research. (See **Questions "The Context of Drought"** p. 22)

As mentioned earlier, water rights have been typically distributed to stake-holders in the Upper and Lower basins as a quantity of acre-feet (on acre-foot is about 326,000 gallons) from the Colorado River (stored or flowing) rather than as a percentage of the available water at a given moment in time.[11] The amount of acre-feet allocated to each stake-holder depends on the use of water (for agricultural irrigation, energy production, ranch usage, drinking water, and so forth) by all the states and tribal lands that lie within the Green and Colorado River watersheds.[12] The division of the Upper and Lower Basin, marked at Lee's Ferry, was a political accommodation of diverse state interests and potential growth. The Upper Basin refers to water usage by Colorado, Wyoming, Utah, and New Mexico, the Lower Basin to water usage by California, Nevada and Arizona. Water rights sometimes can include the right to use surplus water unused by another state and the water from river tributaries that are under a state's jurisdiction. Stored water, flowing river water, and water from tributaries are seen as surface water. Water rights have not traditionally pertained to ground water or aquifers, although this is now changing. The reason ground water is becoming essential to manage and understand is that surface water is often stored in aquifers.[13]

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[11] One acre-foot is the amount of water it takes to flood one acre of land one foot deep, about 326.000 gallons.
[12] Mexico was also allocated rights separately from state and tribal rights.
[13] Cf. "Conjunctive Use," *watereducation.org* "Until 2015, California has not had a statewide groundwater management system and groundwater and surface water have been traditionally treated as separate resources. Now, with water demand frequently outpacing supply, water leaders are often coordinating the use of both."

These water rights reflect, forms of agency and technics used by communities, agricultural operations, cities, and state and federal agencies to quantify and allocate a variable resource for use and ownership. Legal rights also justify and control accessibility to the use of natural resources (land, water, minerals, forests, etc.) and assist in redefining these systems in ways that significantly alter them over time. Water rights, land rights, property rights, and intellectual rights, include, as "natural resources," abstract ideas, innovations, and intellectual/artistic productions. From the side of human societies, these rights are also connected to changing lists of "human rights" that define humanitarian states of being. Under the United States laws, everyone is entitled to freedom of speech and to clean water.

However, water rights would not be required if there was no drought. Drought has happened periodically throughout the history of the Southwest and the American West, but its arrival and duration is unpredictable. Actuary tables used to discern the likelihood of car crashes or life span belong to cultural systems where the behavior of people, societies has been studied for centuries. Climate studies are very recent. So while drought (and its unpredictability) is a constitutive part of the structure of water rights, the variability of water's availability is not taken account of in the allocation of these rights.

The legality of rights is only one part of the picture. How this legality is formed–through treaties, policies, grants, informal agreements, legislation, and other channels, which are collectively called "The Law of the River–is important. The friction between rights and the systems that are to be brought under control, is also important. The unmovable barrier created by the Hoover Dam, for example, which distributes water (according to rights) to users, also must contend with the complex river systems is seeks to control. One problem, frequently mentioned, is the residue picked up by the Colorado River as it flows through Grand Canyon and other landscapes, which piles up as sentiment behind the dam. Because the sediment does

not pass through the ___ of the dam, nutrients important to plant and animal life are substracted from water flowing below the dam. These material "externalities" create significant slippages in the boundaries and character of the quantitative data that codifies the relations between dam and river.

Water rights systems mandate rules that are, themselves, fairly loose: "use it or lose it," or the approval of usage only if it is for "beneficial purposes." These terms are taken seriously by water attorneys but, they also indicate the alliance between rights systems and constitutional structures. Because water, like land, is owned through water and land rights, these loose terms are fortified by hard numbers and quantifications, which are unaffected by qualifications of the resource at hand. Water, like land, becomes property with calculable units and divisions. It would be very peculiar, however, in a landed property exchange, to suggest that the property (at some point and even if decreased in value) would not be the same acreage you paid for up front. Drought, in other words, threatens the property construction of water. The value of land developed as property is almost always dependent on the water resources afforded to it.[14] Most land ownership (domestic, urban, corporate, agricultural) requires direct or indirect access to water. The United States common law legal right systems are quite familiar with abstractions of property that would also allow for the abstraction of measuring water as an amount "acre-feet," in spite of its obvious characteristic of being a fluid system.[15] See **Water Rights Notes** p. 18.

[14] Some of which can be sold separately and some of which run with the land.

[15] The definition of an acre-foot" is the amount of water it takes to flood one acre of land (approximately 326,000 gallons of water). Legal rights adjudications are not particularly problematic in the face of a moving system (the sale of cattle, for example, etc.)?

The Cluster

In our commitment to integrating diverse disciplinary approaches to this subject matter, we are sending this report to a preliminary "cluster" of three people–a hydrologist, an architect-mathematician, and an anthropologist–whom we have asked to respond to this material from their disciplinary points of view. Responses will be included in this report with the permission of the responder.

WATER RIGHTS NOTES

- The relationship between surface (flowing) water rights and groundwater (aquifer) rights constantly evolves. Ground water aquifers often cross watershed, state and international boundaries, complicating the determination of ground water rights between properties on either side of the boundary. Complicating things further, surface water is often pumped into aquifers for storage.

- Water rights adjudications depend on accurate geohydrology of both surface flows and sub-surface aquifers. The USGS is the gold standard for hydrogeological analysis, and 'comprehensive basin studies' represent state-of-the-art deliverable.

- Any given land area may have a combination of water rights existing in state, (federal) Tribal, and federal non-tribal jurisdictions.

- Surface water rights are defined by watersheds, and ground water rights are defined by aquifers. If ground water is 'flowing' (i.e., moving through alluvial materials in connection with a surface flow), it is considered surface water.

- The States own water as a common resource, and maintain records of rights. Most of these records are recorded on paper and unavailable digitally.

- Private ownership of water rights extends only to the right for beneficial use and in the absence of impairment of others.

- Current water rights are largely composed of three kinds of rights:
  Riparian Rights (rights to water on land abutting flowing surface water)
  Prior Appropriation Rights (first come first served)
  Overlying Rights (rights to groundwater under land)

The common law origins of water rights are as follows:

1. *Absolute Dominion*
   (Also referred to as Absolute Ownership, or the English rule.)
2. *Reasonable Use*
   (Also referred to as the American rule, or Rule of Reasonableness.)
3. *Correlative Rights* doctrine
4. *Restatement (Second) of Torts*
   (Also referred to as the Beneficial Purpose doctrine.)
5. *Prior Appropriation* doctrine
   (Same principle as applied to surface waters.)

Absolute Dominion grants the landowner the right to divert, or excessively pump an aquifer to the detriment of any neighboring entities; 11 US states have shown preference to this law, though many have a clause preventing malicious pumping (Page 4).

Reasonable Use is an adaptation of Absolute Dominion that limits the landowner's use to reasonable benefit with respect to the property overlying the groundwater. So long as the water is used on the land over the groundwater in question, and is not wasteful, the landowner is granted the rights to an unlimited amount of water, even to the detriment of neighboring entities; 17 states have shown preference to this law (Page 4).

Correlative Rights is similar to Reasonable Use. The key difference being that off-site usage of pumped water is not prohibited, and proportionality is applied to the equation. The Correlative Rights doctrine prevents landowners from excessive use of groundwater, allowing for a somewhat equitable distribution of rights to the use of the water with others overlying the aquifer; 5 states have a preference for this (Page 5).

Restatement of Torts is essentially a combination of Absolute Dominion and Reasonable Use. A landowner is able to use underlying waters for beneficial purposes, so long as this use does not cause unreasonable harm to a neighbor, or the landowner pumps more than their reasonable share of water, or the landowner's pumping directly affects the flow of water from the region and causes unreasonable harm to others entitled to that region's waters; only 2 states show preference to this (Page 6).

Prior Appropriation, as previously discussed when speaking about surface waters, grants rights to use on a first-come-first-serve basis, though it should be noted that, at least with groundwater, many states have added a permit process to this; 13 states have shown preference to Prior Appropriation (Page 6).

How water rights are determined:

General stream adjudications are judicial proceedings to determine the extent and priority of all water rights in an entire river system. State law, Indian, and federal non-Indian water rights will all be adjudicated. In California, a federal Special Master is appointed by the US District Court for each watershed to preside over adjudications in that watershed.
In California, the scope of the Water Master's duties is governed by the Order of Reference issued by the Federal District Court. The duties include:

1. Actively managing objections by scheduling proceedings, notifying parties, holding status and settlement conferences, and holding hearings.
2. Identifying affected parties to the objections.
3. Taking evidence, overseeing discovery, ruling on procedural and substantive motions.
4. Preparing a report and recommendation for each objection that contains his findings, conclusions, and recommendation.
5. Issuing a Final Decree putting into effect the adjudication of water rights for that watershed.

Prior Appropriation Rule:

Maintains that the first landowner to beneficially use or divert water from a water source is granted priority of right. The amount of ground water this priority, or senior, appropriator may withdraw can be limited based on reasonableness and beneficial purposes. Some states have replaced or supplemented the Prior Appropriation doctrine with a permit system. Twelve states adopted or indicate a preference for the Prior Appropriation rule: Alaska, Colorado, Idaho, Kansas, Montana, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Utah and Washington.

Priority 1 *Within the State of Arizona, the following priorities shall apply in the administration of Mainstream Water. The second and third priorities are coequal.*

Satisfaction of Present Perfected Rights as defined and provided for in the Decree.

Priority 2 *Satisfaction of Secretarial Reservations and Perfected Rights established or effective prior to September 30, 1968.*

Priority 3 *Satisfaction of Entitlements pursuant to contracts between the United States and water users in the State of Arizona executed on or before September 30, 1968.*

Priority 4 *Satisfaction of Entitlements pursuant to: (i) contracts, secretarial reservations, and other arrangements between the United States and water users in the State of Arizona entered into or established subsequent to September 30, 1968 for use on federal, state or privately owned lands in the State of Arizona (for a total quantity not to exceed 164,652 acre feet of diversions annually); and (ii) Contract No. 14-06-W-245 dated December 15, 1972, as amended, between the United States and the Central Arizona Water Conservation District for the delivery of Mainstream Water for the Central Arizona Project, including use of Mainstream Water on Indian lands. Entitlements having a fourth priority as defined in (i) and (ii) herein are co-equal. Reductions in Entitlements having a fourth priority shall be borne by each Entitlement holder in the same proportion as its Entitlement, or as required by law or regulation. If, however, a reduction sharing agreement is entered into between two or more such authorized users, then the reduction shall be shared among the parties as provided in the agreement, subject to approval by the contracting officer after consultation with the Arizona Department of Water Resources.*

Priority 5 *Satisfaction of Entitlements to any Unused Arizona Entitlement or Unused Apportionment Water. Any entity with a contract for fifth-priority water shall utilize its fifth priority Entitlement only after the Contracting Officer has determined that Mainstream Water is available under applicable law or regulation, and the Contracting Officer provides written notification that such Mainstream Water is available in a specific year, subject to the scheduling and the reduction provisions of the contract. Reduction or elimination of the fifth-priority water use shall be determined by the Contracting Officer after consultation with ADWR, or on the basis of the contract dates, or as required by law or regulation.*

Priority 6 *Satisfaction of Entitlements to Surplus Water. Any contractor for sixth-priority water shall utilize its sixth-priority Entitlement only after the Contracting Officer has determined that Mainstream Water is available under applicable law or regulation, and the Contracting Officer provides written notification that such Mainstream Water is available in a specific year, subject to the scheduling and reduction provisions of the contract. Reduction or elimination of the sixth-priority water use shall be as determined by the Contracting Officer or on the basis of the contract dates, or as required by law or regulation.*

Colorado River Compact (1922) and the Law of the River

- Allocation of water rights was approved by the Congress in 1921, prior to the 1922 Colorado River Compact. The compact required "the Upper Basin states not to deplete the flow of the river below 75 million acre-feet during any period of ten consecutive years. Based on rainfall patterns observed in the years before the treaty's signing in 1922, the amount specified in the compact was assumed to allow a roughly equal division of water between the two regions" (i.e. Upper and Lower Basin). "The compact enabled the widespread irrigation of the Southwest, as well as the subsequent development of state and federal water projects under the United States Bureau of Reclamation. Such dams included the Hoover Dam and Lake Powell," (Glen Canyon Dam). The river's stored water system, which began in the Lower Basin with the completion of Hoover Dam and the formation of Lake Mead in1936. [Reference: *wrrc.arizona.edu* History, Public Policy and the Colorado River Compact] Compact was keystone to the piecemeal assemblage of other compacts, federal laws, international treaties, court decisions and decrees, contracts, and regulatory guidelines collectively known as the "Law of the River." "Current annual allotments in the Lower Bain were established in 1928 as part of the Boulder Canyon Project, while the current specific annual allotments in the Upper Basin were established by the Upper Colorado River Basin Compact of 1948." The division between the two basins is still 7.5 million acre-ft/year which is now divided (unequally) between the states in those basins. Investment in stored water, which banked water for future use and guaranteed water to California, Nevada, and Arizona allowed water rights to expand in ways that had less and less to do with the hydrological ebb and flow of the river.

- The Colorado river supplies over 60 percent of the water used annually in Southern California. It is using 20 percent more than it is entitled to under the "Law of the River." California adds the least amount of runoff to the river. Population growth in California the 1920's increased water demand and other states feared that California would establish priority rights to Colorado River water. The *Compact* addressed this concern.

- The 1908 Supreme Court decision recognized native rights regardless of whether a tribe had used the water or not, with rights established at the time reservations were created. The state in which a reservation is located must fulfill the tribal water right per1963 Supreme Court decision per the states of Arizona and California. More water rights were granted for irrigation acreage within reservation boundaries. The Navajo Nation tribal water rights are, as yet, unquantified.

- The *Compact* did not protect the environment of the river. The 1973 Endangered Species Act suggested that the users of the water should be held responsible for the protection of the Colorado River environment.

Questions (the Context of Drought)

1. How do ambiguous nomenclatures describing dryness impair our responses to drought?
    a. Drought = less than 25 years?
    b. Mega-drought = 25 years to 100 years?
    c. Climate change = longer than 100 years?

2. How do the relationships between the principal stakeholders (federal, state, tribal, landowner) shape our responses to drought?
    a. Federal management of multi-state agreements for rivers that cross state boundaries, and for tribal agreements.
    b. States manage water rights ownership and transfers within said state.
    c. Tribal sovereignty is granted via their trustee relationship with the federal government.
    d. Landowner water rights come with the responsibility to put water to beneficial use.

3. What are the key political and legal challenges that impair our responses to drought?
    a. Proposed "fundamental changes" to [California's] water system are "needed to realign demand, supply, and the flexibility of the system."
    b. California has allocated $1.5 billion to buy land with senior water rights from holders willing to sell them voluntarily.
    c. Most senior water rights are appurtenant to the land, making the water right a property interest, so government actions impacting these water rights run the risk of a takings claim by property owners.
    d. Owners may also make a takings claim if regulations go too far in restricting their use of the land due to water rights reductions during drought.

4. How can the system of water rights transfers (leases and sales) better help manage water shortages?
    a. Water access in the western United States is largely controlled by the rights of property to use water.
    b. In most of the region's watersheds, all of the water supply is legally claimed or is projected to be by 2030.
    c. In such locations, new water demands can frequently only be met through reallocation of existing water rights.
    d. Markets for surface water rights exist in every western state. Groundwater rights are the second most commonly traded water right, though groundwater regulation varies significantly between states.
    e. increased water scarcity increases legal barriers to water marketing. As scarcity has grown, legal conflicts have become more protracted.

f. "Use it or lose it" policies discourage conservation.

5. How does the seniority system in water rights result in unwise water utilization?
   a. Seniority date system used as basis for drought reduction plans.
   b. State has authority to dial back the eligible seniority date (California now allocating water only to holders of pre-1914 rights).
   c. Water rights records for past 150 years are still on paper – difficult to access and manage.
   d. In Nevada, litigation over Diamond Valley's groundwater rights ended up at the Nevada Supreme Court, which set a precedent when it ruled 4-3 the state engineer can deviate from Nevada's water laws, which are based on water rights seniority, to regulate Diamond Valley's water under a new groundwater management plan.

6. Why is the recognition and quantification of tribal water rights still incomplete?
   a. 1907 Winters water rights based on agricultural needs; current claims are based on urbanized needs.
   b. Tribes have a strong Winters claim for surface water rights, but uncertain claims for groundwater rights.
   c. There are 30 federally recognized tribes in the Colorado River Basin. Twenty two of these tribes have recognized rights to use 3.2 million-acre feet (maf) of Colorado River system water annually, or approximately 22 to 26 percent of the Basin's average annual water supply.
   d. Under the Upper Colorado River Basin Compact and the U.S. Supreme Court's decree in Arizona v. California, all tribal water uses are counted against the apportionments made to the states.
   e. Twelve of the tribes have unresolved water rights claims, which will likely increase the overall volume of tribal water rights and reducing the available water for non-Indian use in each basin state.
   f. Tribes' rights are generally senior to state law-based water rights and cannot be lost through nonuse.

Addendum

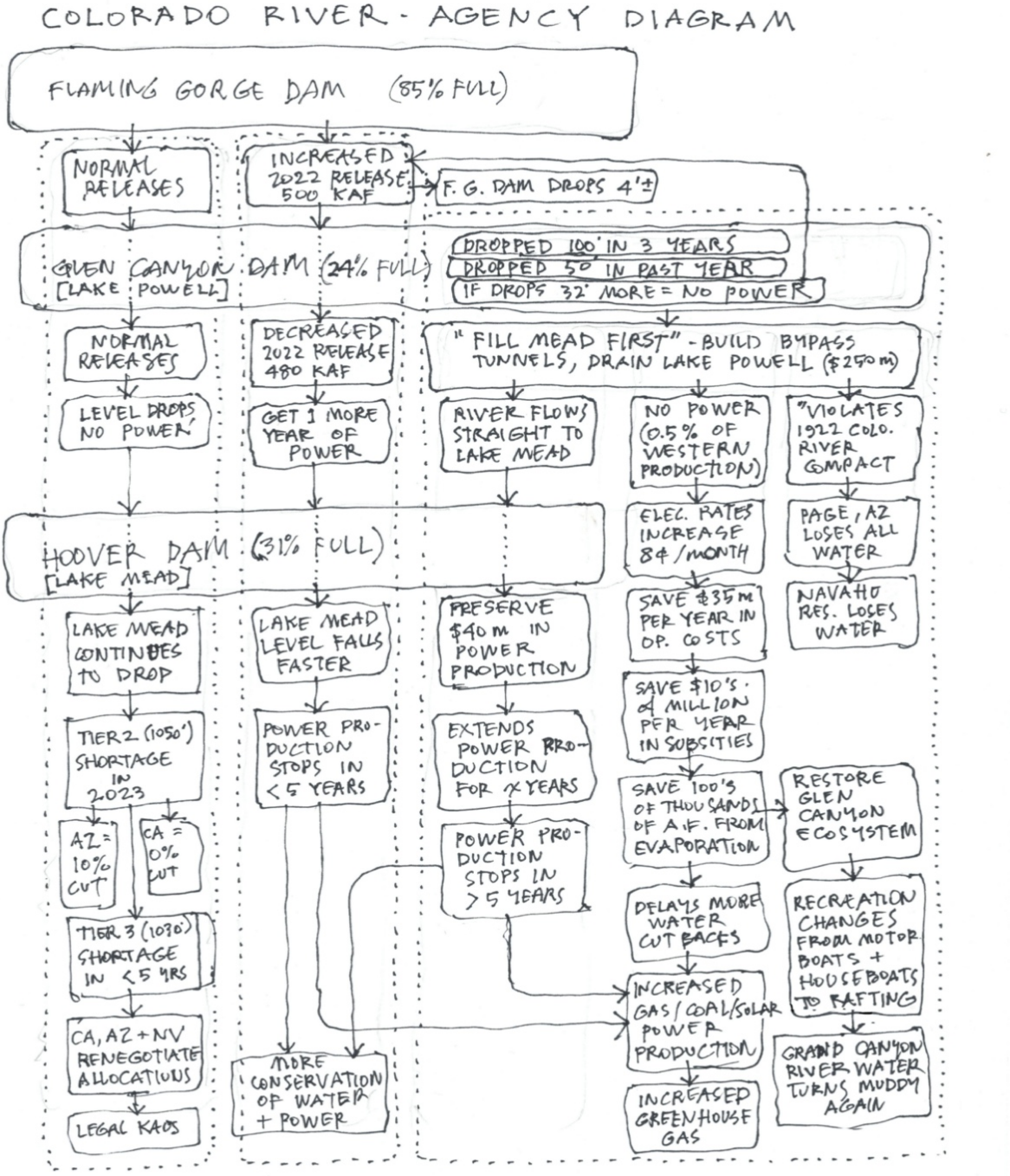
Additional Research Notes:

Literature Search (see attached PDF)	24
Consequences of Scarcity (diagrams of interfaces)	25-30
Map	31

Literature Search

See attached StudyTank literature search PDF

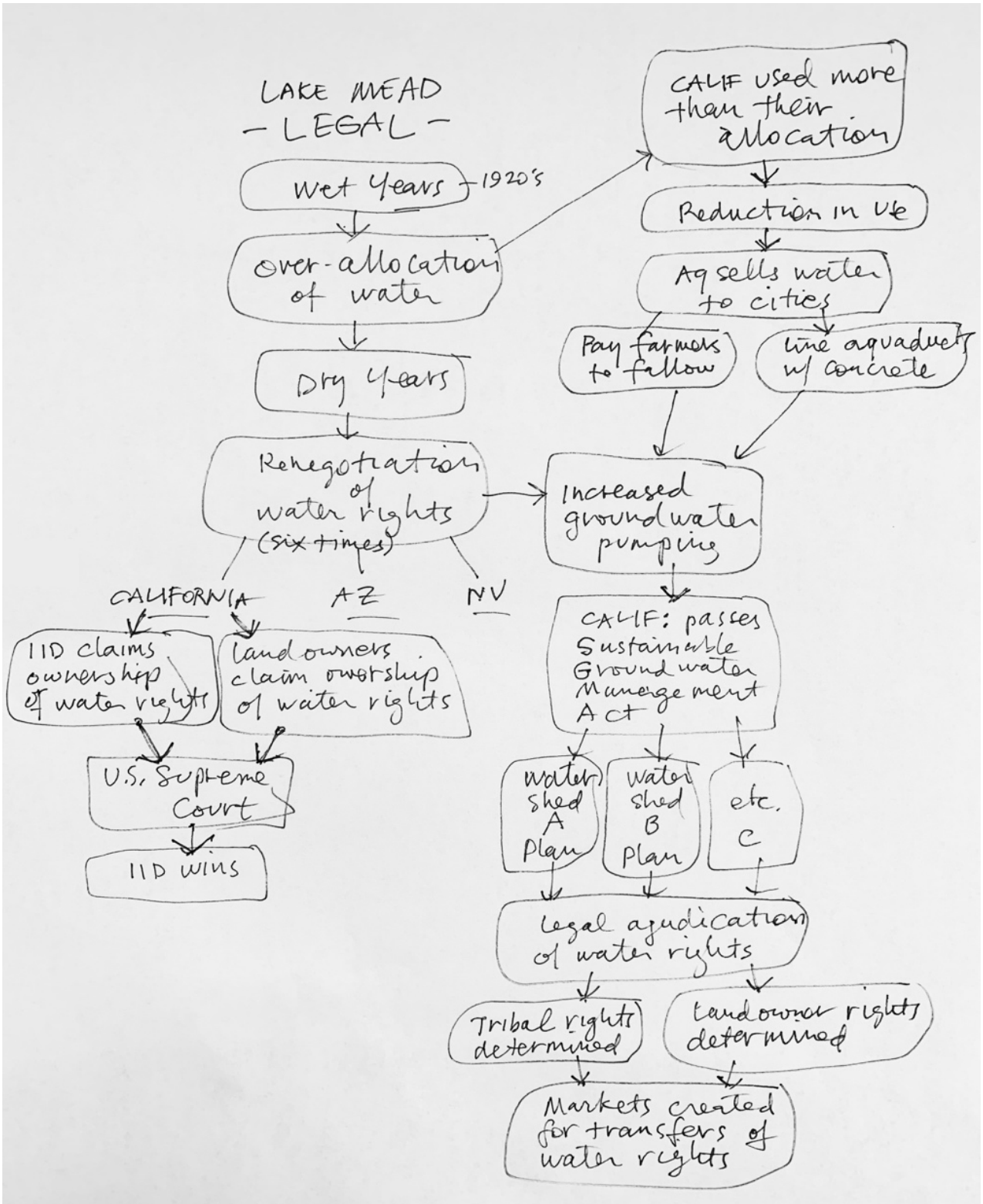
Consequences of Scarcity



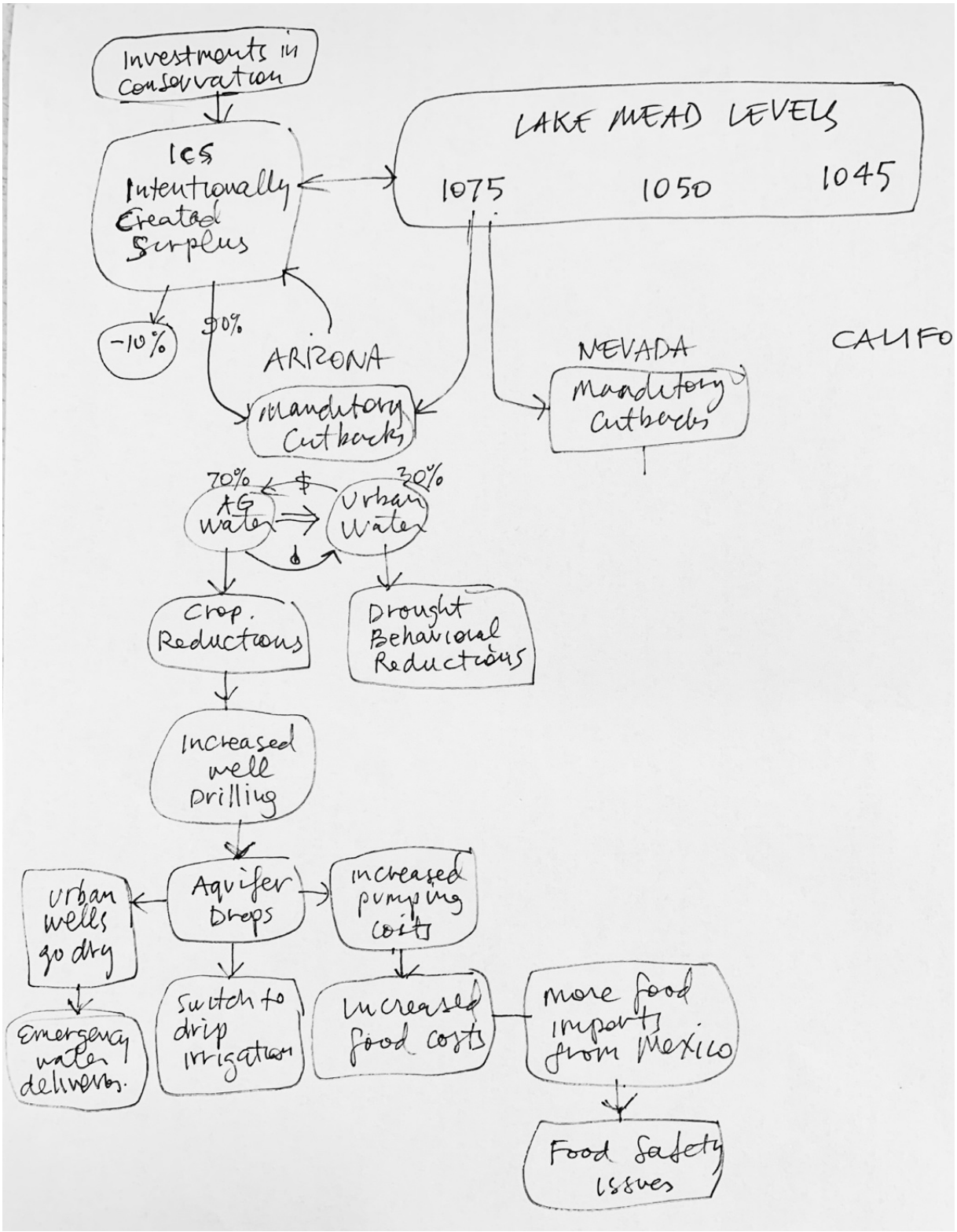
Power, Legal, California Overuse



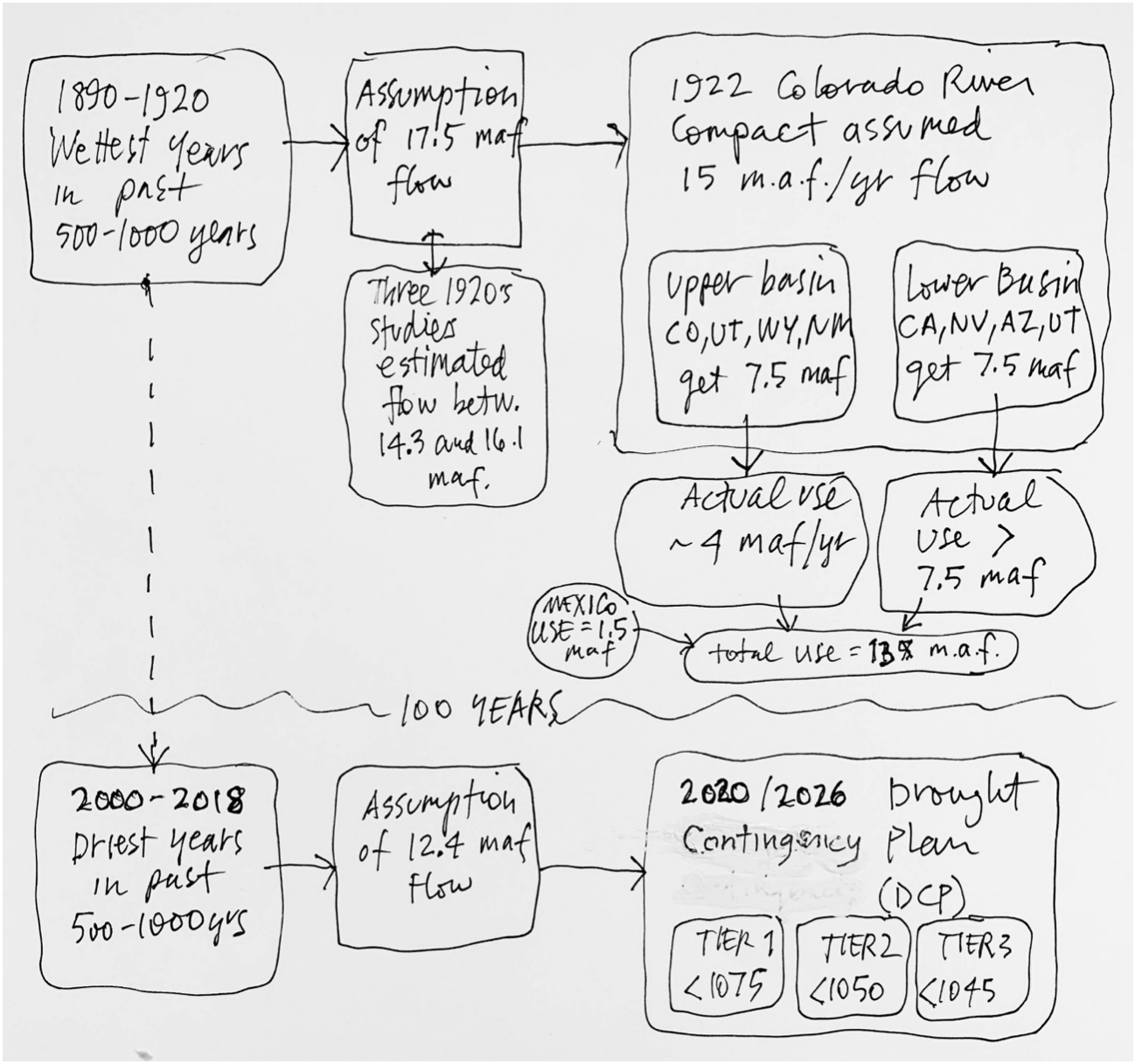
Lake Mead (legal)



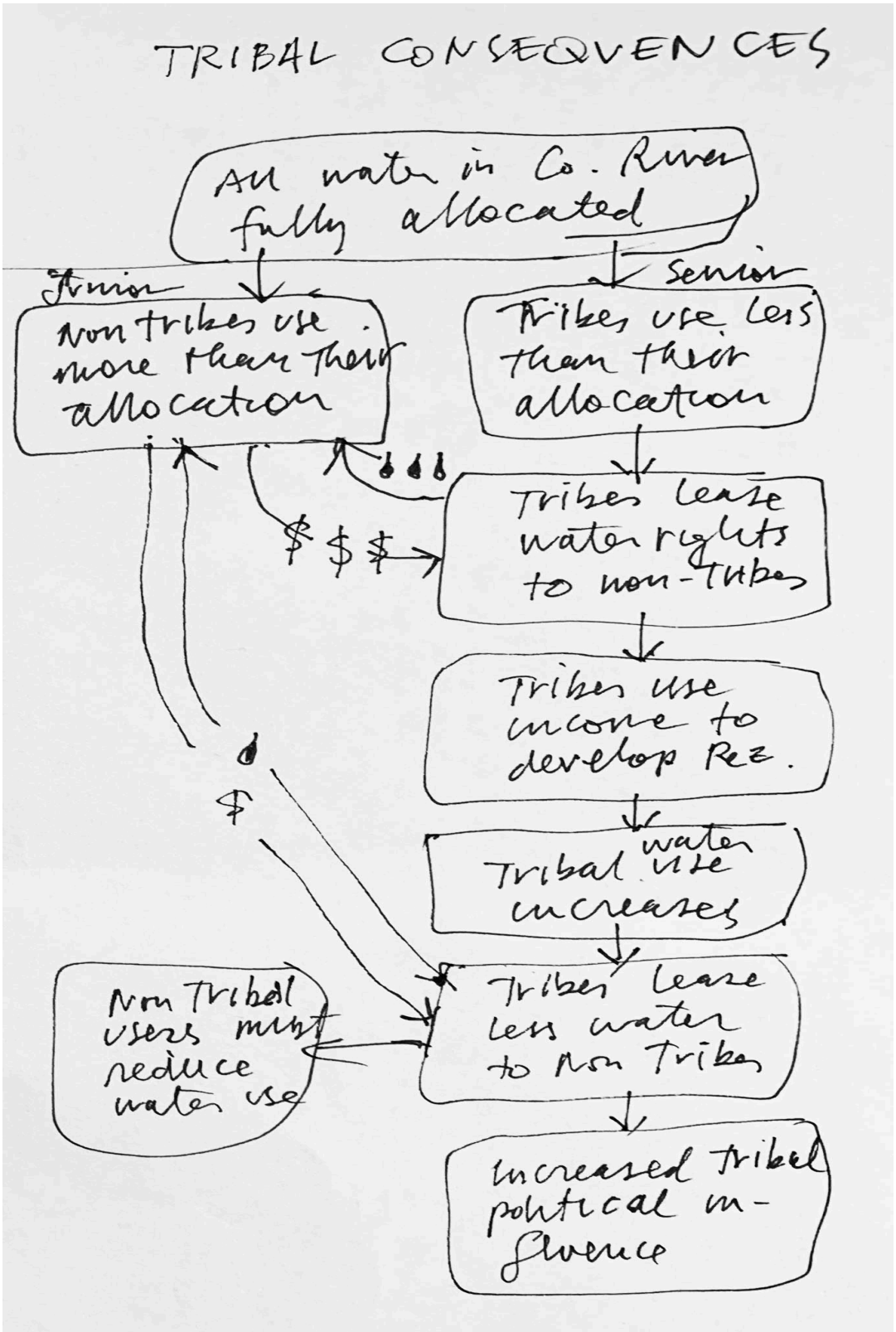
Investments in conservation, Lake Mead Levels



Wettest Years, 1922 Colorado River Compact



Tribal Consequences



Green and Colorado Rivers

