Photo: Don McFarlane, 2 June 2012

Water management issues in the Copiapó Basin, Chile

With some comparisons with Australia

Don McFarlane CSIRO

12 July 2012

Chile location map

4,300 km long and average 175 km wide

The longest country in the world north to south

Talk outline

1. Background to the AusAID-supported study
2. Chile and Australia – a brief comparison
3. Chile's governance and water management system
4. Copiapó Basin – locality and climate
5. Hydrology and hydrogeology
6. Different perspectives on the water over-allocation problem
7. Solutions proposed by interviewees
8. Conclusions

1 Background to the AusAID-supported study:

Copiapó River Basin, Chile – analysis study of shortfalls in water rights, industrial usage and social requirement

1. Led by Mike Trefry under the Public Sector Linkage Program
2. Terry Norgate, Kieren Moffat and Don McFarlane also involved
3. Counterpart organisation in Chile: Ministry of Public Works – Water General Directorate (**DGA**)
4. 1st May to 30th Sept 2012. Contributions from AusAID, CSIRO and DGA
5. Overall objective:

   To develop a set of Terms of Reference that is endorsed by key stakeholders and which is to be used as a basis for developing a much larger collaborative study of water rights governance in the Copiapó Basin

6. Activity: Develop preliminary integrated assessment of:
   - i) industrial, agricultural, environmental and social water use profiles and demand projections
   - ii) hydrological and hydrogeological resources
   - iii) water regulatory framework, and
   - iv) stakeholder perspectives for the Copiapó Basin

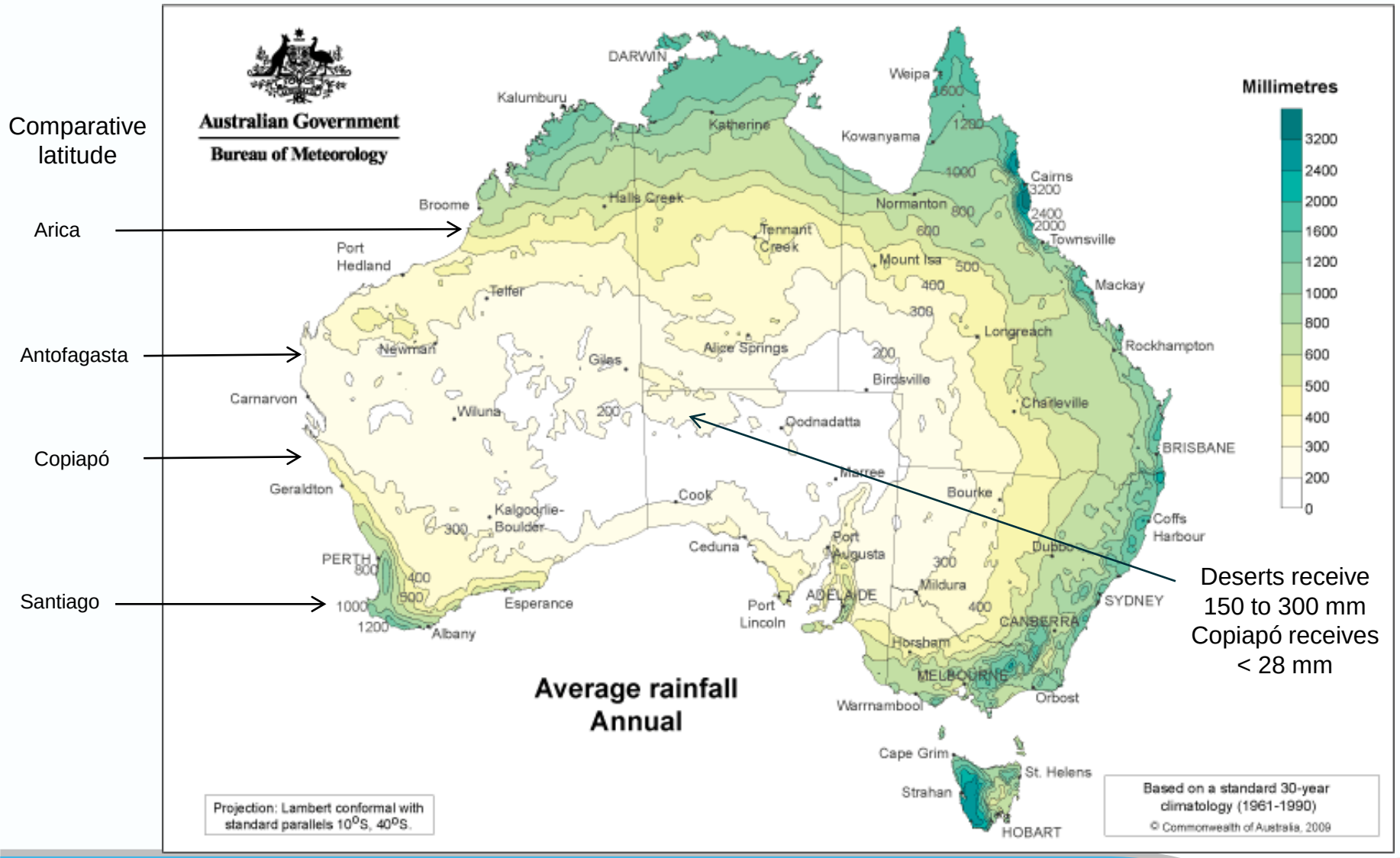
2 Chile and Australia – a brief comparison

Parameter	Chile	Australia
Area (m km^2)	0.76	7.6
Population (m)	17.40	22.95
GDP per capita (US$)	14,413	65,477
Gini coefficient (%) Larger = less income equality	49.4	30.5

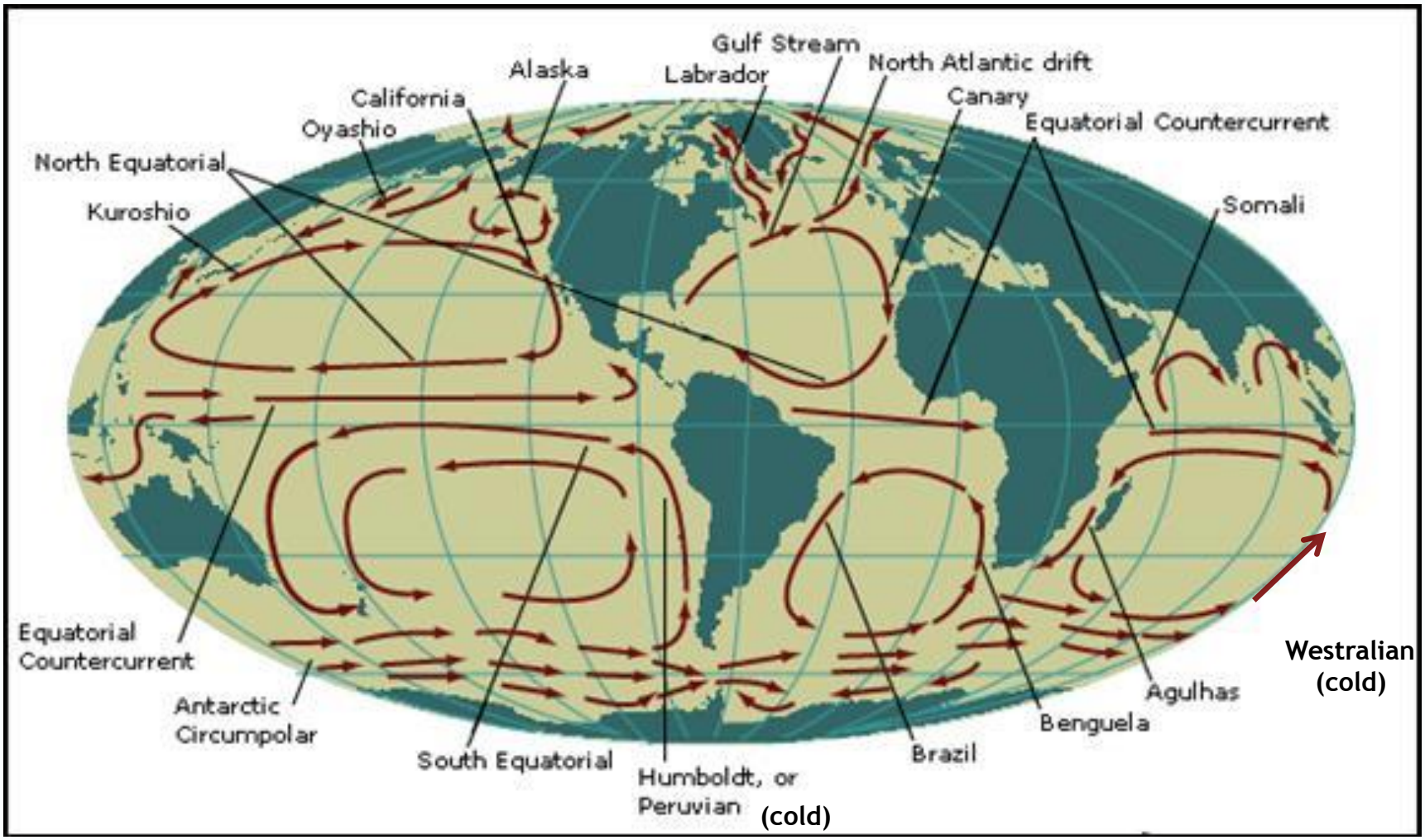
Chile leads Latin American nations in human development, competitiveness, income per capita, globalisation, economic freedom and low perception of corruption

It is the only South American country in the OECD (34 countries)

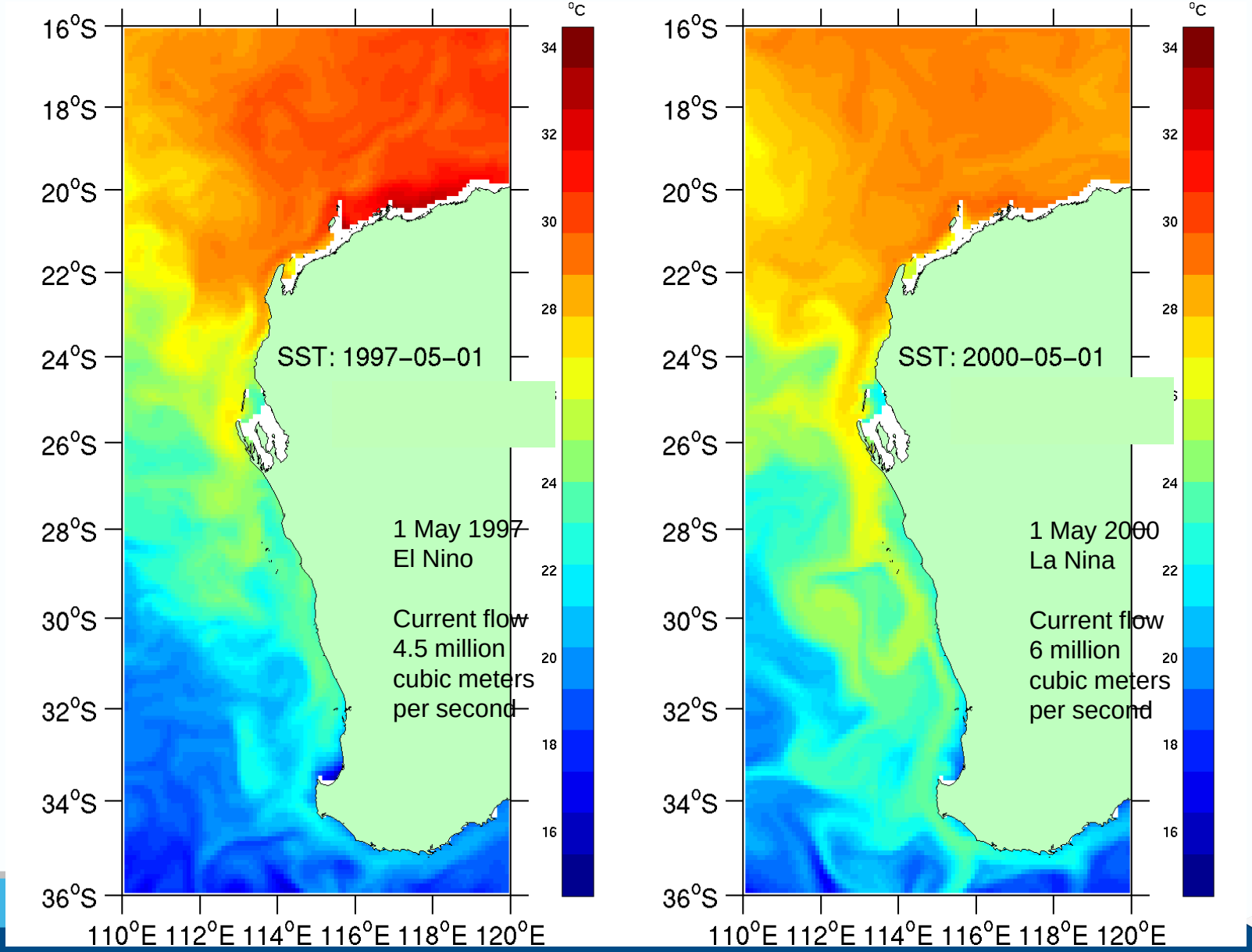
Rainfall in Australia is much higher for same latitudes



Ocean gyres


Gulf Stream
Alaska
Labrador
North Atlantic drift
California
Canary
Oyashio
Equatorial Countercurrent
North Equatorial
Kuroshio
Somali
Equatorial
Countercurrent
Westralian
(cold)
Antarctic
Circumpolar
Agulhas
Benguela
South Equatorial
Brazil
Humboldt, or
Peruvian
(cold)

The Leeuwin current is the strongest pole-ward flowing eastern boundary current in the world - brings warm tropical water along the continental shelf



The Leeuwin Current increases WA rainfall compared with Chile

Western Australia	Annual rainfall (mm)	Chile	Annual rainfall (mm)
Geraldton $28^0 47'S$	460	Copiapó $27^0 22'S$	20
Perth $31^0 96'S$	868	La Serena $29^0 54'S$	96
Bunbury $33^0 33'S$	871	Valparaiso $33^o 03'S$	462

3 Chile's governance and water management system

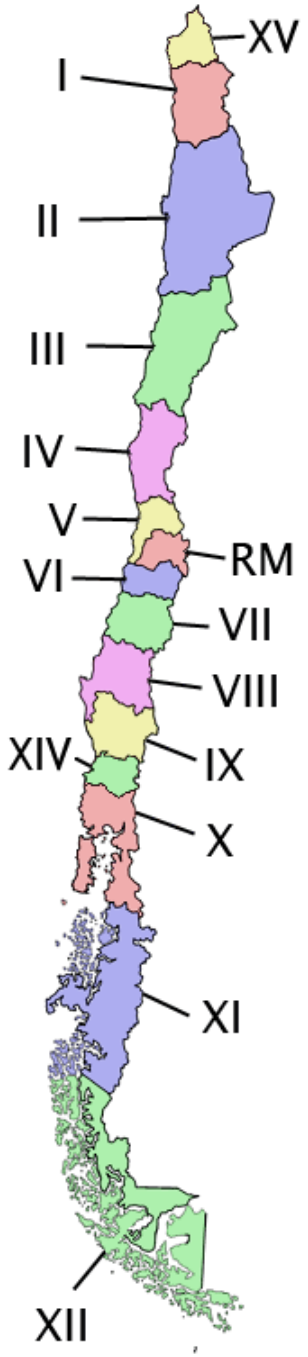
Fifteen regions: Region III = Atacama

Three provinces within Atacama:

- Chañaral
- Copiapó
- Huasco

National management; appointment of leaders

Region: Intendente
Province: Governor
City: Mayor



Chilean Constitution (1980) and Water Code (1981)

Under the 1981 Water Code, water rights are:

i. private property

ii. separate from land

iii. can be freely traded

iv. subject to minimal state regulation, and

v. regulated by civil law

Some amendments were made to the Code in 2005 but the emphasis on private rights and restrictions on government's role is embedded in the Chilean constitution making them hard to change

The focus of water issues in 1980 and 1981 was surface water irrigators (the main water users at that time). The rights of others users (towns, mines) and groundwater users are less well supported

Background and strengths*

- Water rights systems were influenced by the Chicago School of Economics (Milton Friedman) which emphasised small government and letting the market decide the highest value of water use
- The system has been promoted by the World Bank as being superior to heavy government intervention which can result in economic inefficiency, corruption and cronyism
- The use of private markets has been successful where there has been strong competition for water and a method exists to transfer water from seller to buyer (e.g. Limari River Basin)
- The existence of rights and a system for reallocation has negated the need for an alternative system
- The overall approach has influenced the definition of water rights and water trading in Australia, USA etc

* With acknowledgements to Carl Bauer "Siren Call" (2004) and Hearn and Donoso *Water Policy* 7: 53-69 (2005)

Perceived weaknesses are*

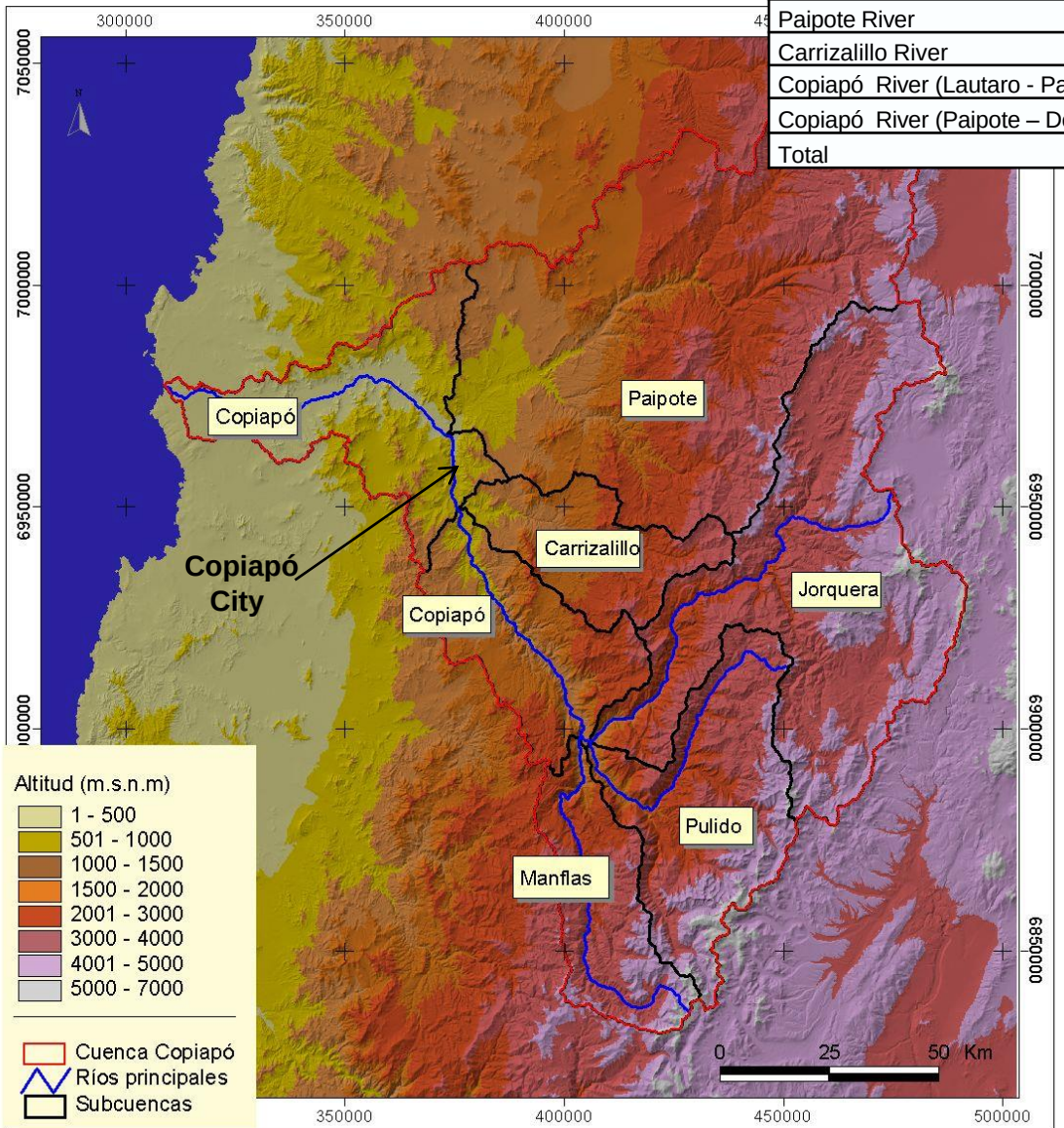
- Social equity – limited power of small farmers and indigenous groups
- Environmental protection - only considered for new rights issued since 2005
- Basin-wide management of all water users is discouraged by vesting most power in Vigilance (Basin) and Canal irrigation groups
- Coordination of multiple water demands and supply options is difficult because of this emphasis on surface water irrigators
- Emphasis on individual rights can make it hard to coordinate within user groups
- Few trades, a gridlocked system and lower infrastructure investment than was expected
- High transaction costs for trading → rights 'swaps' instead of permanent sales
- Resolution of water conflicts by legal means is often expensive, slow and absolute. i.e. win-lose rather than exploring win-win options
- No cost of holding consumptive use rights encourages hoarding and speculation
- Emphasis on economic efficiency to the exclusion of social, environmental and governance aspects
- Government's role is restricted to data collection and studies, enforcing user association rules, issuing rights within a specified time, keeping registers etc.

* With acknowledgements to Carl Bauer "Siren Call" (2004) and Hearn and Donoso *Water Policy* 7: 53-69 (2005)

Copiapó River Basin Topography

Sub-basin characteristics

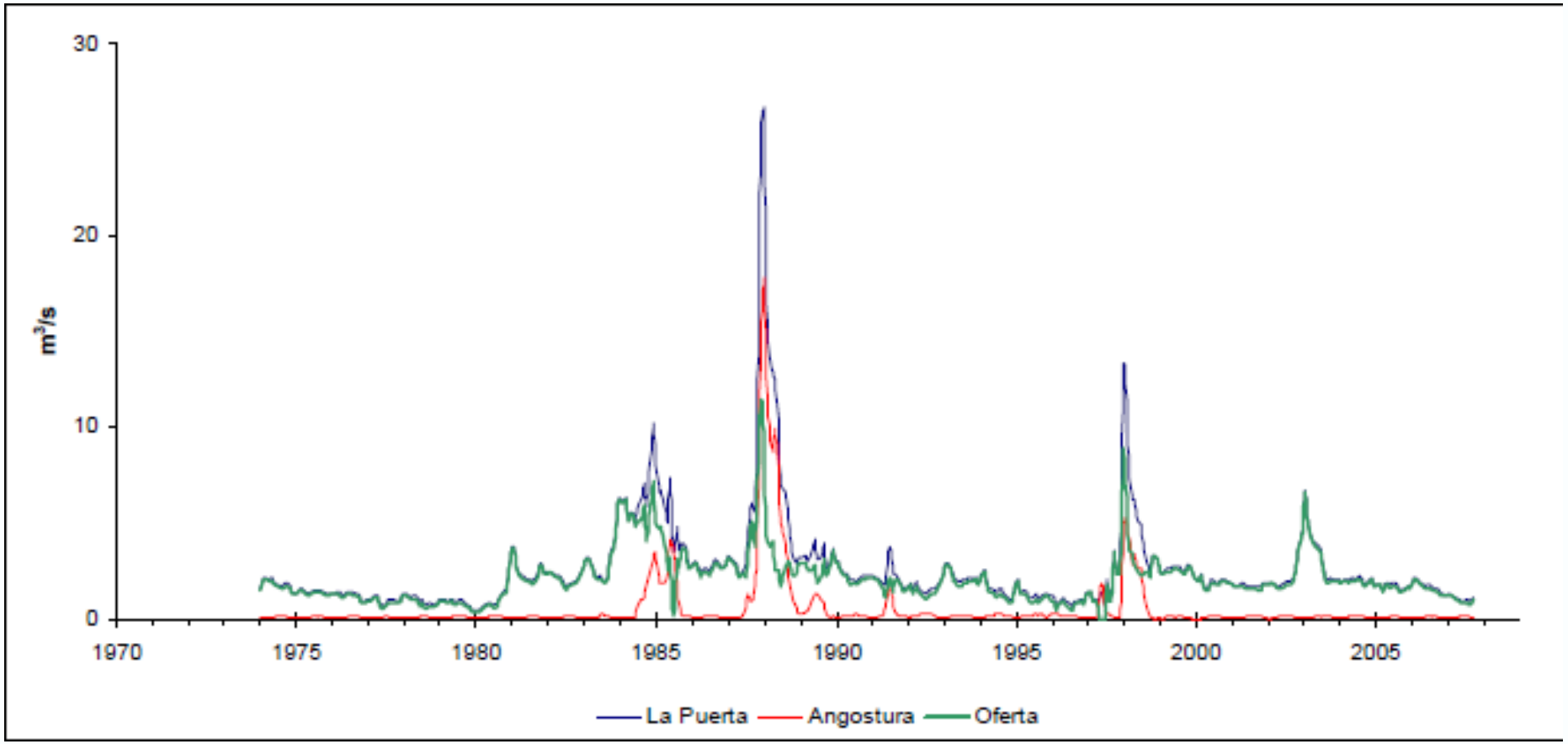
Sub-basin	Área (km2)	%	Min Altitude (m)	Max Altitude (m)	Average Altitude (m)	Average slope (%)
Manflas River	1.205	7%	1,198	5,676	3,362	18.7
Pulido River	2.042	11%	1,230	5,765	3,550	20.6
Jorquera River	4.185	23%	1,228	6,050	3,797	16.6
Paipote River	6.661	35%	441	5,291	2,566	12.8
Carrizalillo River	1.117	6%	595	4,240	2,105	13.7
Copiapó River (Lautaro - Paipote)	1.464	8%	582	3,926	1,715	13.9
Copiapó River (Paipote – Desemb.)	1.862	10%	0	1,775	641	8.2
Total	18.536	100%	0	6,05	2,717	14.6



2010 Chile mine disaster in San José copper-gold mine 45 km N of Copiapo City

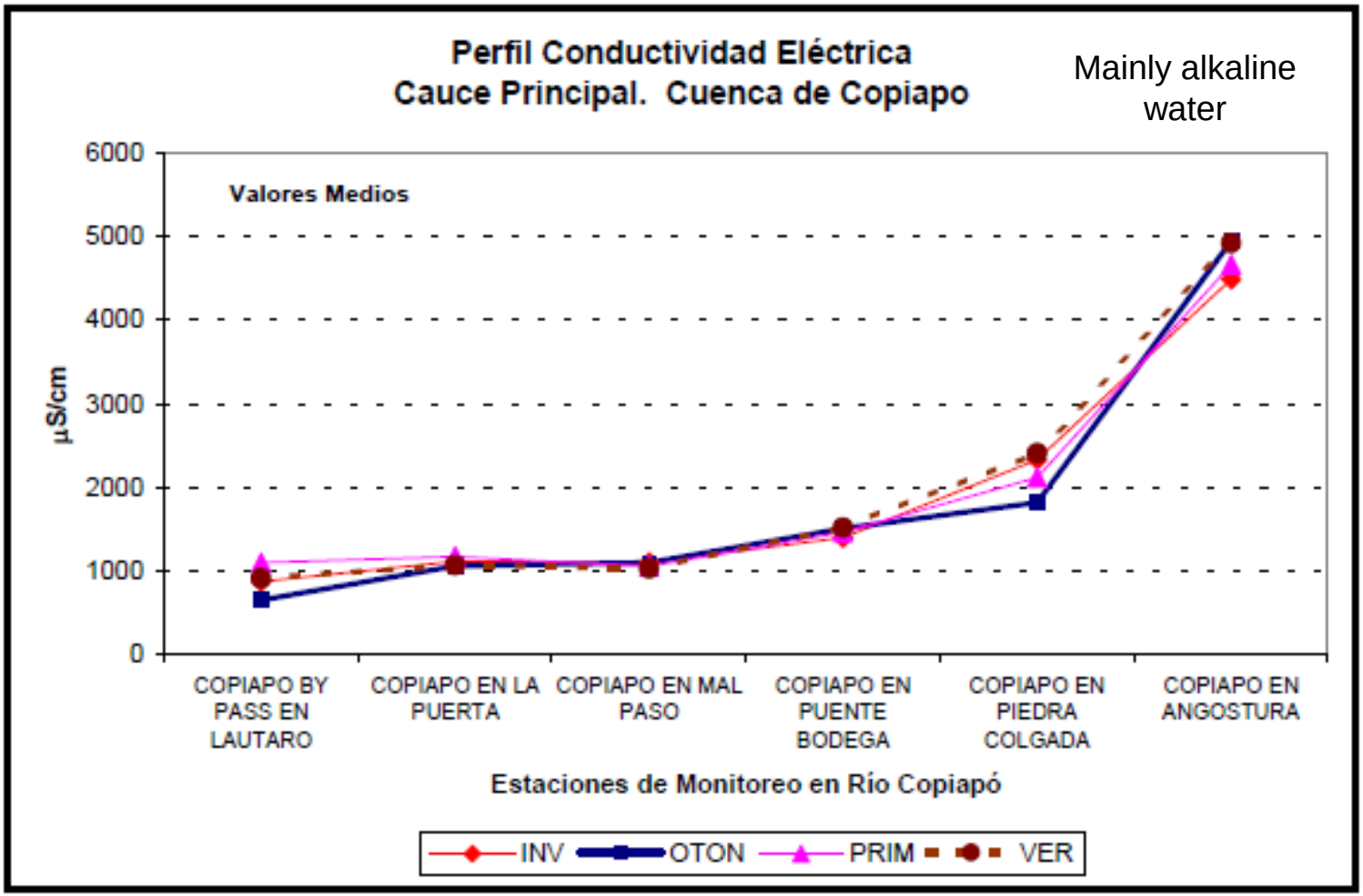
Upper-middle river flows (blue: La Puerta) and outlet flows (red: Angostura) between 1974 and 2008 shows the river has effectively ceased to flow to the ocean since 1998

Source: DGA (2010)



River salinities are low in the upper to mid reaches (left) but increase at the outlet (right) Source: DGA (2004)

NB: there has been almost no river flow in the lower reaches in the past 15 years

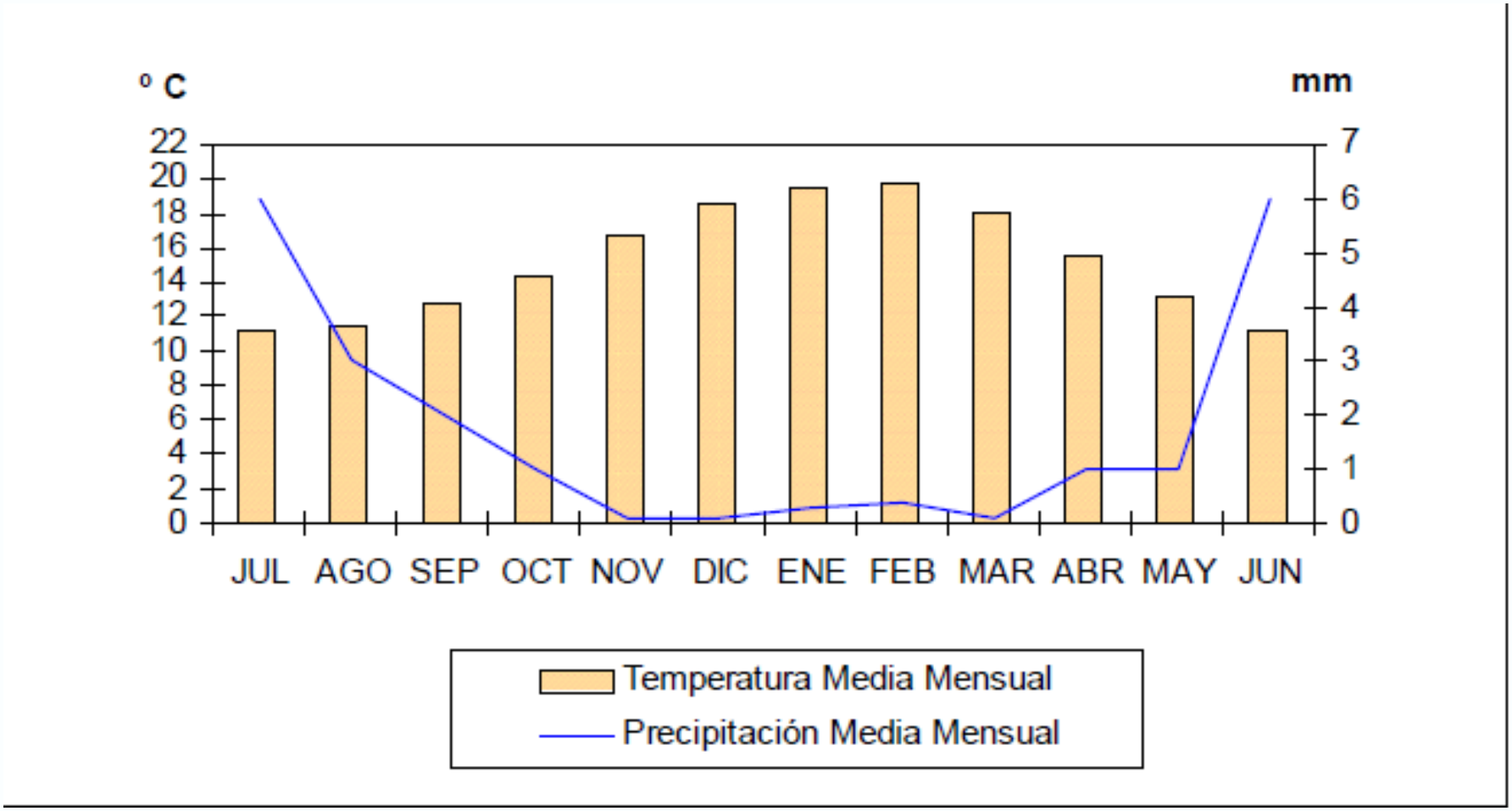


Lautaro Reservoir 96 km SE of Copiapó City Capacity: 23 GL
Built in 1920 Elevation = 1100 m 40 mm pa rainfall

Photo: Kieren Moffat, 2 June 2012

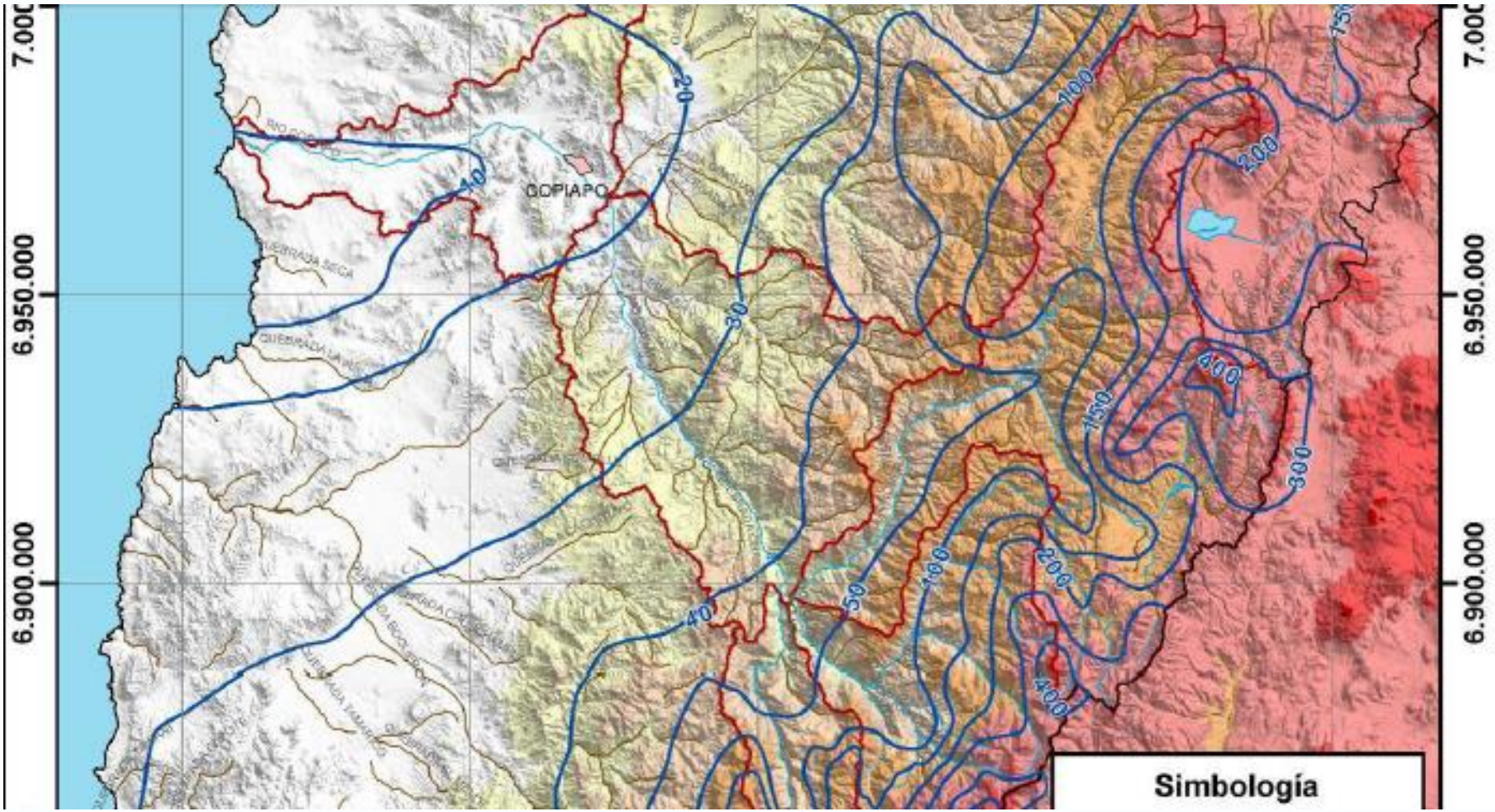
Monthly temperatures and rainfall at the Lautaro Reservoir, Copiapó River

Source: DGA (2004)



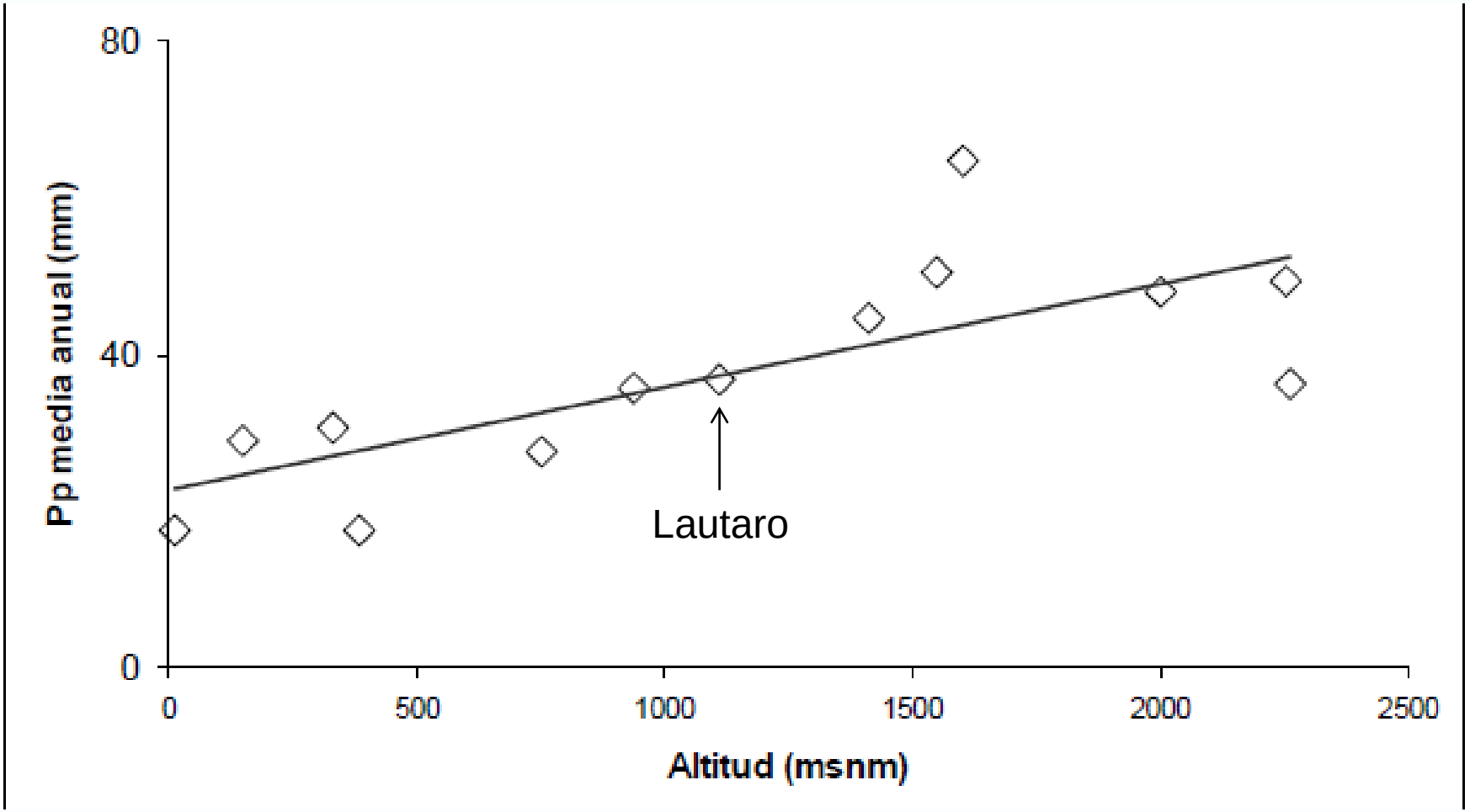
Upper Basin only receives 40 to 400 mm pa

Source: DGA (2010)

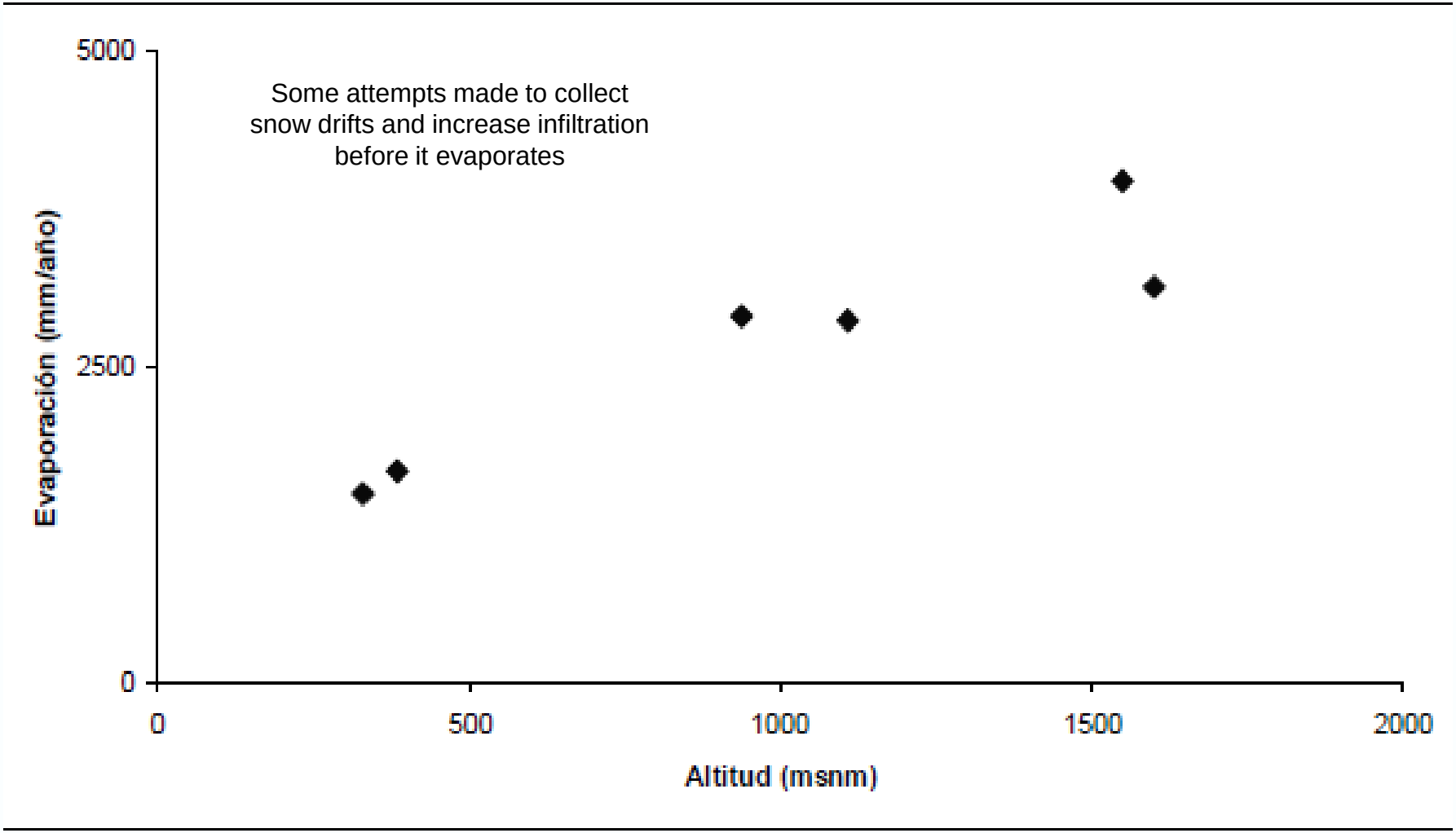


Rainfall increases with elevation but not by much!

Source: DGA (2010)



Wind increases potential evaporation (and moves snow) in upper altitudes
Source: DGA (2010)



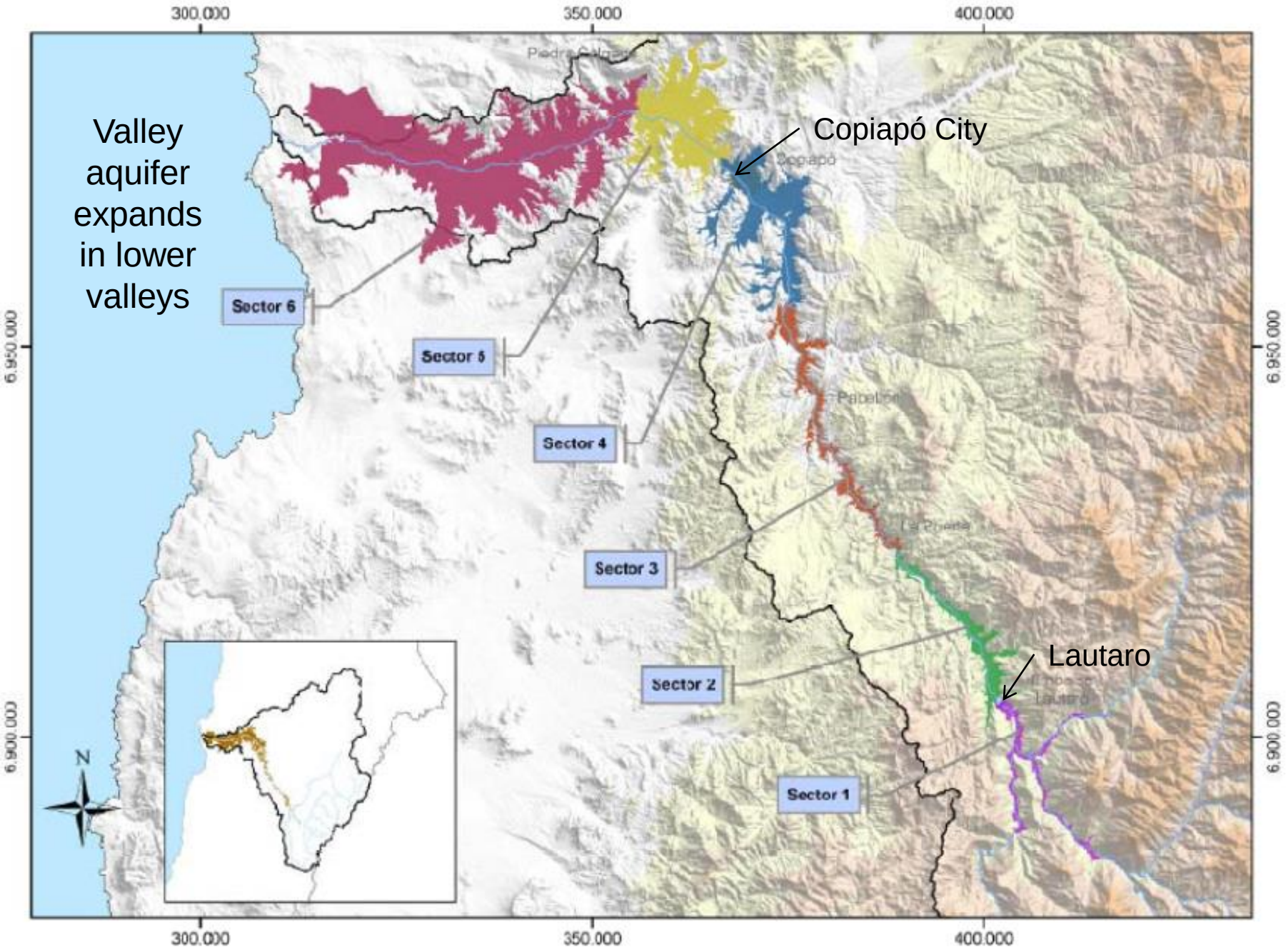
From little things, big things grow*…the Upper Copiapó River

*** Paul Kelly 1991**

Photo: Don McFarlane, 2 June 2012

Table grapes are grown in side valleys using water pumped to several hundred metres elevation above the Copiapó River

Photo: Kieren Moffat, 2 June 2012



Source: DGA (2010)

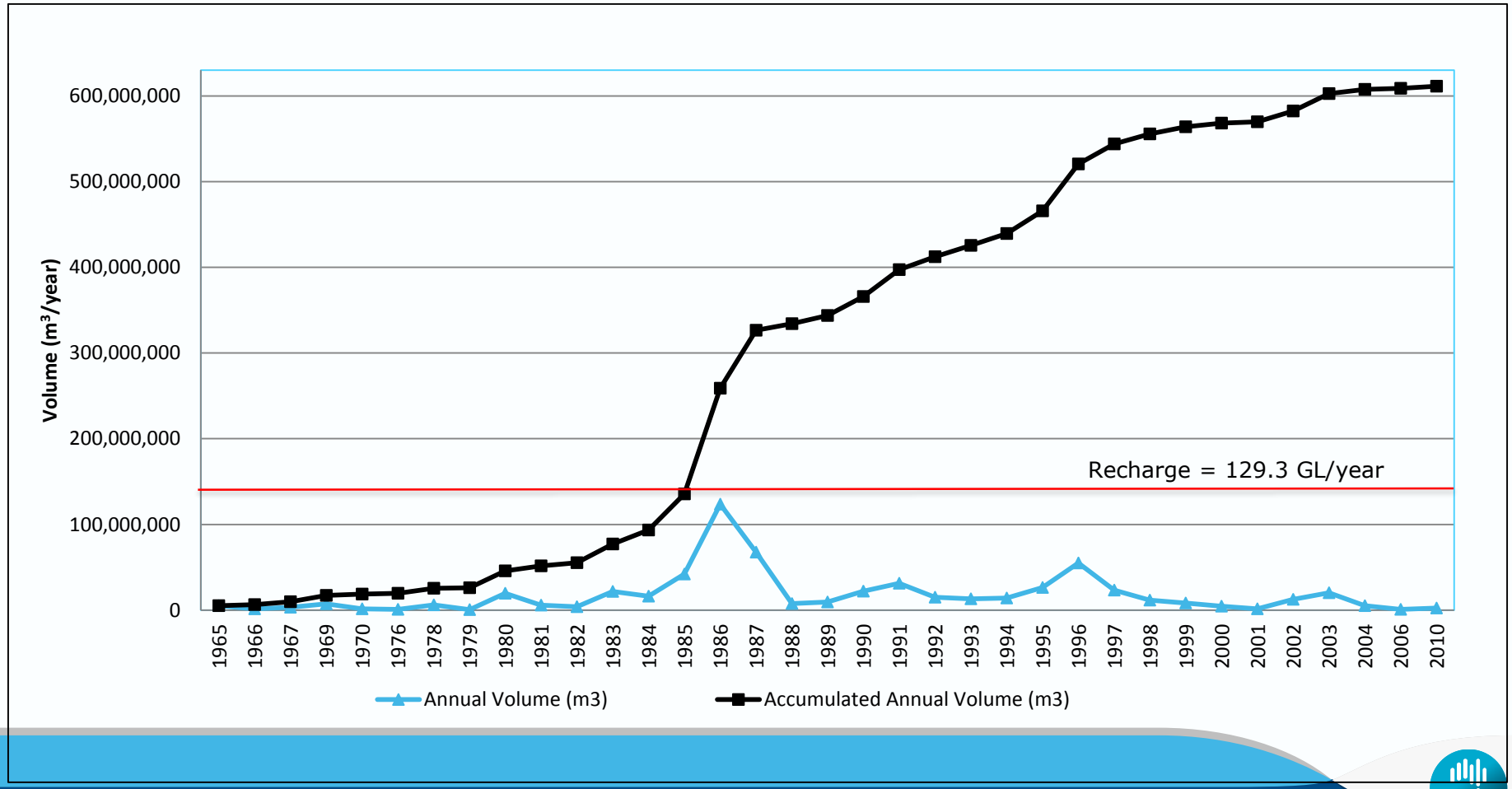
Lower Copiapó River is diverted into a concrete-lined channel in Sector 4 to prevent ‘leakage’ (= recharge)

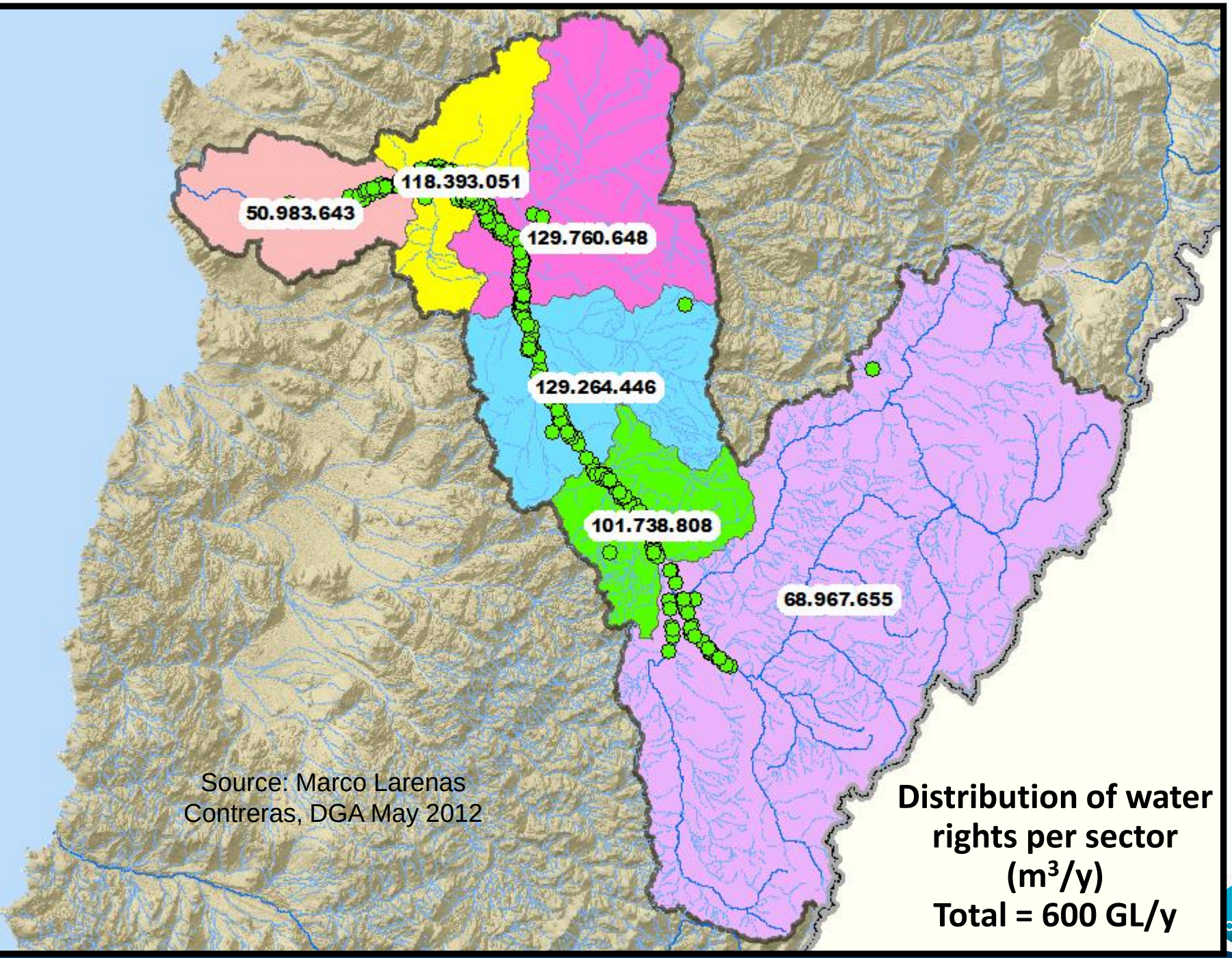
Photo: Don McFarlane, 2 June 2012

Constitutional water rights allocated per year – annually and cumulative

Source of figure: Marco Larenas Contreras, DGA May 2012

- Alamos y Peralta (1987) indicated that there was still groundwater available; levels were stable or rising
- Surveys indicated that agriculturalist were not using all of their rights and there was also return irrigation flow that was issued as new rights
- There is a legal requirement for the DGA to issue rights in a timely manner if water is available
- Agriculturalists started swapping their 'unused' water with miners when this was profitable



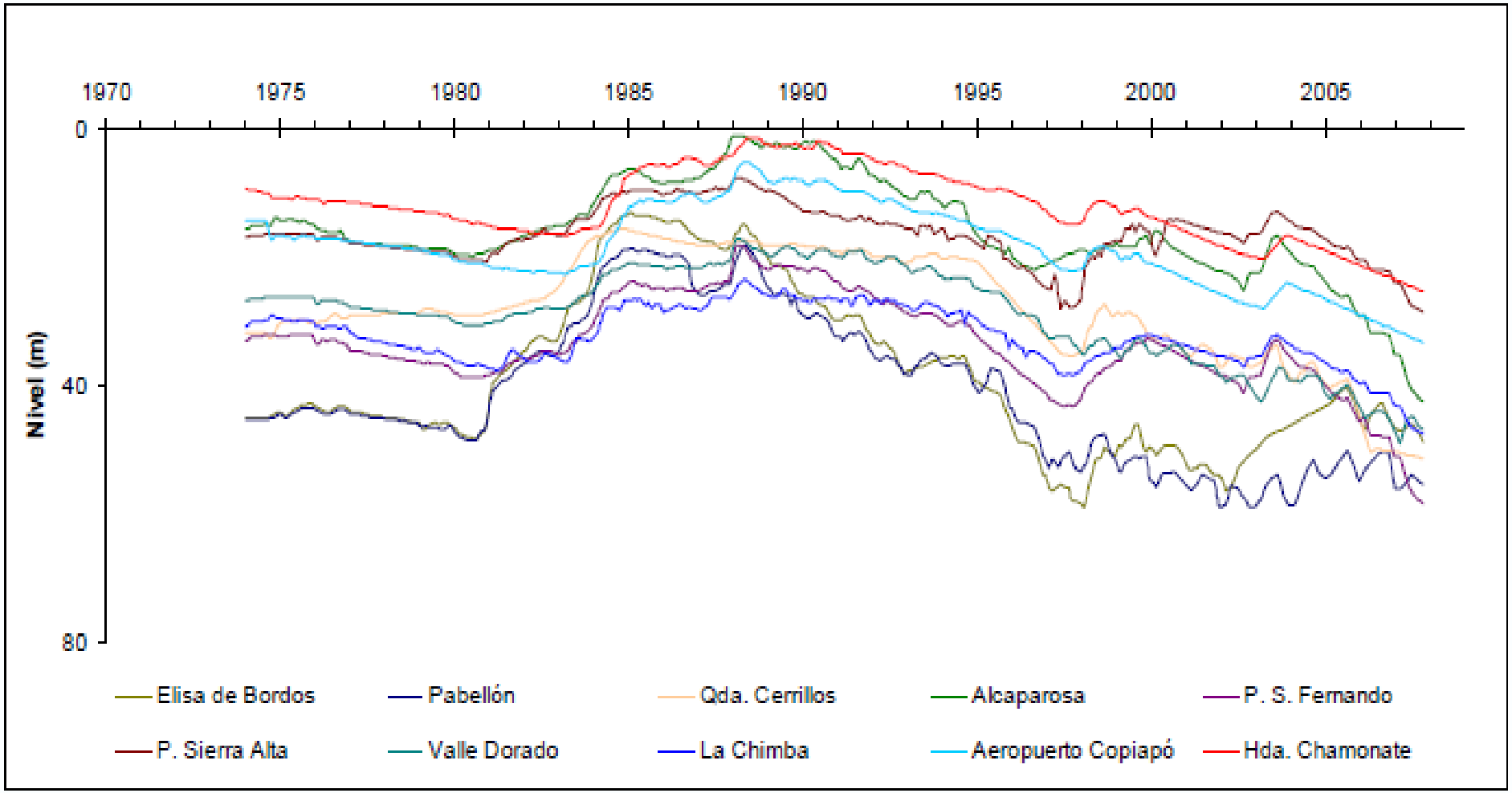

118.393.051
50.983.643
129.760.648
129.264.446
101.738.808
68.967.655
Source: Marco Larenas Contreras, DGA May 2012
Distribution of water rights per sector (m³/y)
Total = 600 GL/y

Looking for a water level in a production bore

Photo: Don McFarlane, 2 June 2012

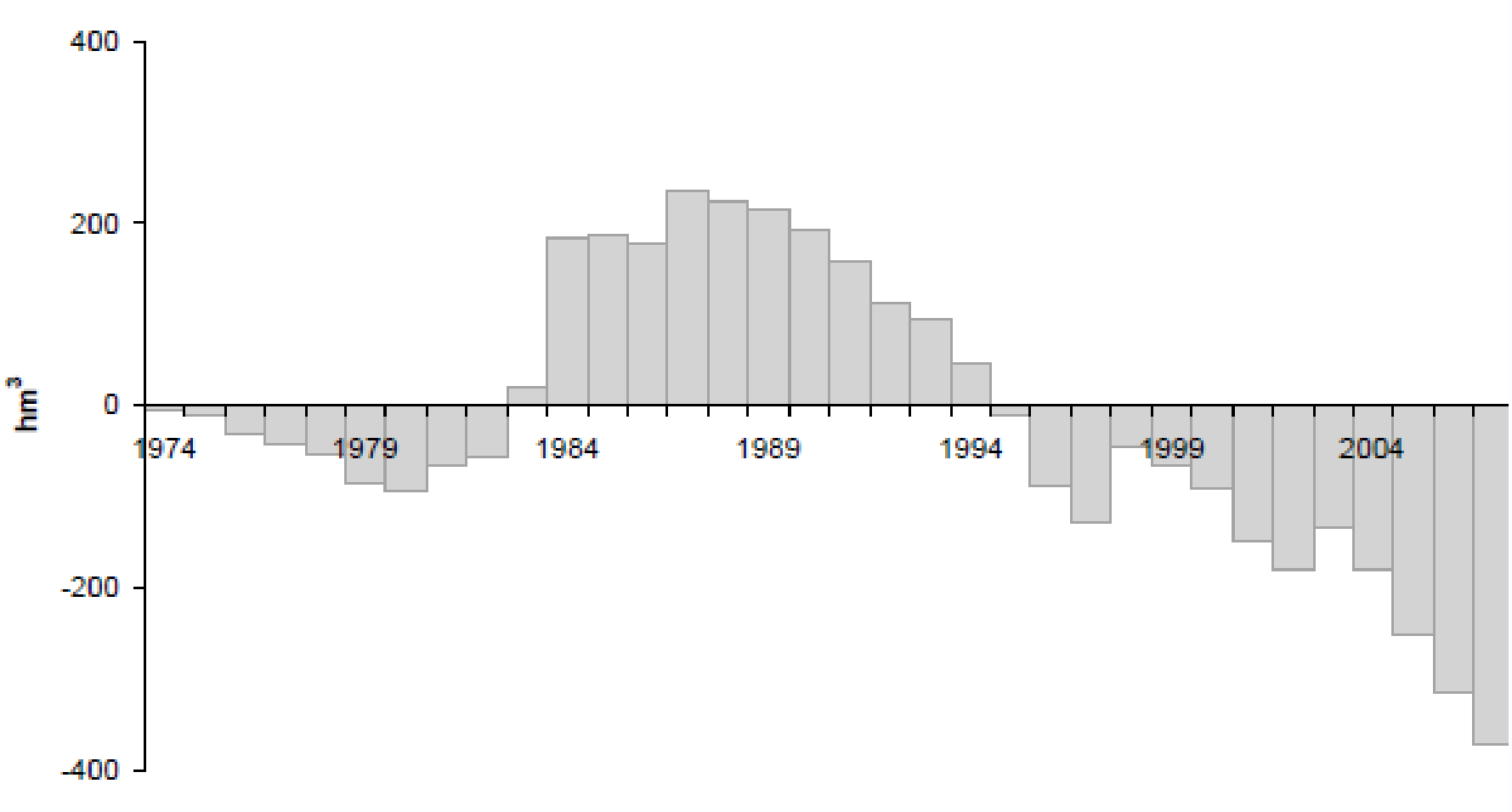
Groundwater levels have fallen by up to 25 m between 1974 and 2008 and are approaching the base of the aquifer in some cases

Source: DGA 2010



Variation in aquifer storage (La Puerta to Angostura) between 1974 and 2007

Source: DGA (2010)



Total demand and supply

Source: DGA May 2012

Total inflows: *ca*: 120 - 130 GL/y

Demands*

• Agriculture	142 GL/y	71%
• Mining	45 GL/y	22%
• Drinking water	13 GL/y	6%
• Other	2 GL/y	1%
• TOTAL	202 GL/y	100%

Potential annual deficit: *ca*. 70 - 80 GL/y

Aquifer storage loss: *ca*: 50 GL/y

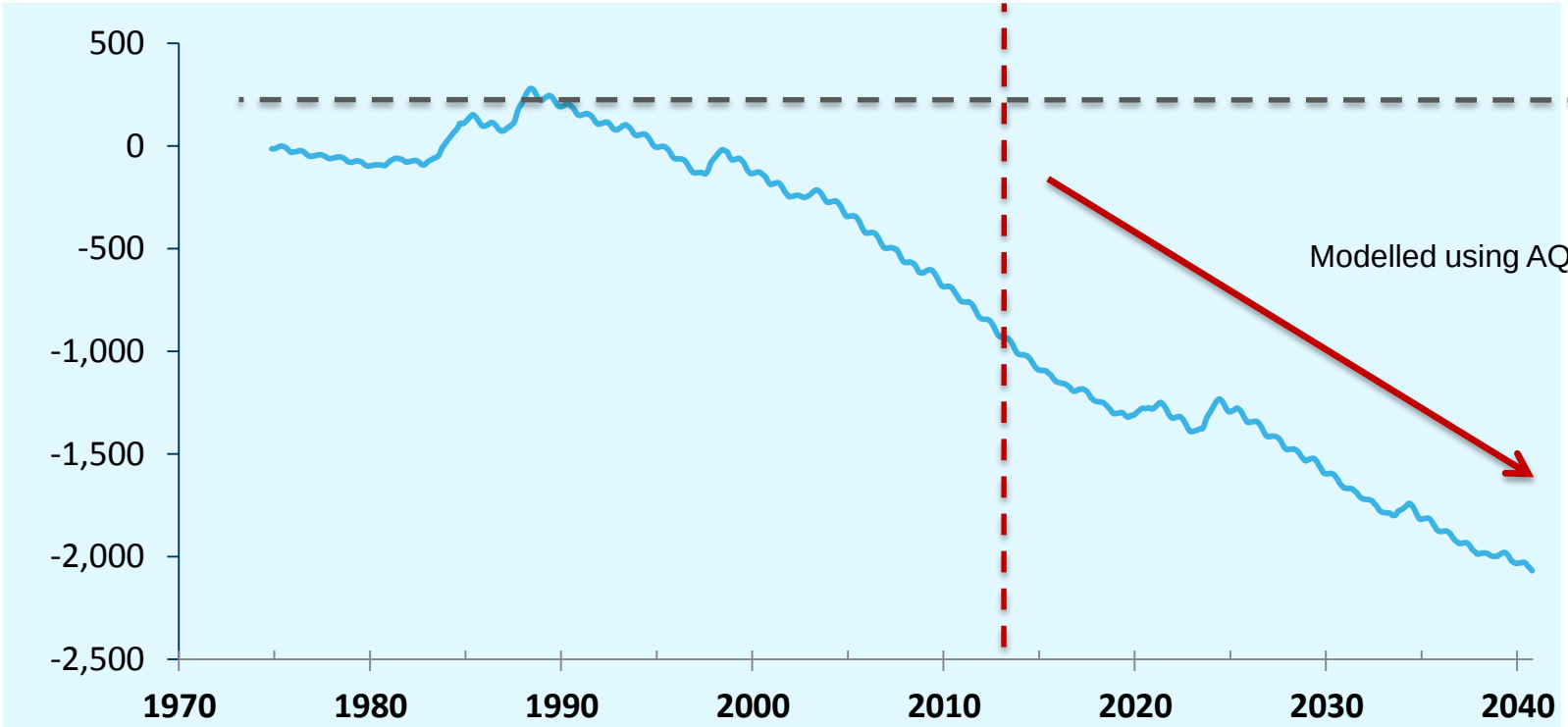
*Rights are not all used due to lack of water or poor water quality. Some users hold rights for water security purposes (which can be viewed as being prudent as 'hoarding'). Unused rights are helping to stop even worse over-use. Supply reliability is not usually reported

Aquifer storage change since 1975 in Sectors 3 to 6

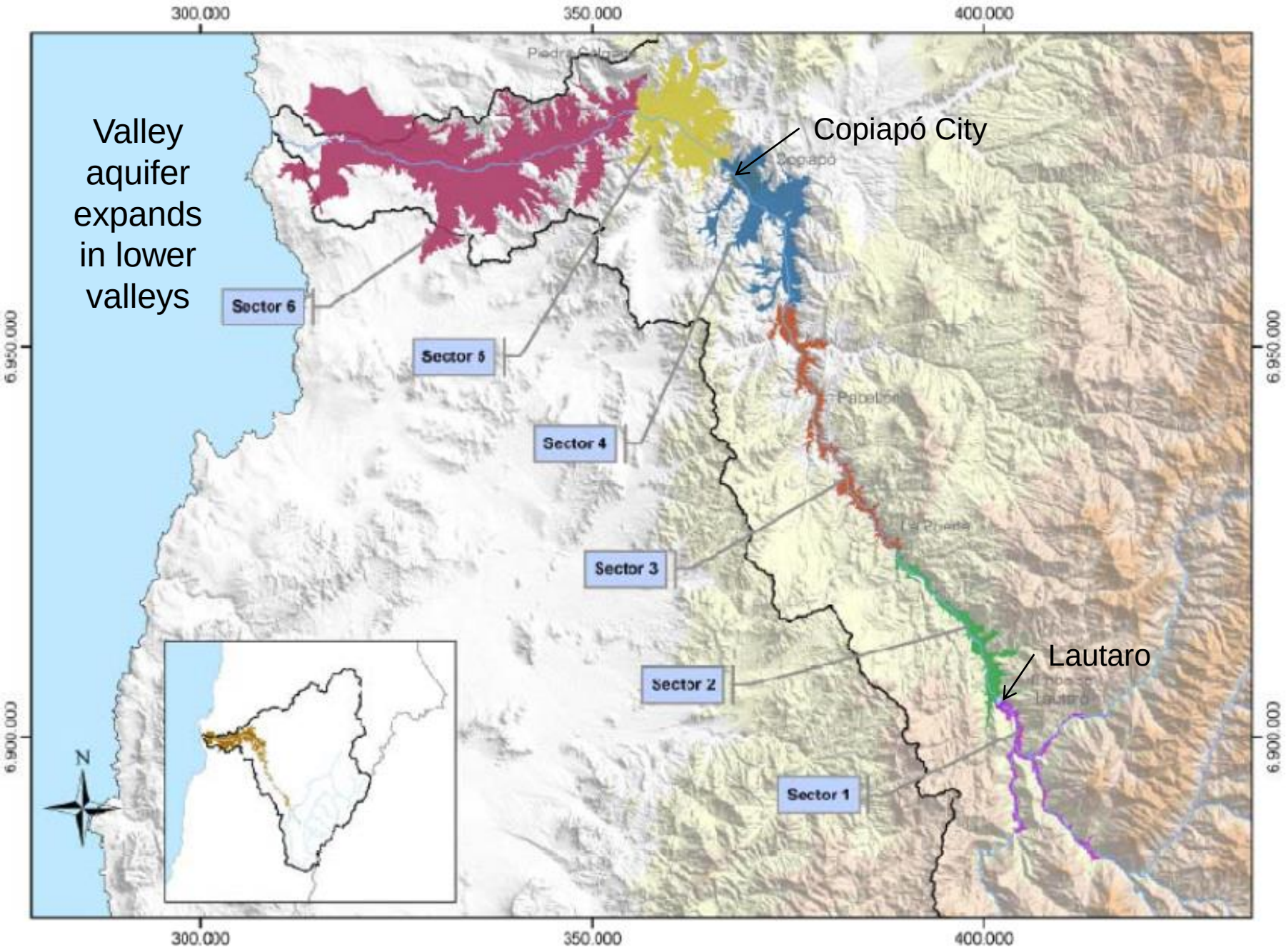
- Discharge has exceeded recharge resulting in storage declines since about 1988
- Average reduction of about 50 GL/y is equivalent to twice drinking water consumption*

Source: Ministry of Public Works (2012)

AQUIFER VOLUME LOSS BETWEEN LA PUERTA AND ANGOSTURA (GL)
ACTUAL UNTIL 2011 PROJECTED TO 2041



* Rate of decline is volumetrically similar to the Gnangara Superficial Aquifer



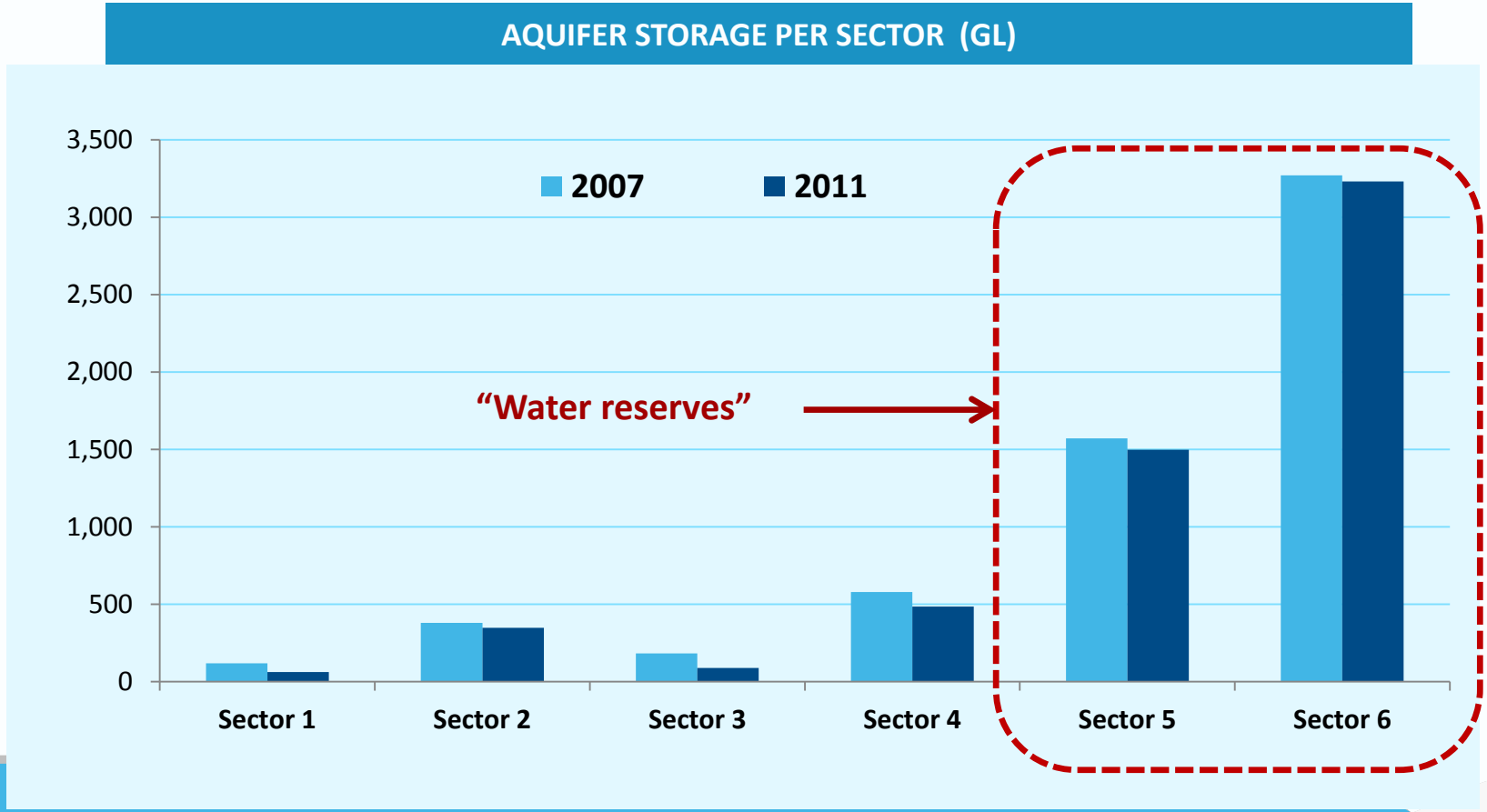
Source: DGA (2010)

Aquifer storage changes between 2007 and 2011

Decrease in levels makes extraction difficult and expensive

- Production decreases requires more and more wells
- Sector 4 presents the available volume, but some soundings have reached bedrock and it is not feasible to extract 100% of the water

Source: Ministry of Public Works (2012)



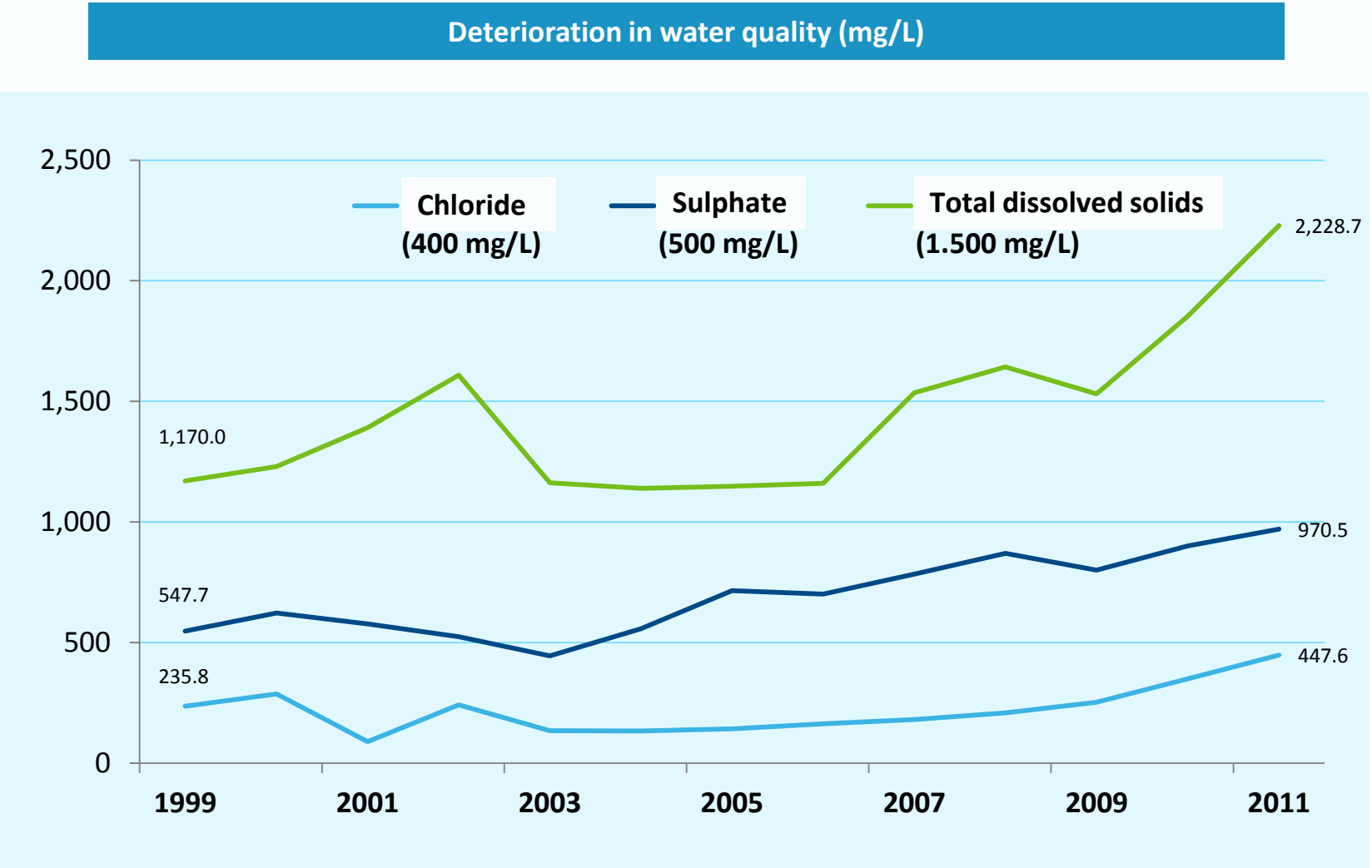
Drinking water bores around Copiapó City: *ca*. 180,000 people ~15% per annum growth (varying estimates)

Blue = in use Red = abandoned due to lack of water, poor quality or both

Source: DGA, May 2012

Drinking water quality exceedences have increased

Source: DGA May 2012



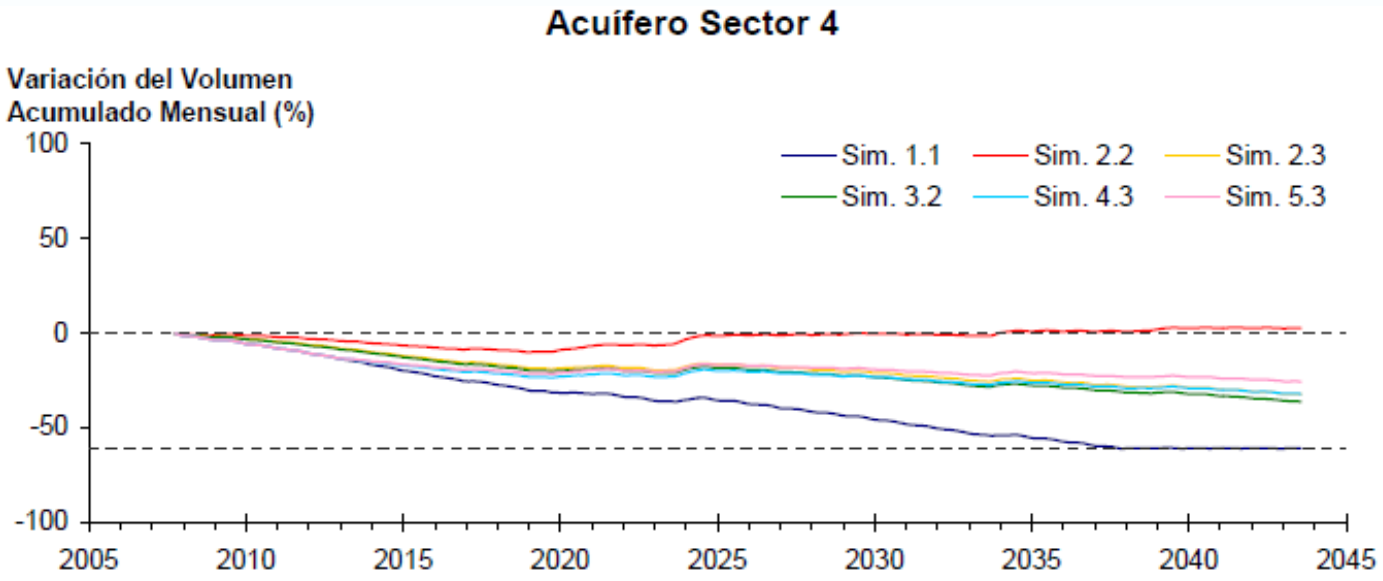
Aquifer volumes in Sectors 4 and 5 under pumping scenarios

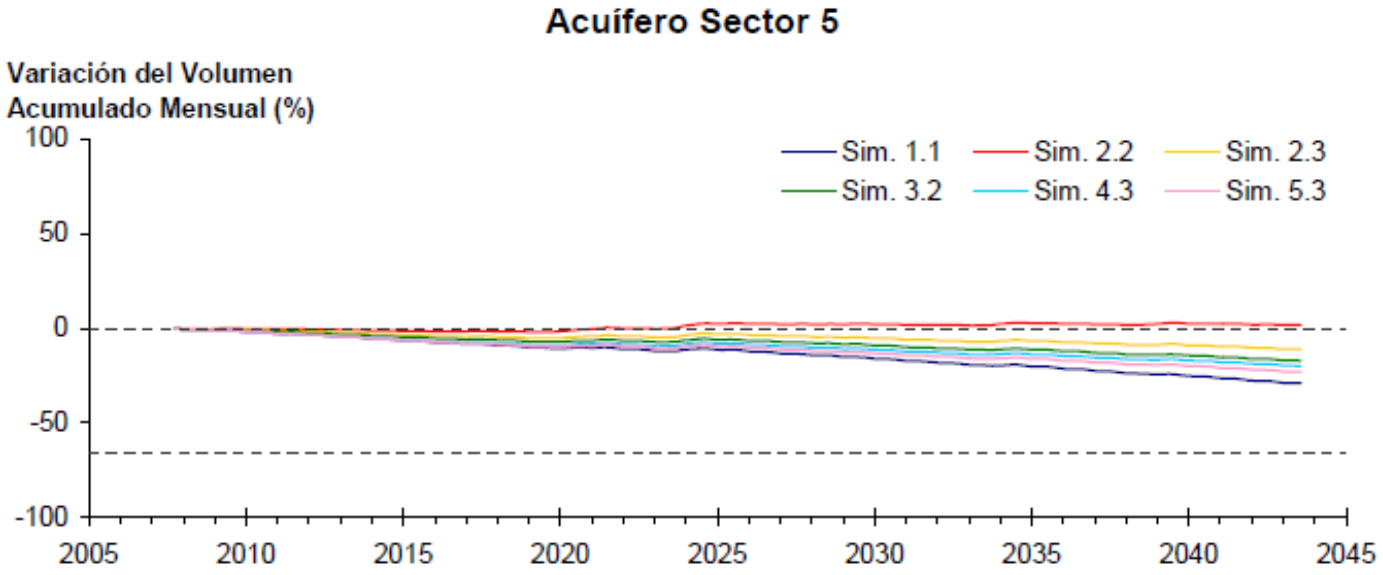
1.1 = Business as usual
2.2 = 50% reduction
2.3 = 30% reduction

Other scenarios distribute demand between either users or sectors

Total pumping needs to be reduced by 50% to maintain the current (low) levels

Source: DGA 2010





Attitudes to the water situation as gleaned from interviews in May and June 2012

- The local indigenous group (Callé) has been affected by the loss of the Copiapó River and reduced water for irrigation since commercial irrigators started growing early-season table grapes for the US market
- Upper-basin (mainly table grape) irrigators have had competition for water from miners although some have benefited from water sales
- Lower-basin (mainly olive) irrigators have faced competition from miners and more recently drinking water demands. They have to pump groundwater from increasing depths and water quality is now poor
- The town water supplier (Aguas Chañar) has had to buy water rights in Sectors 4 and 5 and to desalinate poor quality groundwater. They are legally required to purchase enough water rights and to supply good quality water. There is some dispute as to whether they can increase prices to reflect rising costs
- Miners have reduced their reliance on groundwater as levels have fallen and may soon use mainly desalinated seawater (except those at high altitude)
- All users have had to increase water use efficiency. Urban wastewater is used by miners and down-stream irrigators after limited treatment

Coordination of water supplies and demands

- A basin ‘Vigilance Group’ has powers over water distribution but confines its interests to surface water irrigators in Sectors 1 to 4
- A groundwater irrigator group (CASUB) managers irrigators in Sectors 5 and 6
- Despite the need for river flows to recharge lower aquifers, the Vigilance Group and CASUB do not meet to discuss water sharing
- A public-private ‘Water Negotiation Table’ met between 2007 and 2010 after the Lautaro Reservoir effectively emptied

Solutions proposed by interviewees

1. Miners to use desalinated seawater

- Underway in those mines near the coast; each has its own plant
- Impractical at high elevations; rights ‘swaps’ with coastal users
- Even if all mine extraction ceased, the problem won’t be solved
- Some irrigators benefit from the sales and swaps of water rights

2. Reduce irrigation water use

- All large irrigators are already very efficient, unclear about small users
- Reduce area under irrigation
  - Table grape production in Peru is now more profitable (Chile labour costs high due to mining; early grapes for US market possible in Peru)
  - Small irrigation farms not attractive for capital and youth (rural 'restructuring')
  - Let the market decide if other water uses are more profitable
  - Under the Water Code the government cannot reduce any one user group's access without cutting all equally (i.e. including Aguas Chañar)

3 Seawater desalination plant for Copiapó City

- Power is also in short supply in this part of Chile
- Are users able to afford higher cost water ? Only one tariff band can be charged with subsidies for disadvantaged groups.
- Apparent disagreement between service providers about how tariffs are set (cost-of-service provision or politically ?)
- Santiago's water service provider has plans for a seawater desalination plant 'on hold'
- Aguas Chañar is building a small desal plant to improve bore water quality

4 Pump water from further south

- A French company is proposing to take water from two rivers south of Santiago and bring it to the Atacama using a submarine pipeline
- Cost is purported to be less than seawater desalination
- May take a long time for approvals and feasibility

5 Increase intra-basin planning and water sharing

- Reinstate the Water Negotiation Table including all the main interest groups
- Get the Basin Vigilance Group (upper basin, mainly surface water irrigators) to work closer with CASUB (lower basin groundwater irrigators)

Concluding comments

1. The use to which the people in the Copiapó Basin have put such a small amount of water is amazing
2. Environmental issues play a surprisingly small role in water planning
3. A lack of wet years, diversion of water in the upper part of the Basin, the growth of Copiapó City, and mining demands have all resulted in the river ceasing to flow to the sea and aquifers being depleted
4. The Water Code places an emphasis on individuals solving water problems through trading property rights and through the courts rather than Basin-wide planning and multi-party settlements
5. The DGA is considering reinstating the Water Negotiation Table to improve user-understanding of the causes and seriousness of the situation and to seek Basin-wide solutions
6. If there is a second phase of this project, CSIRO may be involved in more detailed investigations

Thank you

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w http://www.csiro.au/people/Don.McFarlane.html

A dog with Santiago and the Andes in the background Photo: Don McFarlane June 2012

Similarities in water management in Western Australia and Chile

1. On the west side of an ocean in the Southern Hemisphere
2. land between 18 and 35^{o}S
3. interactions between rivers and aquifers
4. increasing reliance on groundwater
5. water demand for mining, towns and agriculture is rising
6. were once part of Gondwana so share geology and biology
7. use water trading to transfer water between user groups

   In WA, the climate has become drier and hotter since 1975 and this is projected to intensify. Chile ?