



International
Water Association



World Health
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**Water Safety
Conference 2010**

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Impacts of Extended Drought on the Water Quality and Operations of Maynilad Water

Is it climate change?

- Weather anomalies
- Localized weather pattern
- Changes in stream flow
- Operational lapses
- Poor resource management

- Scenes in Manila on Sept.29 – 30, 2010
- As typhoon Ondoy makes a landfall
- Bringing 381 mm of rainfall in 6 hours
- Flood record of 150 years return period

- One of the streets of Manila as Ondoy lashes its fury



houses were submerged



Properties and lives were lost



Even electric wires were used as life support



Streets were turned into waterways



3 months after ... the dam level dropped
precipitation was below its normal levels



Water levels continued to drop



Rainfall levels and run off continued to be lower than usual for the next 3 mos.



What used to be submerged resurfaced



Farm crops are affected and again the competition on the supply



The drought in our watershed continued although the onset rainy already commenced



El Nino effects began to reshape our ability to deliver our service obligations



Start on the monitoring of metals in the raw water



Maynilad announces rationing due to cut in supply

Metro water rationing may be extended further

07/19/2010 | 02:08 PM

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(Updated 4 — 9:17 p.m.) More than a million Metro Manila residents may continue to face six-hour water service reductions after reserves in Angat Dam, the Philippine capital's main water source, reached a historic low.

An extension of water rationing "is possible," a source familiar with the matter told GMA News TV on Monday, minutes after Maynilad Water Services Inc. (MWSI), held an early afternoon press briefing about the issue in its Quezon City offices.

Earlier, Maynilad, Metro Manila's west zone water distributor, said that rationing for 1.126 million of its estimated seven million customers will last until Friday, July 23.

Meanwhile, some 3.22 million customers — 46 percent of the total — may endure scheduled service interruptions that may last in excess of an hour or more, the company said.

As a result, residents enjoying 24-hour water service may find their taps running dry during non-peak hours, Maynilad officials said.

Affected areas include Las Piñas, Caloocan, Malabon, Navotas, Valenzuela, Manila, and Parañaque cities.

"Hopefully the situation will quickly improve," the source added, refusing to say when water rationing would end.

As of July 18, water levels in Angat reached 157.56 meters above sea level, considered as "the lowest water level in history," the company said in a press statement.

Raw water produced during the same date reached 1,819.08 million liters of water a day (MLD), one-third lower than the normal level of 2,400 MLD, the company said.

Global warming and lack of rainfall over Angat dam have contributed to low water supplies.

These have also prompted the company to cut its yearly growth forecast for billed volumes — revenues from paying customers — to 10 from 18 percent.

More than half of the water it distributes — at 57 percent — are either wasted or stolen, the company said, citing June 2010 figures. In 2006, its non-revenue water (NRW) ratio was at 67 percent.

The company's current NRW ratio may also be affected since supplies distributed to waterless areas are "free," Herbert Consunji, the company's chief operating officer, told reporters during the briefing.

Two months' worth of water supplies thrown out

Maynilad's situation is not helped by the fact that "two months worth of water supplies" from Angat have been thrown out late last year, Consunji said during the briefing.

METRO

Water rationing stays despite heavy rainfall

by Rio N. Araja

DESPITE the rains, water rationing will be maintained in the West Zone, a top official of the Metropolitan Waterworks and Sewerage System said.

Officer in charge Macra Cruz said five cloud-seeding sorties have materialized over the Anngat watershed in Bulacan but the dam has so far yielded 2,150 million liters of water per day against its average production of 4,000 MLD or 46 cubic meters per second at a normal level of 180 meters.

"Water production at Angat is much higher today than in the previous weeks," she told Manila Standard.

"However, we cannot say that water shortage of Maynilad is already over. The dam is still at its critical level."

She said the P3-million cloud-seeding operation helped induce rains to bring the reservoir out of its record low of 157.56 meters on July 18.

Hydrologist Roy Badilla, of the the weather bureau's Dam Flood Forecasting Division, said elevation went up to 162.02 meters from 160.85 meters on July 24 and 159.6 meters on July 23.

But forecaster Juanito Galang Jr. said an inter-tropical convergence zone was responsible for the rains over Angat.

Cruz said Maynilad would still buy cross border water supply from Ayala-owned Manila Water with rationing in place until "Angat Dam's level goes up to its normal level of 180 meters."

Forty-one standby tankers out of Maynilad's 54 units would continue to deliver in elevated areas such as Quezon City's Payatas, Batasan Hills, Sta. Quiteria, Baesa, Novaliches and Sauyo; parts of Caloocan City, such as Bagong Barrio; Valenzuela City; Malabon City; Navotas City, and Las Piñas City.

Caloocan Mayor Enrico Echeverri ordered about 50 tankers delivering free water to residents in Bagong Barrio, Baesa, Sta. Quiteria, Talipapa and other parched barangays.

According to Maynilad, 117 supply-deficient barangays have been



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Water Safety Conference
November 2-4 2010, Kuching, Malaysia

Government conserves resources

Manila Prepares for Drought

Posted on: Wednesday, 29 November 2006, 00:00 CST

An El Nino-related drought is expected to have a major effect on the Philippines.

The government has announced plans for water rationing in the Manila metropolitan area, the Manila Times reported. The drought could also reduce hydroelectric power generation.

Michael Defensor, President Gloria Arroyo's chief of staff, said she discussed the impending water shortage with the cabinet at a joint meeting of the National Economic and Development Authority board, the National Antipoverty Commission and the National Security Commission.

- **100 TANKERS MOBILIZED FOR WATER RATIONING**

METRO MANILA, March 14, 2005 (STAR) By Katherine Adraneda - One hundred tankers were mobilized to ration water to at least 27.9 percent of Maynilad Water Services' concession in the West Zone which were rendered almost waterless due to the continuous decrease of the water level at the Angat Dam.

- The tankers will make daily rounds in affected barangays and subdivisions in the West Zone. This is in addition to other projects aimed at delivering recovered water to under-served and unserved areas.
- "This remedial measure is meant to alleviate the water shortage problem, even as Maynilad intensifies its leak repairs, disconnection of illegal connections, and replacement of old pipes and facilities. The water firm is also adjusting valves to maximize water distribution to affected areas," Maynilad said.



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The scenes 6 months after the flood



While delivered water is safe and potable...the container, handling, transportation and handling may impair quality of water before usage



Tankers were deployed at designated delivery stations



Schedules were set for the delivery

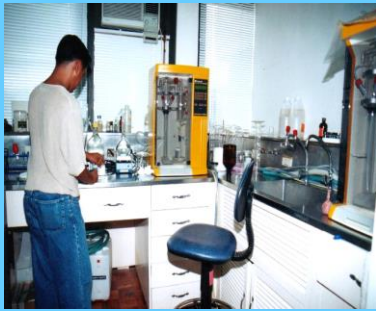


Water containers have to be rinsed



Women were greatly affected





Maynilad Water

Water Safety Plans

Managing drinking-water quality from catchment to consumer

20

Maynilad's WSP

The first and only WSP in the Philippines following the WHO guidelines



“Managing Maynilad’s drinking-water quality from catchment to consumer”



Basic Information on Maynilad

Total Area of Coverage	540	sq. km.
Total No. of Customers	850,000	
Residential	800,000	
Commercial/Industrial	50,000	
Service Population	7,200,000	

WEST ZONE

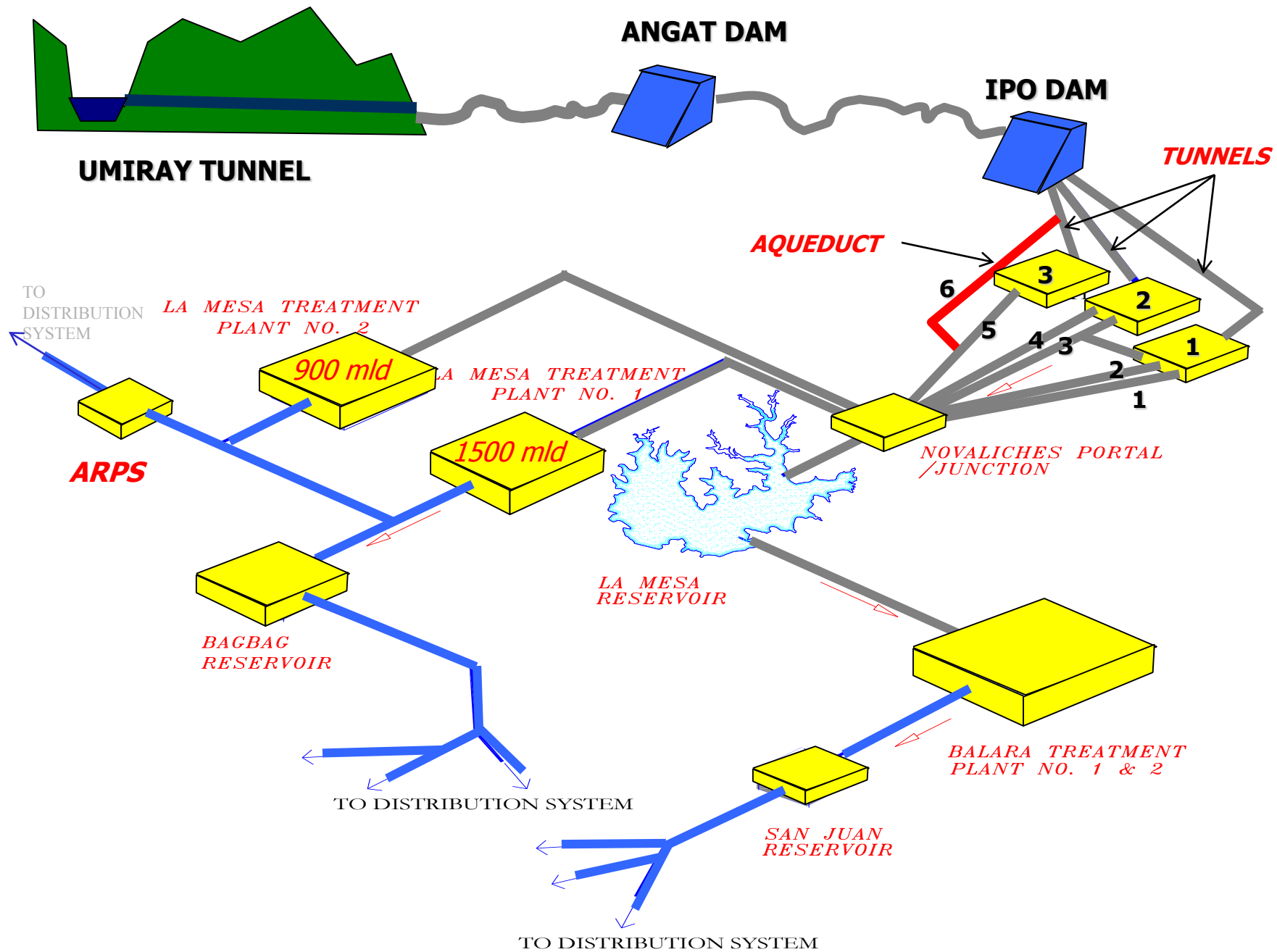
Metro Manila:

Valenzuela
Caloocan
Malabon
Navotas
Parts of Quezon City
Manila

Pasay
Parts of Makati
Las Piñas
Parañaque
Muntinlupa

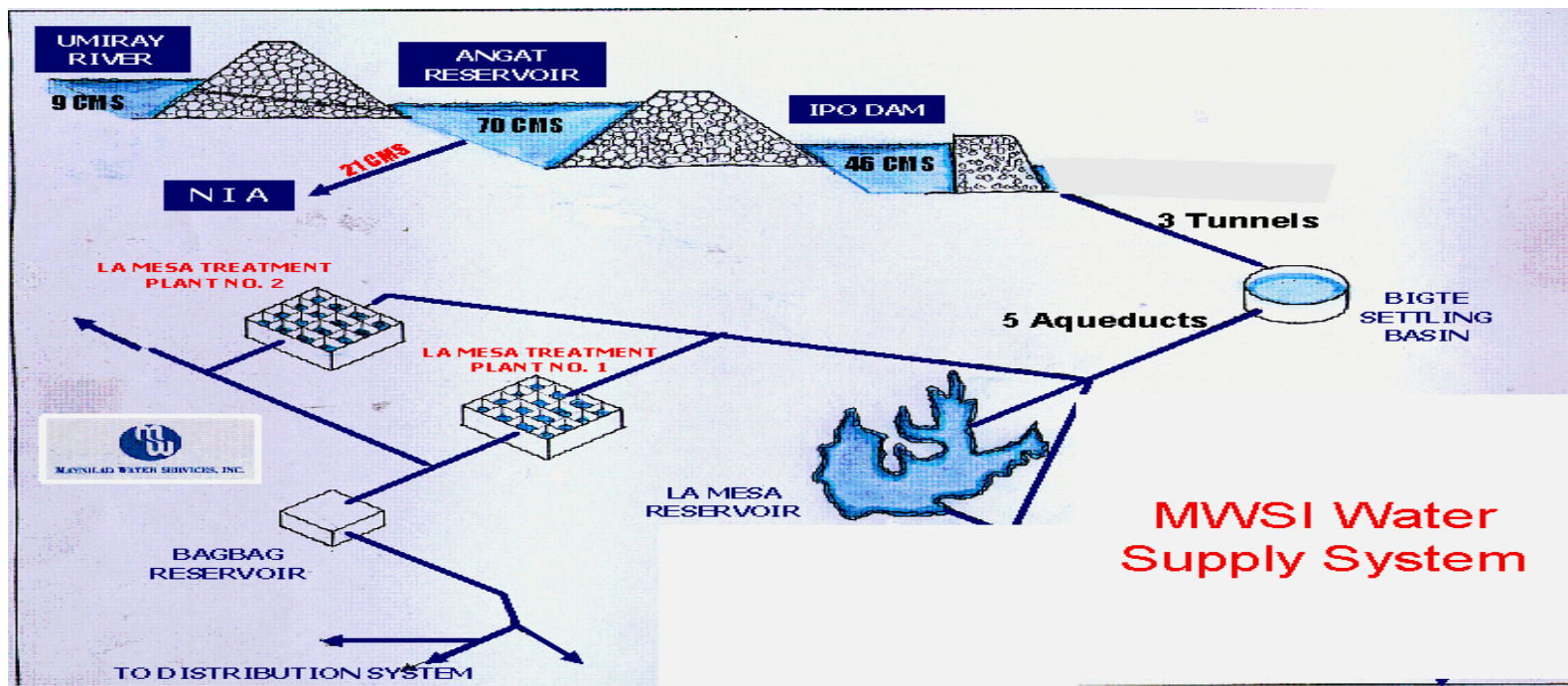
Cavite Province:

Cavite City
Rosario
Imus
Noveleta
Bacoar
Kawit



Water Supply System of Maynilad

Raw water is sourced from three watersheds and stored in two dams with series of conveyance networks



Basic Information on Maynilad

Facilities		
Raw Water Conveyance		
Tunnels	2	
Aqueducts	5	
Total Treatment Plant Capacity	2,550	mld
La Mesa Water Treatment Plant 1		
Peak Capacity	1650	mld
La Mesa Water Treatment Plant 2		
Peak Capacity	900	mld
Number of Reservoirs	10	
Number of Pumping Stations	14	
Number of Deepwells	64	
Length of distribution line		
150 mm to 3200 mm diameter pipe	3,500	km

Basic Information on Maynilad

Water Availability 24 hour coverage Less than 24 hour	65 35	% %
Sources of Water Surface Water (98%) Umiray-Angat-Ipo Watershed Umiray River Angat Dam Ipo Dam	46.50 9.00 37.00 0.50	cms (4000mld) cms cms
Ground Water (2%) From small independent network	0.50	cms (40 mld)
Water Quality Monitoring Stations in the distribution line	850	

A new treatment plant with capacity of 100 mld has been built using Laguna Lake as water source

Main Source of Water

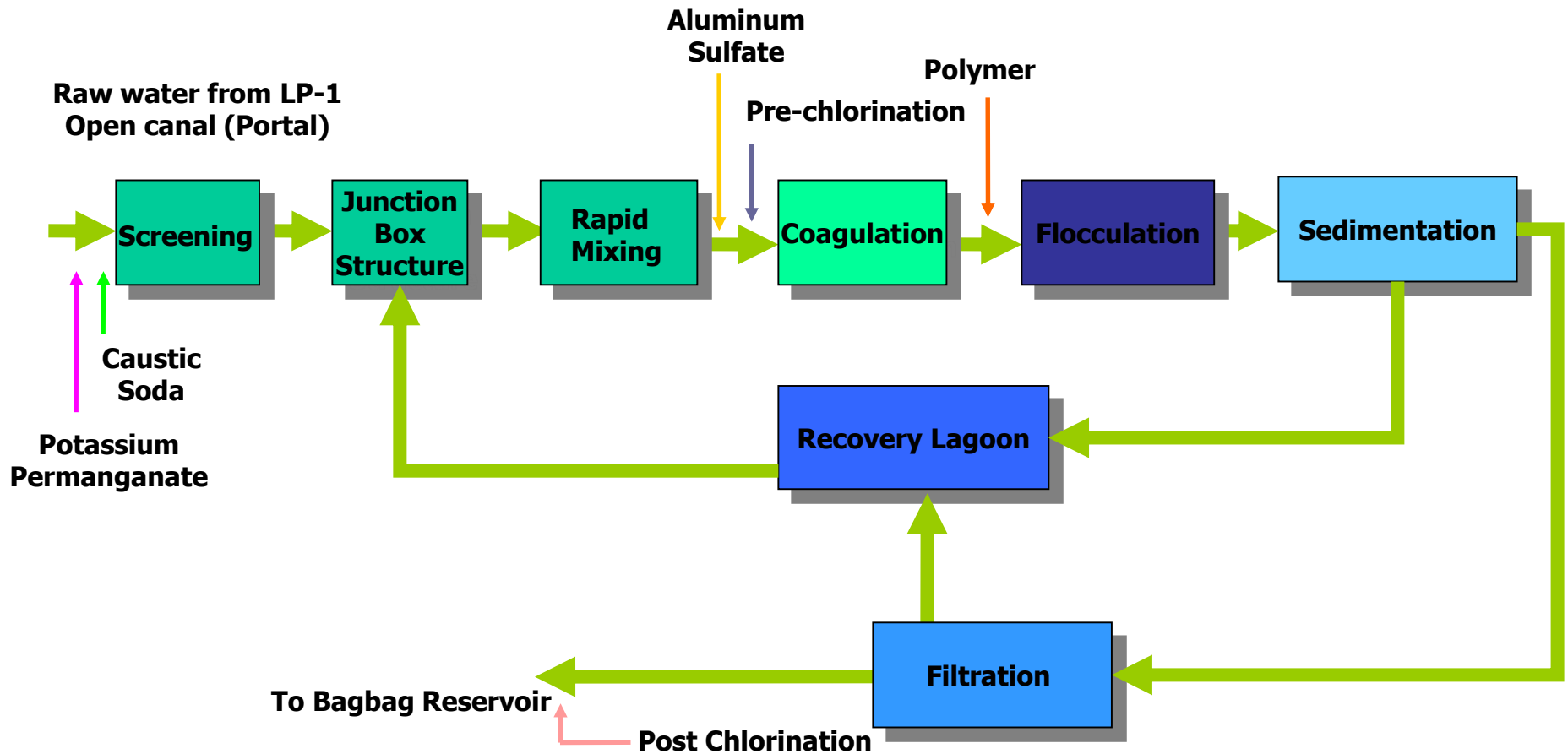
ANGAT DAM

- **Multi Purpose Dam**
 - **Power generation**
 - **Water supply**
 - **Irrigation**
 - **Flood mitigation**
- **Overflow Level: 217 m**
- **Capacity: 850 MCM**
- **Watershed: 62,000 Hectares**



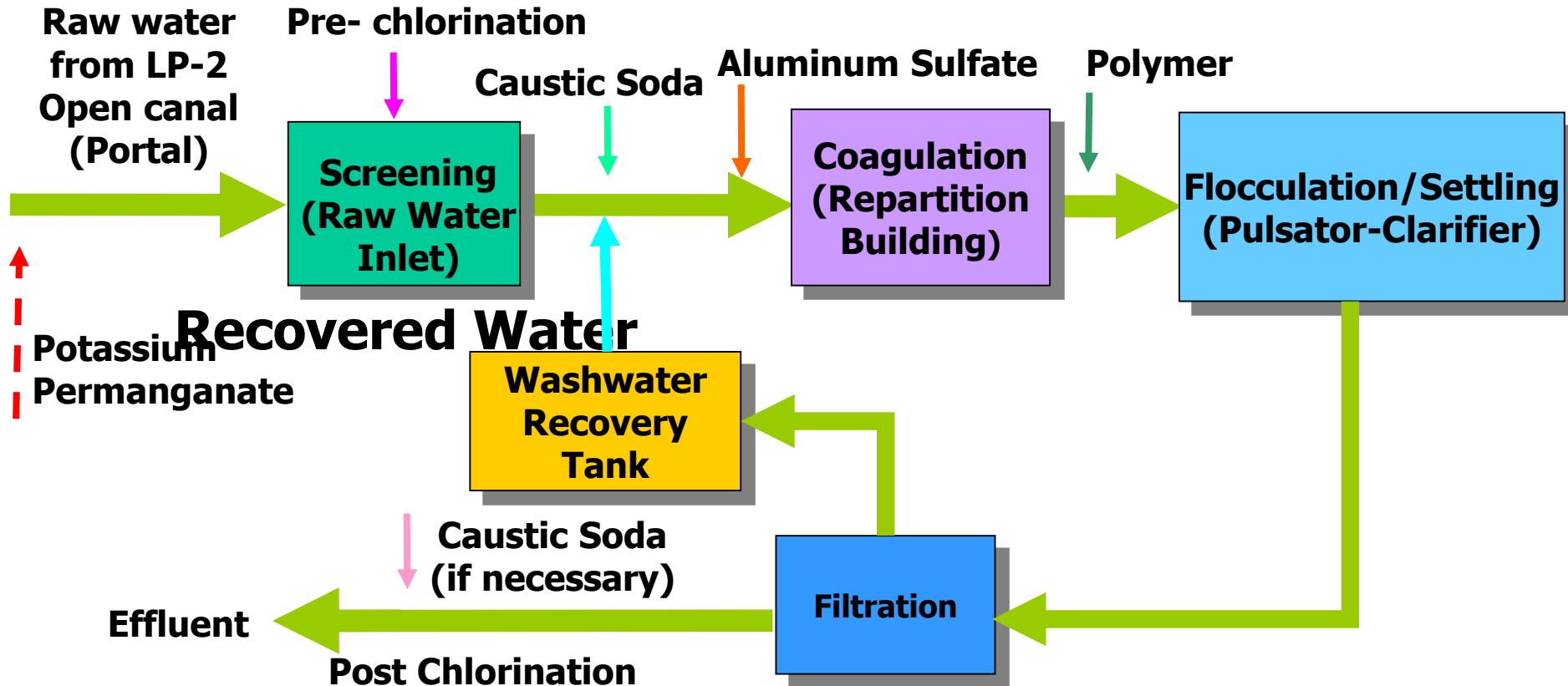
LA MESA TREATMENT PLANT 1

WATER TREATMENT PROCESS



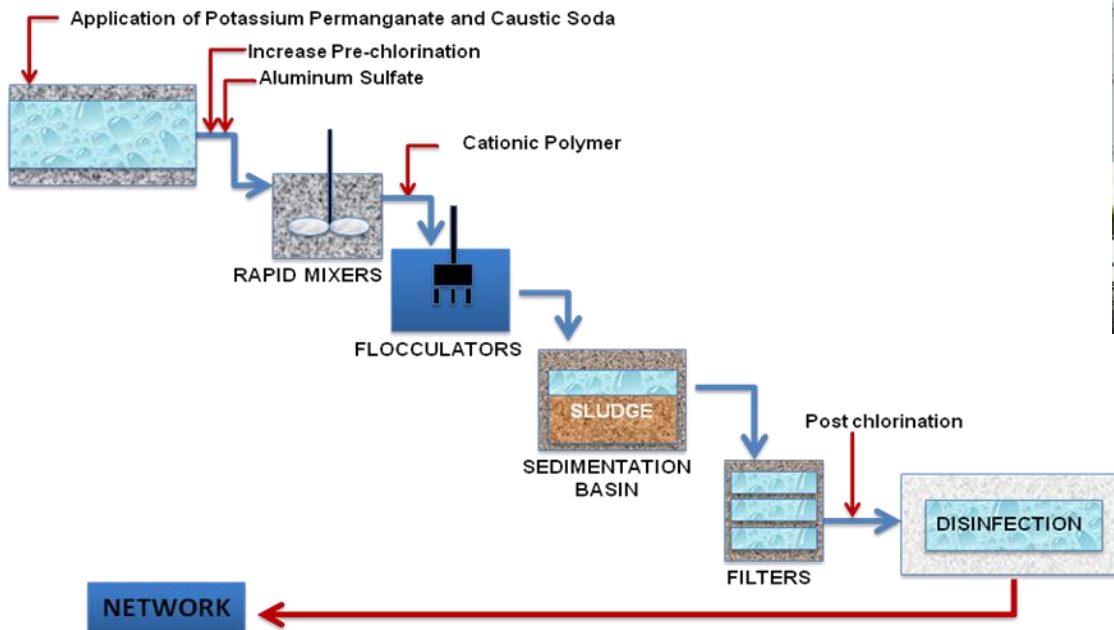
LA MESA TREATMENT PLANT 2

WATER TREATMENT PROCESS



Manganese Treatment Facilities

treatment involves oxidation of chromium at elevated pH



Causes of Water Quality Problems and Potential Hazards in the Distribution

1. Low Water Pressure
2. Illegal Connections
3. Use of Booster Pumps
4. System Leaks



Angat Dam Elevation

Water level in Angat Dam continued to drop from Feb. – July 2010 despite the onset of the season



Problems on Extended Drought

Water Quantity

- Conflict on allocation
- Reduction on supply
- Reduction in water pressure
- Irregular and intermittent supply
- Water tankering
- Water rationing



Problems on Extended Drought

Effects on quality on reduction of supply

- deposition of silt
- back flow from leaking pipes
- customers resort in using booster pumps
- poor water handling from tankered and rationed water
- need to regularly flush lines after interruptions
- need to operate ground water wells



Problems on Extended Drought

Effects on quality

- presence of manganese in raw water causing black precipitate
- High levels of iron
- Increased turbidity at the onset of the rain
- Higher residual Al
- Presence of fluoride and manganese on raw water



Problems on Extended Drought

Effects on quality for our new water source Laguna Lake

- salt water intrusion
- High total dissolved solids
- High chlorides
- Presence of ammonia and other volatile gases
- High algal content
- Color, odor taste problems
- Higher dosages of chlorine
- Presence of precipitated metals and other disinfectant by products



Problems on Extended Drought

Effects on operation

- Need to operate manganese treatment facilities
- Need to test raw water for most effective
 - coagulant
 - flocculant aid
- Operate pre chlorination facilities
- Determine combination of chlorination and potassium permanganate process



Problems on Extended Drought

Effects on operation

- Need for flushing of lines
- Operate relay chlorination facilities
- Additional cost for tankers
- More water quality monitoring points
- Continuous public updates
- Higher operations costs



Problems on Extended Drought

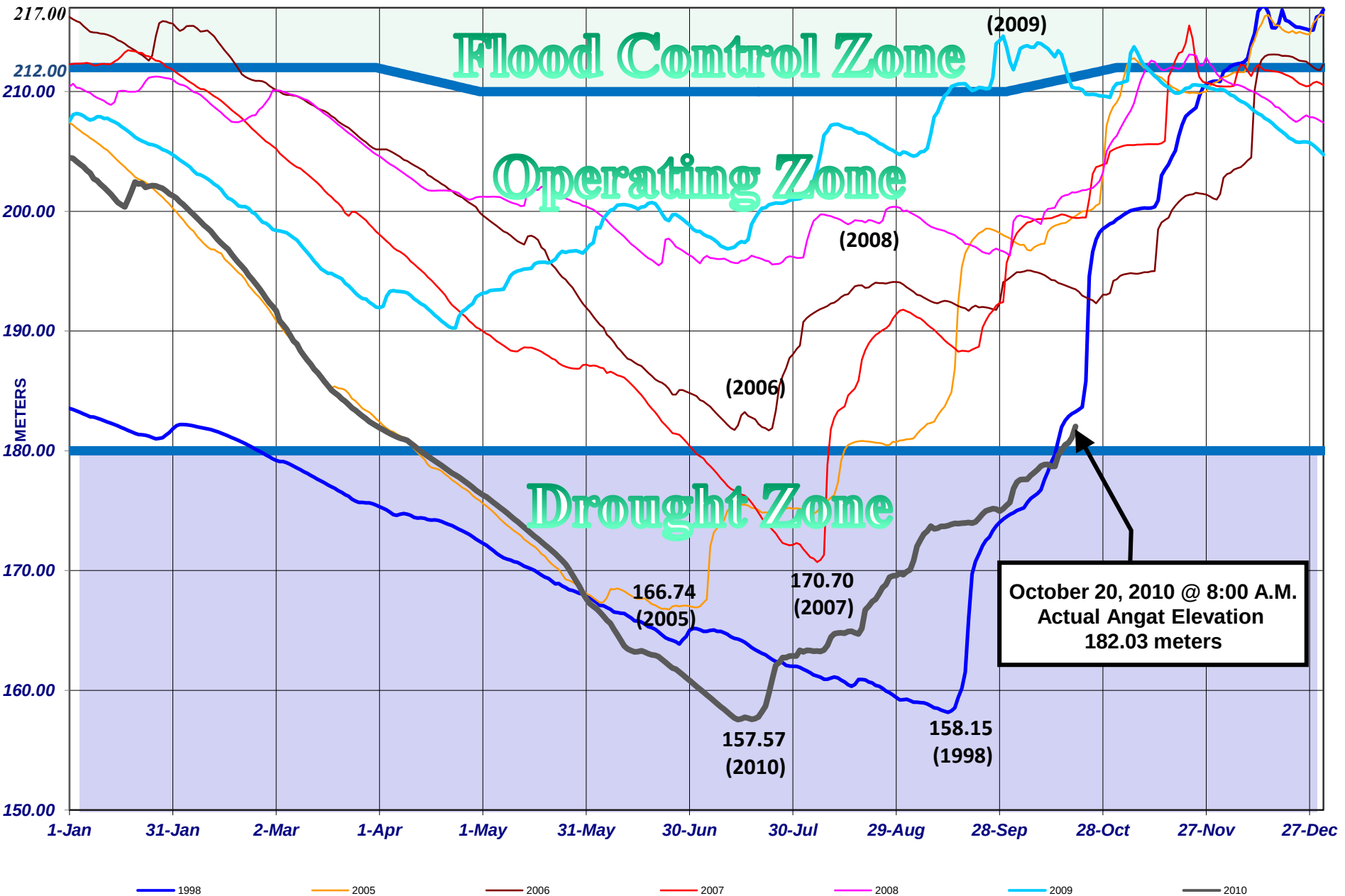
Effects on operations

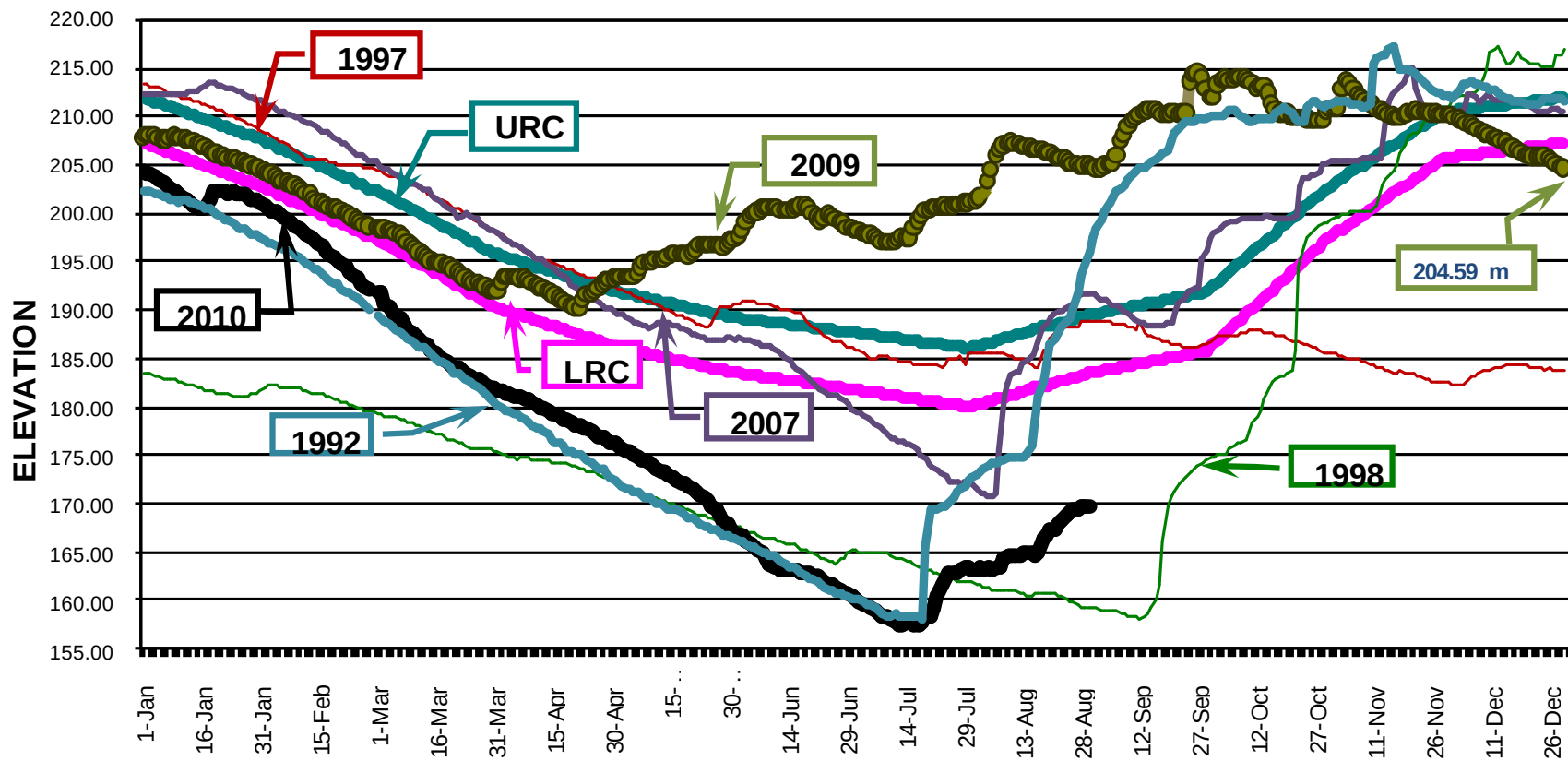
- High chemical cost
- Availability of chemicals
- Higher buffer stock of coagulant
- Need to try different disinfectant
- Additional treatment facilities
- More customer complaints
- Cloud seeding operations



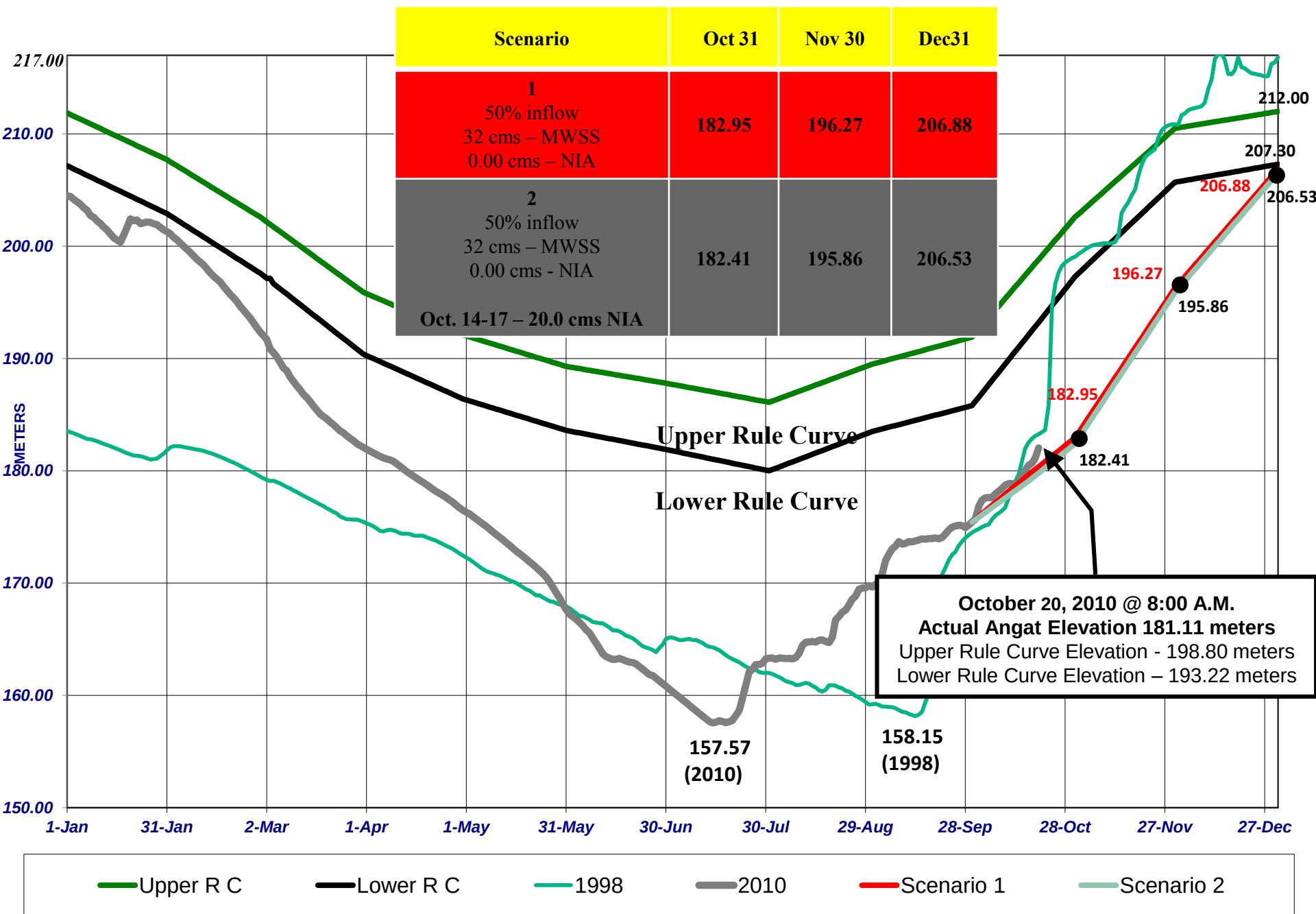
ANGAT ELEVATION STATUS

January 1998 - October 2010





ANGAT ELEVATION PROJECTION



Angat Dam Elevation, Rainfall and Inflows

comparison with El Nino Episode of 1998

Angat Reservoir Status												
Month	Elevation (meter)			Inflow (cms)			Releases			Rainfall (mm)		
	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010
January	210.22	206.76	202.23	93.94	68.68	49.70	48.50	42.50	34.69	3.52	2.33	2.81
February	208.89	201.64	197.04	77.14	43.08	12.86	49.00	44.70	38.97	2.89	2.44	0.14
March	207.92	195.36	186.26	37.16	29.87	13.00	45.39	41.38	38.02	1.20	2.70	1.95
April	202.31	192.08	179.40	34.23	59.81	13.55	45.23	40.30	35.92	3.08	10.51	2.55
May	201.14	195.25	172.65	66.58	62.16	7.04	41.80	37.50	35.67	11.34	11.48	2.71
June	197.58	199.73	163.65	55.66	79.80	15.20	41.01	43.26	34.69	10.31	14.93	7.54
July	195.96	198.85	159.65	64.71	69.30	41.28	33.16	23.43	31.14	14.10	17.41	5.90
August	199.18	205.34	165.82	86.29	85.35	52.90	24.86	24.07	29.52	19.26	14.64	8.74
September	197.92	209.25		46.61	144.11		30.54	38.98		9.73	20.43	
October	201.05	211.79		135.41	143.26		13.57	81.62		13.57	17.52	
November	211.25	210.97		135.48	124.45		35.90	64.40		13.73	12.51	
December	209.09	207.44		49.20	29.82		36.53	37.04		3.74	0.97	

Operations of manganese treatment facilities

1. At low manganese and iron in the raw water, increase of the dosage of polymer to ensure that the dissolved metals can be coagulated or captured during the flocculation process.
2. Operation of the pre chlorination system to oxidize the dissolved metals and to precipitate it as hydroxides, using its available alkalinity.

Operations of manganese treatment facilities

3. Application of caustic soda with the pre chlorination facility of the plant for the oxidation of manganese at an elevated pH for the complete conversion of the Mn^{+2} to Mn^{+4} .
4. Application of the potassium permanganate when the dissolved manganese level is at 0.5 mg/l
5. Stop the application of potassium permanganate to when manganese level drops to 0.10mg/l (dissolved Mn) or when manganese at raw water or nil at treated water

Operations at La Mesa Treatment Plant 1 July 2010 for Turbidity and Manganese Removal

Table 2. Daily water quality (raw and treated) for July,2010 at the La Mesa Water Treatment Plant 1

(LP – 1) for Manganese

LP-1	raw water			treated water			Protocol
July 2010	Turbidity (NTU)	Manganese (ppm)		Turbidity (NTU)	Manganese (ppm)		
		Total	Dissolved		Total	Dissolved	
1	14.55	0.16	0.00	0.80	0.00	0.00	-
2	14.24	0.19	0.00	0.75	0.00	0.00	-
3	13.80	0.22	0.00	0.80	0.00	0.00	-
4	13.69	0.22	0.00	0.98	0.00	0.00	-
5	13.13	0.19	0.00	0.94	0.00	0.00	-
6	12.32	0.21	0.00	0.91	0.00	0.00	-
7	126.91	0.14	0.00	1.11	0.00	0.00	Shift from non-ionic to cationic polymer
8	193.00	0.20	0.00	0.81	0.00	0.00	-
9	93.88	0.44	0.06	0.93	0.00	0.00	Increase Cationic Polymer application
10	66.70	0.56	0.12	1.20	0.00	0.00	Increase Cationic Polymer application
11	84.32	0.54	0.33	1.30	0.03	0.00	Additional increase in cationic polymer and pre-chlorination
12	75.66	0.65	0.24	1.51	0.08	0.02	
13	66.16	0.70	0.26	1.55	0.33	0.15	
14	61.53	0.69	0.34	1.65	0.22	0.11	
15	68.54	0.68	0.38	1.72	0.12	0.04	Start application of Caustic Soda
16	76.84	0.89	0.36	1.65	0.27	0.08	Continue application of NaOH, Pre-Chlorination and Cationic Polymer
17	71.73	0.91	0.41	1.42	0.29	0.11	
18	61.60	1.00	0.56	1.46	0.36	0.18	
19	50.60	1.03	0.49	1.44	0.22	0.12	Start application of low concentration KMnO4
20	84.65	1.07	0.50	1.21	0.20	0.11	Continue application of low concentration KMnO4
21	180.42	1.08	0.47	1.23	0.09	0.04	Increased concentration of KMnO4
22	169.71	0.61	0.23	1.48	0.00	0.00	Continue application of NaOH and KMnO4
23	131.46	0.48	0.24	3.09	0.01	0.00	
24	78.78	0.70	0.28	2.96	0.00	0.00	
25	70.60	0.65	0.29	3.32	0.00	0.00	
26	58.65	0.56	0.27	3.37	0.01	0.00	
27	31.40	0.66	0.28	3.09	0.01	0.00	
28	32.60	0.59	0.25	3.04	0.01	0.00	
29	31.26	0.57	0.22	3.29	0.00	0.00	
30	33.40	0.52	0.22	3.37	0.00	0.00	
31	37.20	0.48	0.13	3.75	0.00	0.00	

Operations at La Mesa Treatment Plant 1 Aug. 2010 for Turbidity and Manganese Removal

LP-1	raw water			treated water			Action Taken
Aug 2010	Turbidity (NTU)	Manganese (ppm)		Turbidity (NTU)	Manganese (ppm)		
		Total	Dissolved		Total	Dissolved	
1	*29.73	0.48	0.13	3.42	0.00	0.00	Continue application of NaOH and KMnO4
2	23.80	0.47	0.12	3.10	0.00	0.00	
3	19.70	0.48	0.12	2.96	0.00	0.00	
4	22.86	0.42	0.14	3.39	0.00	0.00	
5	24.35	0.49	0.14	2.85	0.01	0.00	Increase Potassium Permanganate Application
6	20.95	0.50	0.16	2.30	0.01	0.00	
7	20.77	0.46	0.15	2.41	0.00	0.00	
8	23.40	0.47	0.13	2.57	0.00	0.00	Continue application of NaOH and KMnO4
9	29.94	0.42	0.10	3.36	0.00	0.00	Stopped Application of Caustic Soda and Potassium Permanganate
10	18.23	0.37	0.09	4.18	0.01	0.00	
11	14.32	0.40	0.10	3.44	0.01	0.00	
12	15.61	0.41	0.10	2.94	0.00	0.00	
13	16.08	0.41	0.11	2.96	0.00	0.00	
14	15.32	0.43	0.10	2.70	0.00	0.00	
15	16.12	0.44	0.11	2.38	0.00	0.00	
16	18.13	0.42	0.11	2.69	0.00	0.00	
17	20.54	0.39	0.10	2.38	0.00	0.00	
18	18.24	0.38	0.06	1.86	0.00	0.00	
19	17.36	0.32	0.03	1.65	0.00	0.00	
20	16.93	0.30	0.01	1.67	0.00	0.00	
21	18.14	0.36	0.03	1.59	0.00	0.00	
22	24.22	0.43	0.07	2.11	0.00	0.00	
23	50.15	0.44	0.06	2.57	0.01	0.00	
24	45.34	0.38	0.04	3.32	0.00	0.00	
25	36.43	0.30	0.00	4.38	0.00	0.00	
26	43.76	0.29	0.00	3.18	0.00	0.00	
27	48.18	0.25	0.00	3.84	0.00	0.00	
28	34.89	0.26	0.00	4.53	0.00	0.00	
29	29.62	0.28	0.00	5.64	0.00	0.00	
30	27.67	0.27	0.00	3.72	0.00	0.00	
31	27.43	0.30	0.00	3.36	0.00	0.00	

* After NaOH application

Operations at La Mesa Treatment Plant 1 July. 2010 for Iron Removal

LP-1 July 2010	raw water			treated water		
	Turbidity (NTU)	Iron (ppm)		Turbidity (NTU)	Iron (ppm)	
		Total	Dissolved		Total	Dissolved
1	14.55	0.10	-	0.80	0.00	-
2	14.24	0.17	-	0.75	0.01	-
3	13.80	0.14	-	0.80	0.02	-
4	13.69	0.14	-	0.98	0.02	-
5	13.13	0.15	-	0.94	0.00	-
6	12.32	0.11	-	0.91	0.00	-
7	126.91	0.12	-	1.11	0.00	-
8	193.00	0.95	0.05	0.81	0.04	-
9	93.88	0.92	0.10	0.93	0.07	0.02
10	66.70	0.43	-	1.20	0.05	-
11	84.32	0.24	-	1.30	0.02	-
12	75.66	0.61	0.02	1.51	0.02	-
13	66.16	0.69	0.05	1.55	0.04	0.02
14	61.53	0.68	0.03	1.65	0.05	-
15	68.54	0.76	0.02	1.72	0.00	-
16	76.84	0.63	0.02	1.65	0.03	-
17	71.73	0.81	-	1.42	0.02	-
18	61.60	0.65	0.02	1.46	0.02	-
19	50.60	0.44	0.03	1.44	0.00	-
20	84.65	0.62	-	1.21	0.00	-
21	180.42	1.94	0.02	1.23	0.90	-
22	169.71	0.80	-	1.48	0.02	-
23	131.46	0.99	0.02	3.09	0.02	-
24	78.78	0.47	-	2.96	0.03	-
25	70.60	0.45	0.01	3.32	0.03	-
26	58.65	0.53	0.08	3.37	0.03	-
27	31.40	0.27	-	3.09	0.02	-
28	32.60	0.17	-	3.04	0.00	-
29	31.26	0.55	0.01	3.29	0.03	-
30	33.40	0.28	0.04	3.37	0.01	-
31	37.20	0.16	-	3.75	0.03	-

Operations at La Mesa Treatment Plant 1 August. 2010 for Turbidity and Iron Removal

LP-1 Aug 2010	raw water			treated water		
	Turbidity (NTU)	Iron (ppm)		Turbidity (NTU)	Iron (ppm)	
		Total	Dissolved		Total	Dissolved
1	*29.73	0.16	-	3.42	0.00	-
2	23.80	0.30	-	3.10	0.03	-
3	19.70	0.20	-	2.96	0.02	-
4	22.86	-	-	3.39	-	-
5	24.35	0.18	-	2.85	0.00	-
6	20.95	0.19	-	2.30	0.00	-
7	20.77	0.04	-	2.41	0.00	-
8	23.40	0.06	-	2.57	0.00	-
9	29.94	0.34	-	3.36	0.03	-
10	18.23	0.12	-	4.18	0.01	-
11	14.32	0.14	-	3.44	0.02	-
12	15.61	0.15	-	2.94	0.00	-
13	16.08	0.06	-	2.96	0.00	-
14	15.32	0.10	-	2.70	0.00	-
15	16.12	0.08	-	2.38	0.00	-
16	18.13	0.10	-	2.69	0.02	-
17	20.54	0.13	-	2.38	0.03	-
18	18.24	0.17	-	1.86	0.03	-
19	17.36	0.15	-	1.65	0.00	-
20	16.93	0.09	-	1.67	0.00	-
21	18.14	0.12	-	1.59	0.00	-
22	24.22	0.14	-	2.11	0.00	-
23	50.15	0.41	0.02	2.57	0.02	-
24	45.34	0.44	0.02	3.32	0.03	-
25	36.43	0.19	-	4.38	0.03	-
26	43.76	0.28	-	3.18	0.02	-
27	48.18	0.20	-	3.84	0.00	-
28	34.89	0.15	-	4.53	0.00	-
29	29.62	0.24	-	5.64	0.02	-
30	27.67	0.27	-	3.72	0.05	-
31	27.43	0.21	-	3.36	0.05	-

* After NaOH application

Operations at La Mesa Treatment Plant 2 July 2010 for Turbidity and Manganese Removal

LP-2	raw water			treated water			Action Taken
July 2010	Turbidity (NTU)	Manganese (ppm)		Turbidity (NTU)	Manganese (ppm)		
		Total	Dissolved		Total	Dissolved	
1	15.33	0.16	0.00	0.82	0.00	0.00	-
2	14.43	0.10	0.00	0.97	0.00	0.00	-
3	14.33	0.28	0.00	0.97	0.00	0.00	-
4	13.68	0.21	0.00	1.08	0.00	0.00	-
5	13.47	0.32	0.00	1.31	0.00	0.00	-
6	12.76	0.23	0.00	1.20	0.00	0.00	-
7	154.99	0.22	0.00	1.36	0.00	0.00	-
8	172.89	0.18	0.00	1.48	0.00	0.00	Shift from non-ionic to cationic polymer
9	93.21	0.35	0.09	1.27	0.00	0.00	Increase Cationic Polymer application
10	67.68	0.57	0.10	0.66	0.00	0.00	Increase Cationic Polymer application
11	84.25	0.57	0.33	0.54	0.03	0.00	Additional increase in cationic polymer and pre-chlorination
12	75.61	0.61	0.23	0.62	0.00	0.00	
13	69.45	0.70	0.34	0.54	0.02	0.00	
14	63.53	0.77	0.31	0.54	0.04	0.01	Additional increase in Pre-Chlorination
15	67.73	0.66	0.35	0.72	0.01	0.00	
16	75.89	0.83	0.31	0.43	0.04	0.01	Continue application of Pre-Chlorination and Cationic Polymer
17	72.73	0.91	0.43	0.40	0.01	0.00	
18	62.57	0.98	0.48	0.45	0.01	0.00	Additional increase in Pre-Chlorination
19	51.64	1.01	0.42	0.47	0.00	0.00	Additional increase in Pre-Chlorination
20	85.21	1.07	0.48	0.53	0.01	0.00	Start application of NaOH and KMnO ₄
21	198.67	1.09	0.44	0.58	0.18	0.10	Continue application of NaOH and KMnO ₄
22	180.67	0.56	0.24	0.65	0.00	0.00	Stopped NaOH and KMnO ₄ application
23	116.60	0.45	0.23	1.01	0.00	0.00	Resume application of NaOH and KMnO ₄
24	76.76	0.52	0.26	0.96	0.00	0.00	
25	75.24	0.59	0.28	0.78	0.00	0.00	Continue application of NaOH and KMnO ₄
26	56.35	0.56	0.27	0.59	0.00	0.00	
27	30.30	0.64	0.27	0.49	0.00	0.00	
28	35.00	0.62	0.23	0.75	0.00	0.00	
29	33.40	0.53	0.24	0.89	0.00	0.00	
30	30.50	0.50	0.21	0.76	0.00	0.00	
31	35.05	0.49	0.14	0.80	0.00	0.00	

Observations on elevation, rainfall, turbidity and manganese

1. At the dam's lowest elevation of 156 m the turbidity is 61.53 NTU, but highest recorded turbidity are at level of 180 NTU and was observed when the elevation is 160 m, and 193 NTU at level of 158 m (but manganese levels were low this level).
2. At the dam's lowest elevation, the manganese was at 0.70mg/l for total Mn and 0.26 mg/l for dissolved Mn. The highest level of Manganese was recorded at elevation of 1.58 m. This matched with one of the highest turbidity. The values are at 1.08 mg/l total for manganese and 0.47 mg/l dissolved manganese.

3. It was only when the rainfall fell on the dam; the incident of upwelling occurred that disturbed the dam's stratification resulting in the release of the dissolved metals in the raw water.

4. In the jar tests conducted, cationic polymer was found to be more effective than non-ionic polymer in manganese/iron removal. Thus, cationic was the polymer of choice for the operations.

5. Different coagulants were tested, aluminium sulfate (alum), poly aluminium chloride (PAC), aluminium chlorhydrate. Results show that aluminium sulfate, alum showed best coagulation results compared to the two coagulants, yielding better turbidity and lower values of metals at treated water



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Treatment protocol adopted

A. Treatment of Manganese (Mn) with the following chemicals applied at certain schedule and concentration of manganese in the raw water.

1. Potassium Permanganate
2. Caustic Soda
3. Pre-chlorination
4. Aluminum Sulfate and Cationic Polymer
5. Post chlorination

B. Hourly monitoring of the raw water quality and treated water for turbidity, manganese and residual chlorine

F. Proceed with water rationing thru stationary water tanks and mobile water tankers in the event that water becomes unacceptable for the consumers.

G. Reactivation of the deepwells in the event the treatment plant will be out of operation.

H. Issuance of regular updates and advisory using all forms of media



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C. Close coordination with the laboratory, water network and Business/Commercial Offices for information on water quality.

D. Ensure the immediate operations of on-line chlorinators/relay chlorination in the distribution lines

E. Immediate flushing of the lines should black precipitates and iron deposits pose serious aesthetic problems

Improvement Works Implemented and Being Implemented For the WS

ACTION	PERSON / OFFICE	TIME FRAME
Presence of back-up pumps or duplicate facilities to ensure continuous operation in cases of emergencies	Ground Water	2008 Completed Back-up pumps and spare parts were purchased to ensure continuous operation
Change to liquid Chlorine or start using better quality Chlorine like Chlorine tablets instead of Calcium Hypochlorite (HTH) to reduce or even prevent clogging at injection points.	Ground water	2008 Implemented to some ground water wells
Emergency / disaster response to be developed in case of natural calamities like earthquake that would lead to destruction of facilities.	Entire MWSI	2009 Completed (Emergency plans were submitted to NDCC)
Addition of downstream controls like a pre-settling dam	Water Sources	
Installation of mechanical grit remover along the open canals leading to the plants before the screens to remove debris and other floatables	Water Treatment	2014
Provide / construct permanent Potassium Permanganate facilities for both plants	Water Treatment	2010 On-going design
Installation of Chlorine cradles for LMTP1	Water Treatment	2008 Completed
Repair / re-install provision for Caustic Soda or lime application at coagulation point for both LMTP 1&2	Water Treatment	2007 Completed Temporary system for application of caustic soda/lime in place
Rehabilitation of the 24 filter units for LMTP1 due to noted depletion of filter media and possible clogging of the teepees	Water Treatment	2009 Completed

Support Programs/ Improvement Works for Implementation

ACTION	PERSON / OFFICE	TIME FRAME
Replacement of Alum dosing system for LP 1 and LP 2, to ensure continuous and accurate dosing of alum	Water Treatment	2011
Installation of programmable LOGIC Controller in polymer skid tank to ensure continuous operation of skid tank and accurate mixing of polymer solution	Water Treatment	2011
Replacement of polymer and chlorine systems for LP1 and LP2 to ensure continuous operation and application of chemicals	Water Treatment	2012
Replacement of silica sand in LP2 for effective filtration treatment process	Water Treatment	2014

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