Appendix 8
Cost Data and Cost Analyses

Overview

This Appendix describes key activities undertaken by City staff and the project technical team to support the Water Supply Advisory Committee (WSAC or Committee) as it evaluated alternatives and later defined the recommended water resources plan and associated costs (capital, operations and maintenance [O&M], and present value).

Progression: Ideas to Building Block Development to a Robust Adaptive Program

Figure A8-1 presents an overall flow schematic for the progressive development that moved from public and staff ideas offered at the Strategies and Ideas Convention (October 2014), through consolidated alternatives (CAs) to building blocks (BBs), portfolios, and final elements and strategies.

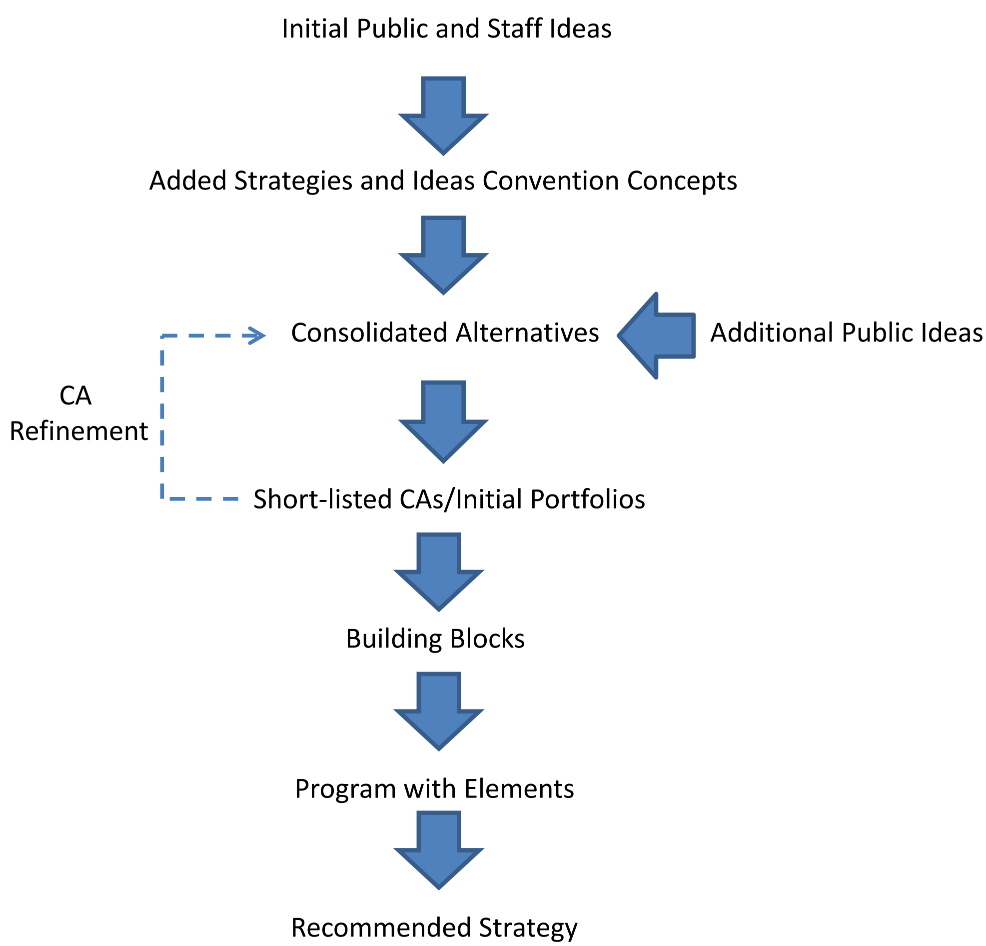


Figure A8-1 Overall flow schematic for the progressive development of the Proposed Water Supply Program

The April/May 2015 WSAC meeting marked the start of the modeling of the manner in which supply/ infrastructure alternatives address the reliability issues identified to that point. Analyses were performed on the following Consolidated Alternatives (CAs):

- Harvesting Winter Flows (CA-9, CA-16, CA-18)
- Ranney Collectors and Additional Storage (CA-19)
- North Coast Reclaimed Water Exchange (CA-13)
- Indirect Potable Reuse (CA-10)
- Additional Water Conservation (Program CRec) (CA-03)

By the June 2015 WSAC meeting, the Consolidated Alternatives considered above had evolved into several portfolios. All of the portfolios included the CRec conservation programs (CA-3). In addition, each portfolio included a Plan A and a Plan B. The initial supply/infrastructure additions represented by Plan A depended in whole or in part on storing excess winter flows in groundwater aquifers. The Plan B additions consisted of drought-proof supplies that did not vary with streamflow.

The portfolios were refined in several iterations, and the final set that was discussed at the June meeting was intended to enable the Committee to wrestle with different adaptive approaches to dealing with the uncertainties associated with all of the alternatives, particularly the abilities of the regional aquifers to store and allow recovery of significant volumes of water. Resolution of these uncertainties requires a robust program of groundwater modeling, analysis, and testing, and the portfolios recognized the significant risk of simply relying on the Plan A alternatives.

Based on WSAC discussions around these potential portfolios assembled from parts of the CAs, City staff and the Project Team developed BBs that WSAC combined into its preferred/recommended Elements. In this process, CAs were refined and consolidated into BB portfolios that could accomplish key water production, transfer and return goals. Elements from the BB portfolios were then extracted and further refined as separate potential projects. These elements were as follows:

1. In lieu recharge to Soquel Creek Water District (SqCWD) and Scotts Valley Water District (SVWD),
2. ASR as a supplement or in place of in lieu recharge to SqCWD and SVWD, and
3. Advanced Treated Recycled Water or Desalination.

The Elements form an adaptive program that the City, likely with cooperation with adjacent agencies, will implement and modify based on relative success of the Elements. Attachment 1 presents a summary of the recommended elements, including estimated capital costs, energy use, yield, etc., of the Elements in this Plan. Attachment 2 is a Gantt Chart timeline for implementation. Attachment 3 is the companion piece describing the decision points and milestones. And Attachment 4 includes the three subway diagrams that can be used with the other attachments to understand in the implementation plan.

Key Physical Components

The City plans to use existing facilities wherever possible and build new facilities as needed to augment its existing supply. Key existing components include:

- The City's diversions (North Coast streams and San Lorenzo River via Tait Street and Felton),
- Beltz Wells,
- Loch Lomond Reservoir,
- Graham Hill Water Treatment Plant (GHWTP),
- Associated storage and conveyance infrastructure (raw water and treated water pipelines, pumping stations and distribution system reservoirs),
- The City's wastewater treatment plant (WWTP) and ocean effluent outfall.

Potential new facilities include:

- Upgrades to the GHWTP,
- Modifications to diversions (e.g., Ranney collectors and/or upgraded Felton and Tait Street facilities, and replacement of the pipeline from Felton Pump Station to the Newell Creek Dam/Loch Lomond),
- New wastewater effluent advanced purification facilities (likely at the WWTP),
- Replacement or addition of new infrastructure (both within the City and connecting to/within the Soquel Creek Water District and Scotts Valley Water District), and
- New wells within the City, Soquel Creek Water District (SqCWD), and/or Scotts Valley Water District (SVWD).

The diagrams in Figures A8-2, A8-3, and A8-4 show examples of how the pieces could fit together into functioning systems.

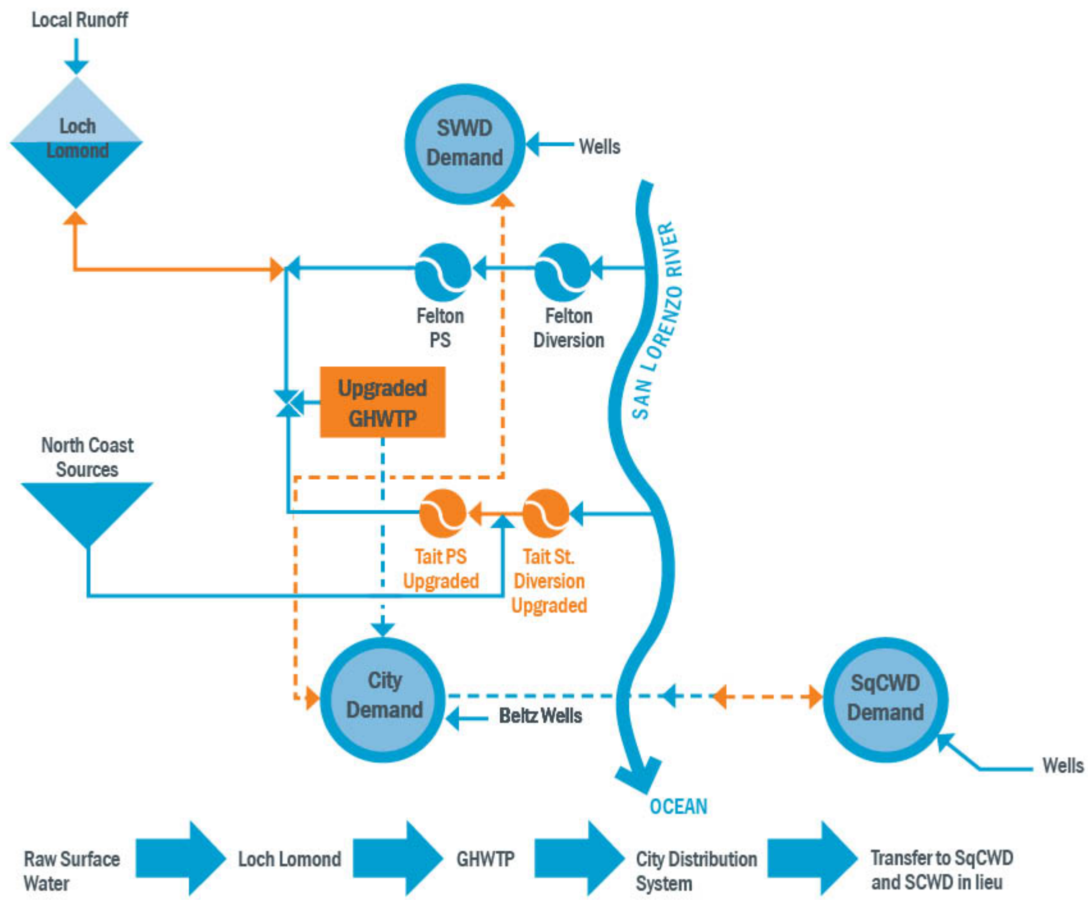


Figure A8-2. Illustration of the Conceptual Approach for Element 1, In lieu Recharge

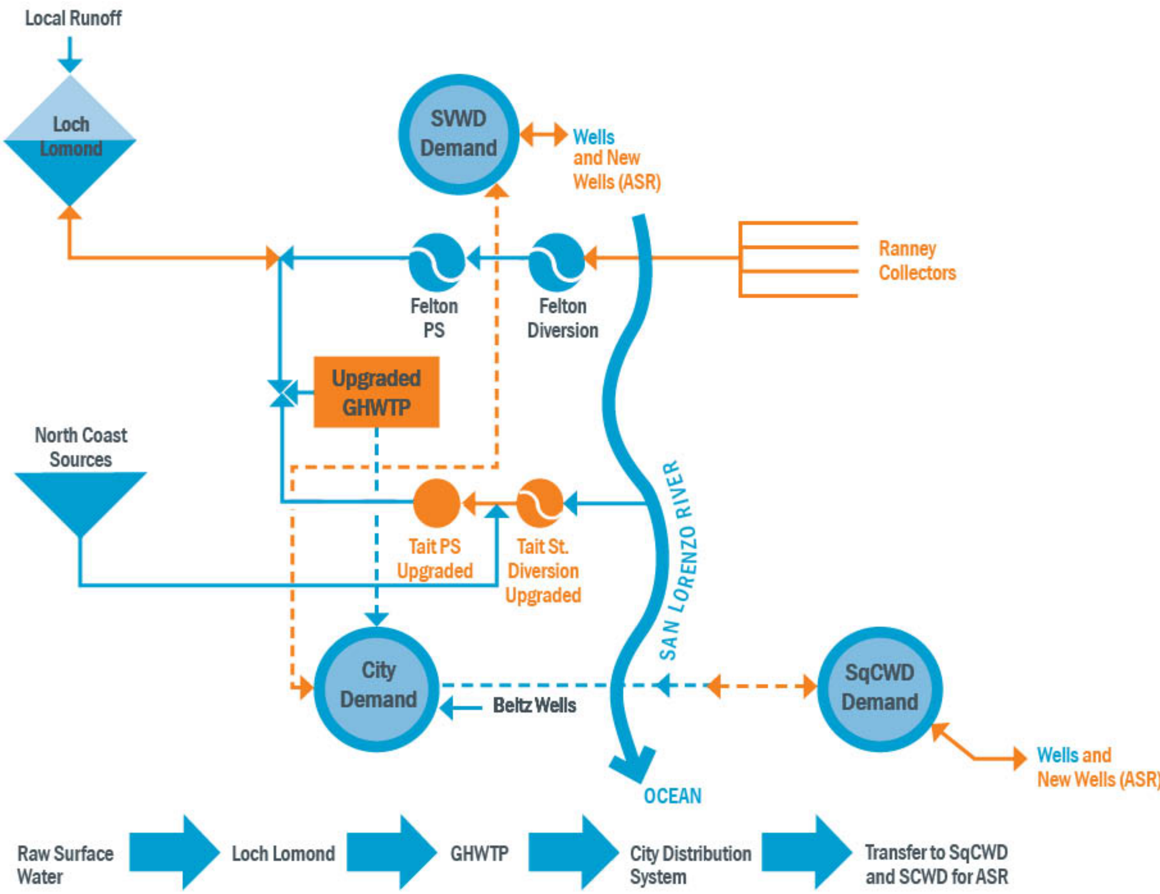


Figure A8-3. Illustration of the Conceptual Approach for Element 2, ASR.

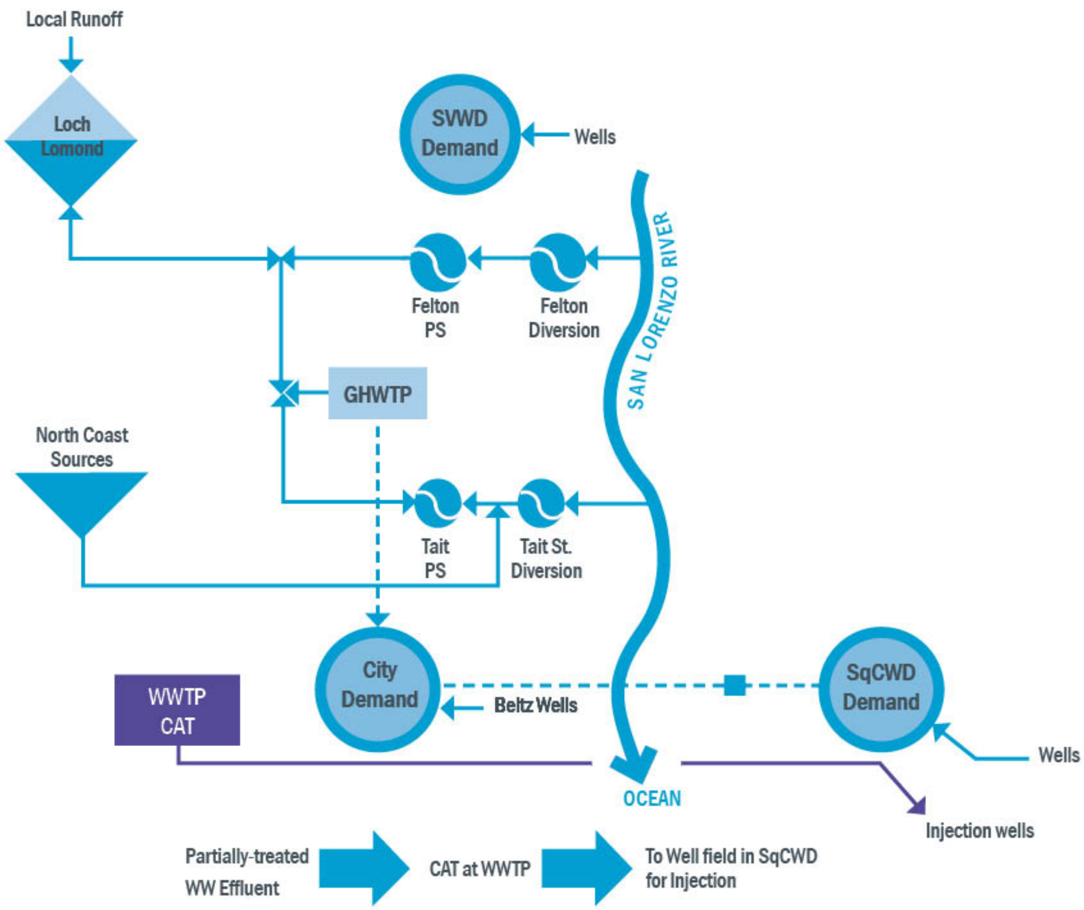


Figure A8-4. Illustration of the Conceptual Approach for Element 3a, Potable Reuse via Groundwater Recharge—i.e., Indirect Potable Reuse

Cost Estimating

The technical team developed costs (capital, operations and maintenance [O&M] and present value) at several stages of potential program component development**.** All costs, from the Portfolio stage through the original Building Block concepts (which were expanded on by committee members) to the final Recommended Project Elements were based on the conceptual-level construction and operating costs on project components like those shown in the schematics above. Information available in previous technical studies conducted by the City, Santa Cruz County, SVWD, and SqCWD and previous projects/studies by Brown and Caldwell (BC) were used to inform this work. For example, the 2015 Pueblo ASR report informed the development of the ASR well number and cost estimates; the new conveyance between Soquel Creek Water District and the City is based on the alignment for a potential intertie and pump station developed for the City by Kennedy Jenks; and the treatment train concept for this work was based on the most exhaustive complete advanced treatment (CAT) process being piloted in California as of Summer 2015: nitrification of the wastewater effluent—ozone with biologically active carbon (O_3/BAC)—microfiltration (MF)—reverse osmosis (RO)—advanced oxidation ultraviolet light with peroxide (UV-AOP) conditioning of the product water, as illustrated in Figure A8-5. This process train is very robust since regulations for potable reuse via reservoir augmentation and direct reuse are still in flux and the City may wish to pursue one of these options. The more robust process train also responds to concerns expressed by citizens at WSAC meetings. The proposed train would ensure a greater removal of constituents such as emerging contaminants of concern (e.g., pharmaceuticals).

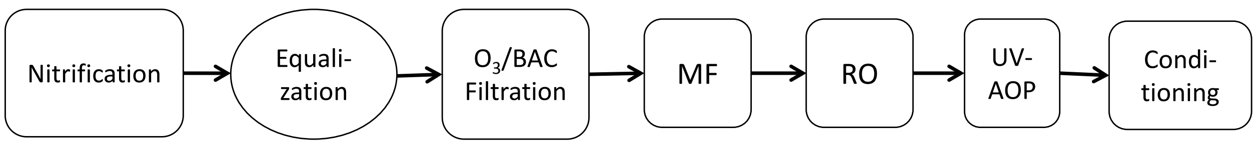


Figure A8-5. Illustration of the CAT Conceptual Approach for Element 3a, Potable Reuse

Table A8-1 below describes the final project elements. The cost estimates for Elements 1, 2 and 3 all contain a range of uncertainty. For example, while it is possible that the final cost for implementing Strategy 1 may be substantially less, it is also possible the costs may be more. Focusing only on Strategy 1, the factors that may lead to lower costs include the following:

1. It is beyond the scope of the WSAC to recommend the actual design of these Elements. For example, in lieu recharge (Element 1) might be implemented in many different ways, depending on the interests of neighboring districts, the constraints of water treatment, the constraints of existing distribution pipelines, etc. Similarly, direct injection (Element 2) may be conducted by the City alone, or in conjunction with neighboring districts, focused on one aquifer strata, or focused on several strata, etc. I.e., there are many unknowns that must be answered to define the final project.
2. The Project Elements Summary does not include the revenue from sale of water to neighboring districts, or other means of potential cost-sharing. It is premature to estimate that cost sharing contribution or possible revenues back to Santa Cruz.
3. The cost of upgrade of GHWTP, $62 million, is the largest single line item on the Gantt Chart. The purpose of this expenditure is to allow treatment of more winter water from the San Lorenzo River for the purpose of maximizing Elements 1 and 2. To be able to produce and deliver more water in the winter, we may need to deal with water with turbidity levels that are beyond that which can be effectively treated by the GHWTP. Lower cost options for addressing this purpose may be available and include: a) using existing GHWTP treatment capacity, b) constructing a Ranney Collector to reduce turbidity, and/or c) installation of a small-scale satellite treatment plant. The information needed to assess the feasibility of these alternatives is currently

unavailable. A principal piece of needed data is an understanding of the current GHWTP's ability to treat water at the quality and quantity needed for Elements 1 and 2, followed by an understanding of the most cost-effective way of meeting treatment goals associated with these elements where the GHWTP might fall short.

4. The cost of upgrading the Tait St. Diversion, $14 million, is included in the cost estimate and is a placeholder for achieving increased diversion capacity on the San Lorenzo River for the purposes of maximizing Elements 1 and 2. However, with the City adoption of the aquifer recharge strategy and the completion of a Habitat Conservation Plan, the expectation is that state and federal fisheries agencies will remove their long-standing protest of the City's water rights application to use Felton Diversion for direct pumping to Graham Hill Treatment Plant. State approval of this water rights revision may allow the City to use the Felton Diversion for additional winter water diversion, rather than expand the Tait St. Diversion.
5. Current calculations are based on a 30-year life-cycle and do not account for residual value in capital expenditures beyond 30 years. Longer-lived infrastructure, such as pipelines between Santa Cruz and neighboring districts, likely has value that is not included in the cost accounting.
6. Costs could be significantly greater in order to generate yield sufficient to meet the gap, e.g., final pipeline routes could be longer or geological conditions could require more injection wells.
7. Strategy 1 will be implemented in incremental fashion. Initial expenditures are intended to define the project(s) and its feasibility at meeting the Plan's goals in the most cost effective way possible. Subsequent expenditures would be made based on feasibility and cost effectiveness with little risk of creating stranded assets.

Table A8-1. Project Element Capital Cost Components and Assumptions

Element Number/Type	Capital Cost Components	Basis for Assumptions
1 – In lieu	Existing Infrastructure Improvements • Tait Street Diversion Improvements • Graham Hill WTP Improvements Pumps and Pipelines • 3,600 gpm Pump Station (City to Scotts Valley)at Intertie No. 1 • 16-inch Intertie 1 Pipeline (City to Scotts Valley), 3,600 linear feet (LF) • 3,600 gpm Pump Station (Soquel to City) at SqCWD Intertie • 16-inch Intertie Pipeline (City to Soquel Creek), 25,000 LF Wells • 4 350-gpm extraction wells in SVWD • 4 350-gpm extraction wells in SqCWD • Iron & manganese treatment, 8 wells • Land acquisition for wells, 4 sites in SqCWD and 4 sites in SVWD	• In lieu is based on winter demands for SqCWD and SVWD. • Water could be transferred to wells within the City, to SqCWD, and to SVWD. • Infrastructure is sized to accommodate 2.5-mgd (million gallons per day) peak flow between the City and SVWD and between the City and SqCWD. This sizing is to allow inclusion additional flows for ASR in the future. • The ultimate number and distribution of wells between agencies will be determined during project development. • The Tait Street and GHWTP improvements are based on current information that indicates that these facility upgrades are needed to treat a larger volume of higher turbidity water. This will be better defined moving forward. • It is assumed that the wells will all have a peak extraction flow rate of 350 gpm. • It is assumed that on-site iron and manganese treatment will be needed at each well. • Well footprints are estimated at 0.1 acre each. •
2 – ASR	Pumps and Pipelines • In-City pipeline to Beltz Wells, 4,000 LF Wells • 2 350-gpm Wells in SVWD)	• ASR is based on the assumption that there is adequate capacity in the basin to store and produce water as supplied from available winter flows. It is also assumed that early project activities will include field work to evaluate the validity of these initial assumptions (i.e., how well ASR is likely to work in terms of both storage capacity and future yield). • The project elements for the ASR program build on the project elements already developed in

	• 2 350-gpm Wells in SqCWD • 4 350-gpm Wells in Santa Cruz • Iron & manganese treatment, 4 wells • Land acquisition, 0.1 ac. each in SVWD and SqCWD	Element 1. • Water could be transferred to wells within the City, to SqCWD, and to SVWD. • Infrastructure is sized to accommodate 2.5-mgd peak flow between the City and SVWD and between the City and SqCWD. • The ultimate number and distribution of wells between agencies will be determined during project development. • It is assumed that the wells will all have a peak injection flow rate of 250 gpm and a peak extraction flow rate of 350 gpm. • It is assumed that on-site iron and manganese treatment will be needed at each well. • Well footprints are estimated at 0.1 acre each.
3 – Indirect potable reuse via groundwater recharge	CAT Process • Nitrification (3.9 mgd) • Ozone/BAC Filters (3.9 mgd) • Microfiltration (3.9 mgd) • Reverse Osmosis (3.5 mgd) • Advanced Oxidation (Peroxide + UV) (3.0 mgd) • Conditioning Facilities (3.0 mgd) • Effluent Diffuser Modification <u>Pumps and Pipelines</u> • 2,700 gpm Pumping System—WWTP to CAT • Pipeline Installation—WWTP to CAT, 200 LF • Equalization Basin, 0.5 million gallons • 2,100 gpm Pumping System—WWTP to Soquel Creek • 16-inch Pipeline to Wells, 20,100 LF • 16-inch Pipeline under San Lorenzo River, 350 LF • 16-inch Pipeline Under Woods Lagoon, 445 LF	• Potable reuse capacity is designed for 3-mgd product water 365 days a year based on treating only City of Santa Cruz flows. (I.e., conservatively assuming raw sewage and/or effluent from SqCWD and SVWD was unavailable.) • Infrastructure for potable reuse treatment is identical for all potable reuse alternatives. Treatment is on-site at the WWTP. Costs to treat blended water at GHWTP not included (~$2.7M/yr for 3 mgd daily flow) • Groundwater recharge is assumed to occur near the coast.

	• 16-inch Pipeline Installation—transmission line to well 1, 2,640 LF • 14-inch Pipeline Installation— well 1 to well 2, 2,640 LF • 12-inch Pipeline Installation— well 2 to well 3 to well 4, 5,280 LF • 10-inch Pipeline Installation (WWTP to wells 5-6, 10"), 5,280 LF • 8-inch Pipeline Installation—well 6 to well 7, 2,640 LF • 6-inch Pipeline Installation—well 7 to well 8, 2,640 LF <u>Wells</u> • 8 350-gpm Injection Wells at SqCWD	
4 – City desalination	• City Desalination Plant Capital Cost (from earlier Santa Cruz work) • Effluent Outfall Modifications	• The City desalination option capacity is 3 mgd product water 365 days a year. • Cost includes property rights acquisition. • Water from the facility would be added in at Bay Street has been added (instead of into the distribution system at a lower point).

Capital Costs.

The capital cost estimates represent an order-of-magnitude (AACEI Class 5) approach. For an order of magnitude estimate the planners, hydrogeologists and engineers have defined major project components (see examples above), estimated approximate required capacities, established preliminary design criteria, and selected rough locations for facilities and routings for connection infrastructure such as pipelines. BC used capital cost information from other similar projects (for example, City of San Diego Pure Water and Orange County Sanitation District/Orange County Water District Groundwater Replenishment Supply—GWRS) and many Northern California pumping stations and pipelines from previous BC planning and design assignments. Pueblo Water Resources supplied information about well construction costs. In terms of costs, Class 5 planning-level estimates, which include a 50 percent contingency factor, are also accompanied by an accuracy range of -30% to +50%. For example, a project presented with a $100M cost including contingency allowance ($66.7 million plus $33.3 million = $ 100 million) likely would have a final cost between $70 million and $150 million. Table A8-2 and Figure A8-6 below summarize the AACE Estimate Classification System.

Table A8-2 AACE Estimate Classification System, adapted from AACE RP No. 18R-97, *Cost Estimate Classification System – As Applied in Engineering, Procurement and Construction for the Process Industries* (1998)

Estimate Class	**Primary Characteristic**	**Secondary Characteristic**			
	Level of Project Definition (% complete)	**End Use**	**Methodology**	**Expected Accuracy Range** (Typical variation in low and high ranges)	**Preparation Effort** (Typical degree of effort relative to least cost index of 1)
Class 5	0-2%	Concept Screening	Capacity factored, parametric models, judgement or analogy	L: -20% to -50% H: +30% to 100%	1
Class 4	1-15%	Study or Feasibility	Equipment factored or parametric models	L: -15% to -30% H: +20% to +50%	2 – 4
Class 3	10-40%	Budget Authorization or Control	Semi-detailed unit costs with assembly-level line items	L: -10% to -20% H: +10% to +30%	3 – 10
Class 2	30-70%	Control or Bid/Tender	Detailed unit cost with forced detailed take-off	L: -5% to – 15% H: +5% to 20%	4 – 20
Class 1	50-100%	Check Estimate or Bid/Tender	Detailed unit cost with detailed take-off	L: -3% to – 10% H: +3% to 15%	5 - 100

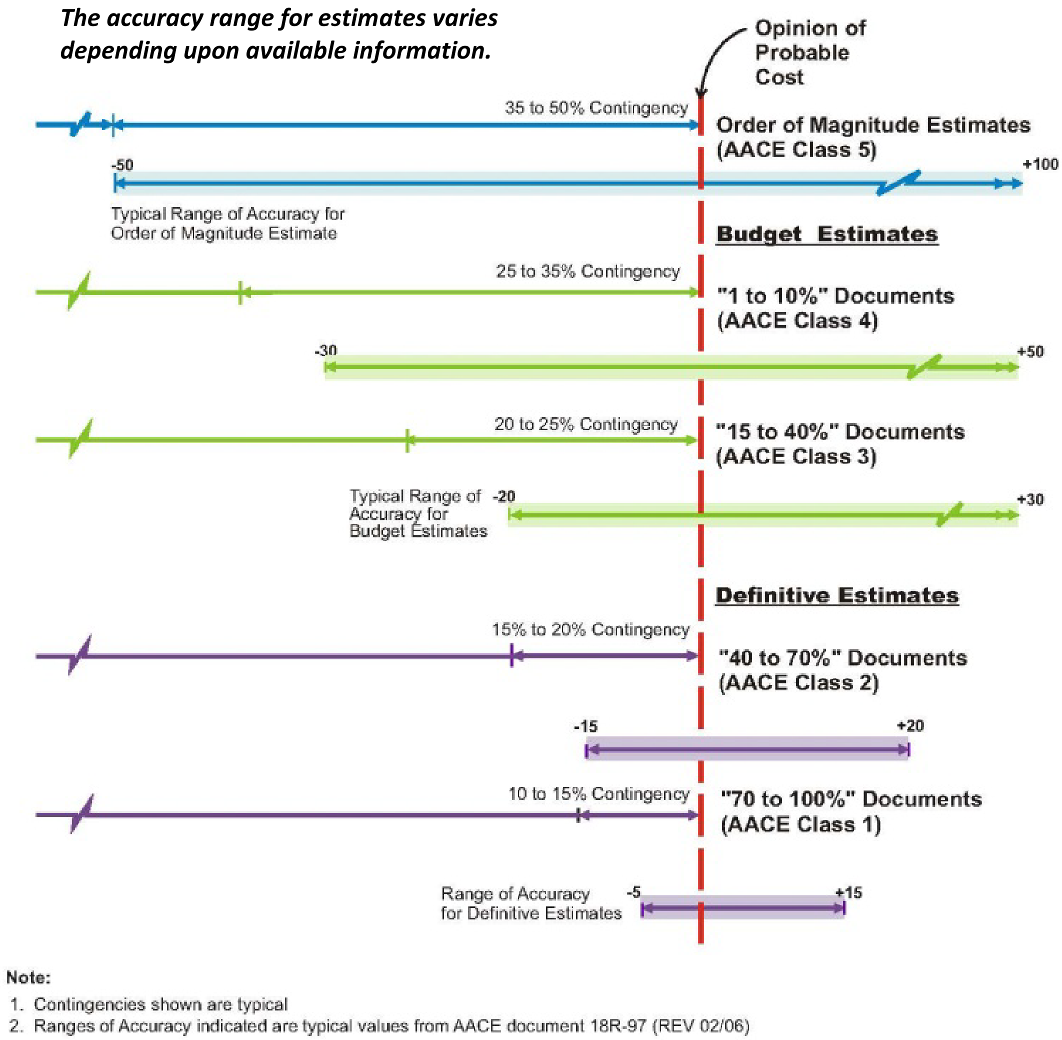


Figure A8-6 Opinions of Probable Cost Typical Contingencies and Ranges of Accuracy

The standard cost multipliers used on the construction subtotal (1.5X the base capital materials cost) in the capital estimates included:

- Engineering and Administration 20%
- Legal 5%
- Geotechnical Investigation 1%
- Permitting - CEQA/NEPA 5%

Project sizing, e.g., flow rate for a pumping station or pipeline, came from a combination of Confluence® model runs (for available raw water from the City's current sources) and assessment of available resources such as raw wastewater flows and estimated recovery of recycled water after allowing for production losses. For this project, the reader should note that each estimated construction cost includes a contingency allowance for both "known unknowns" and "unknown unknowns." Known unknowns include items such as site geotechnical conditions (at most sites no investigations have occurred yet but some sites such as the WWTP are built over originally swampy ground) and existing potential utility interferences. Unknown unknowns could be things such as endangered species habitat that requires rerouting/relocation of facilities or potential well site exploration that would show unsuitable underlying geology. The contingency allowance was set at 50 percent to reflect the very early conceptual level for the work.

Capital costs also recognize that the City will expend considerable funds in its planning, design, and facilities permitting.

<u>O&M Costs</u>

O&M costs include a wide variety of ongoing project costs. CAT-specific treatment O&M costs were based on South District WWTP (Miami-Dade Sanitation District Miami, FL) costs prepared by BC. Basic O&M cost elements included:

- Electricity to run equipment and to pump (based on elevation lift and frictional losses) at $0.013/kW-hr,
- Infrastructure and mechanical spare parts, equipment repairs and replacement:
    - <u>Pumping Systems</u>: Pump replacement every 15 years + pumping system replacement every 30 years.
    - <u>Pipelines</u>: Annual O&M 1.5% of capital cost + 60-year replacement.
    - <u>Storage Tank</u>: Annual O&M at 0.5% of capital cost + painting every 20 years + 60-year replacement.
    - <u>Treatment Processes Nitrification, Ozone/BAC, Conditioning Facilities</u> – Annual O&M 1.5% of capital cost + 60-year replacement for full unit.
    - <u>Treatment Processes MF, RO, and UV-AOP:</u> Microfiltration and RO based on expected average membrane life and company warranty, UV and Ballast based on average life and company warranty. This also includes 60-year replacement for full unit.
- Treatment chemicals (e.g., greensand and chlorine for the wellhead treatment systems, anti-scalant for the RO system, caustic for pH adjustment post-RO), and
- Cost of treating water through the GHWTP (if the City would choose direct potable reuse later in project implementation).

The O&M costs have similar uncertainty to capital costs.

Unit Costs

BC based unit costs on those prepared by BC for North City Water Reclamation Plant (NCWRP), Harbor Drive Advanced Water Purification Facility (HD AWPF), and North City Water Reclamation Plant, NCWRP Upgrades/Improvements. BC used the sizing criteria from San Diego's Pure Water program for unit processes with a general assumption that the City could modify the existing highly under-loaded SC TF/SC WWTP to achieve nitrification. BC knows the effluent flow rates available and general water quality. The cost curves and the six-tenth rule served as the basis for adjusting estimated capital costs for facility scale changes. For final analysis, a 3-mgd output facility was considered that would treat only City wastewater.

Why was "yield" selected as the basis of the cost comparison?

An important metric for evaluating different water supply (and conservation) enhancement options can be developed by examining the cost per some unit of water-related benefit provided. Two water-related benefit measures that might be applied in this context are:

1. ***Yield*** is defined within the WSAC context as the amount by which a water option, or a portfolio of options, decreases the gap between peak season demand and the supply of water available in that peak season. Yield is typically measured in terms of the estimated millions of gallons (mg) by which the gap is reduced over the peak season. Yield may also be portrayed in terms of the size of the remaining peak season gap in a given projected water year (measured in MG, and/or in terms of the percent of peak season demand remaining unmet). Yield estimates reflect how the water supply components operate together as part of the overall SCWD *system*, and yield estimates are generated through application of the *Confluence* model.
2. ***Production*** is the volume of water potentially generated when operating at full design capacity by a water supply option, and is typically described in terms of volume produced in a typical day (e.g., 3 mgd). Production also may be described as how much water would likely be produced over a year (e.g., a 3 mgd facility producing water at that rate for 365 days would produce almost 1,100 MG per year). Production can be a somewhat hypothetical measure of the actual amount of water generated, as many options do not operate at full scale every day of the year (e.g., they may be constrained by the amount of river flows, and/or limited by other components of the overall water system). Production estimates do not account for how components of the overall system interact, but they are useful for scaling the size of the necessary infrastructure and estimating annual operation and maintenance costs.

Either of these water measures can be applied in a "unit cost" metric – i.e., one can use a cost per yield metric and/or a cost per production metric or both.

Of these two possible metrics, the “cost per yield” version was selected by the WSAC as the most informative and relevant during the evaluation phase. This is because “yield” reflects the true value to the community of the water generated by an alternative–it reflects how much an option (or portfolio of options) helps address water shortages in the times of year when shortages otherwise would arise and result in curtailments being imposed on the Water Department’s customers.

In contrast, water “production” reflects how much water might theoretically be generated in total, but not necessarily how much water would be truly generated, nor how much of the water shortage problem it might help address.

- **How will “Annualized Cost per Average Year Yield” be used with other metrics in comparing projects?**

A metric selected by WSAC for evaluating options is the Annualized Cost per Average Year Yield (ACAYY). This metric applies the estimated total annualized cost of an option (the annualized capital expense, such as would be incurred through bond repayments, plus the annual operation and maintenance costs), divided by the estimated average year yield (AYY).

The total annualized costs portion of the metric provides a useful approximation of how much the community will pay each year for the alternative. The AYY portion of the metric reflects the estimated value realized by the community (in terms of yield–the amount by which water shortage problems are resolved) averaged across projected future water year outcomes. This metric thus provides an indication of costs borne relative to the benefit received by rate payers.

This metric will be used to help guide deliberations about how the preferred water plan elements may be adjusted over time, as more information becomes available through the initial stages of investigation and implementation. For example, if technical or institutional complications (or simplifications) arise that render the expected cost of a preferred alternative considerably higher (or lower) than initially estimated, and/or result in lower (or higher) anticipated water yields, then the expected ACAYY cost per yield metric for that element will increase (or decrease). If the increase (or decrease) in ACAYY is sufficiently large, then the unit cost information will be considered—along with other factors—with respect to whether there should be some change in the portfolio moving forward (e.g., to enlarge or reduce the scale of one element as compared to another).

It is important to note that there is <u>not</u> a hard cut-off value for ACAYY for when an alternative may be modified or dropped from further consideration. WSAC opted for a benchmark of a 130% difference in the ACAYY unit cost metric, for comparing one portfolio element against another, as a basis for whether or not an adaptive change in strategy should be *considered*.

However, WSAC also clearly indicated that an ACAYY beyond the 130% level should not necessarily result in a change in strategy. WSAC also noted that some options provide ancillary benefits that are not necessarily reflected in the ACAYY metric (e.g., aquifer restoration may enhance instream flows), and such additional benefits may justify a higher unit cost compared to the ACAYY of other options.

List of Attachments

Attachment 1 Project Element Summary

Attachment 2 Gantt Chart, Implementation Plan and Timeline

Attachment 3 Table of Decision Nodes and Related Milestones

Attachment 4 Subway Diagrams

Project Elements Summary

	Element	1	2	3a	3b	3c	3d
	Building Block Approach	**In-Lieu**	**ASR and In-Lieu Combined***	**DPR Small (3 mgd)**	**IPR-Loch (3 mgd)**	**IPR-GW (3 mgd)**	**Local Desal (3mgd)**
a	Capital Cost ($ M)	131	159	89	132	119	147
b	Annual O&M cost ($ M/yr)	2.6	3.7	3.5	5.2	4.2	3.9
c	Total Annualized Cost ($ M/yr)	11.6	14.6	9.6	14.3	12.4	14.0
d	Present Value Costs ($M)	185	237	162	241	207	229
h	Worst Year Yield (MG)	750	760	810	660	740	810
i	Average Year Yield (MG)	350	380	440	430	380	440
j	Worst year yield unit cost (Total Ann Cost/Wst Yr Yield)	15,500	19,300	11,900	21,600	16,700	17,300
k	ACAYY** (Total Ann Cost/Ave Yr Yield)	33,200	38,500	21,900	33,200	32,600	31,800
l	Worst Year Peak Season Shortage (MG)	480	470	420	570	490	420
m	Worst Year Peak Season Shortage (%)	25%	24%	22%	29%	25%	22%
n	Average Year Peak Season Shortage (MG)	120	90	30	40	90	30
o	Average Year Peak Season Shortage (%)	6%	5%	2%	2%	5%	2%

* Both the costs and yields in this column reflect the combined costs of implementing both in-lieu and ASR.

**ACAYY = Annualized Cost per million gallons of Average Year Yield

NOTES:

1 All estimates are preliminary, rounded, and subject to revision and refinement as more detailed analysis is developed.

2 Total annualized costs based on amortizing capital outlays using a capital recovery factor of 0.0688 (reflecting a 30-year bond term at a 5.5% rate of interest to estimate the annual payment), and adding annual O&M costs.

3 Present Value Costs calculated based on capital outlays occuring in first year, followed by 30 years of annual O&M expense, discounted to present worth using a 2.5% real discount rate. No inflation escalation included.

4 ASR costs and yields reflect the *combined* cost and yields associated with adding ASR to the In-lieu program. Energy use for the combined ASR and In-Lieu elements reflect a volume-weighted average across the two elements.

5 Potential for revenues from water sales, cost sharing, and grant funding are not reflected.

6 All Element 3 options scaled at 3 mgd, reflecting potential reuse production based soley on City of Santa Cruz effluent flows.

7 See additional notes on following page.

C = Averaged Costs (All BBs)

	-30%	Mean	+30%
Worst Yr	11,935	17,050	22,165
Avg Yr	22,307	31,867	41,427
	median	32,900	1.03

C' = Averaged Costs (Element 3 BBs)

	-30%	Mean	+30%
Worst Yr	11,813	16,875	21,938
Avg Yr	20,912	29,875	38,837
	median	32,200	1.08

C'' = Averaged Costs (Element 1 & 2 BBs)

	-30%	Mean	+30%
Worst Yr	12,180	17,400	22,620
Avg Yr	25,095	35,850	46,605
	median	35,850	1

ADDITIONAL NOTES

Elements 1&2: In lieu/ASR: Capital Costs

1. Infrastructure is sized to accommodate In-lieu plus ASR (to allow peak flow for recharge of 5 mgd -- 2.5 mgd out to Soquel Creek and 2.5 mgd to Scotts Valley).
2. All infrastructure costs needed for the in lieu program are included in the in lieu option. The ASR capital costs added to the in-lieu costs for the combined option include only additional elements that would be needed for doing recharge and recovery: pipeline to Beltz wells, upgrade of in lieu extraction wells to allow for injection, and additional wells and treatment of the extracted water.
3. In a departure from previous Building Blocks, in the ASR option, a pipeline to the Beltz Wells and 4 wells in Santa Cruz are included. This addition is to allow flexibility in where the water is moved.
4. The capital costs associated with in lieu and ASR include $62M for upgrading the GHWTP and $14M to upgrade the San Lorenzo River Tait Street Diversion. Feasibility studies will evaluate whether there are alternative(s) to these two large projects to meet the same goals at a lower cost. One alternative, as it relates to ASR & in lieu combined, may be installing Ranney Collectors at Felton Diversion. Together with a modified water right to allow for direct diversion from Felton Diversion to GHWTP. This change could lower the cost of this strategy by as much as ~$60M. This would result in an Average year yield unit cost of $27,700.

O&M Costs

1. Operations for recharge and for recovery are set at 180 days each for both in lieu and ASR. That means moving water out for 180 days and moving water back for 180 days. Real-world costs will vary over time.
2. Flow rates are similar to previous building block scenarios. Cost includes both sending water out to SqCWD and SVWD and later sending water back to SCWD.
3. Average flow rate for costing in lieu returns = 4 mgd, split evenly between Soquel Creek and Scotts Valley.
4. Average flow rate for costing ASR = 5 mgd out (same volume would be available for transfer whether it was in lieu or ASR, and this also maintains consistency), split evenly between SqCWD and SVWD. Flow back would be 80% of that volume, or 4 mgd split evenly between SqCWD and SVWD. Real-world recovery will vary from well-to-well.
5. Well extraction pumping in SVWD or SqCWD is ***not*** included - it is roughly balanced out by the energy savings of not running wells in SqCWD and in SVWD when in lieu water is being sent.
6. Cost and energy use estimates for combined In-lieu and ASR would be higher if less water were directed to in-lieu and instead directed to ASR (e.g., more water injected if more goes to ASR).

Element 3

General assumptions

1. Potable reuse capacity is designed for 3-mgd *product water 365 days a year* based on treating only City of Santa Cruz flows. (I.e., conservatively assuming effluent from SqCWD and SVWD are unavailable.)
2. Infrastructure for potable reuse treatment is identical for all potable reuse alternatives. Treatment is on-site at the WWTP. Costs to treat blended water at GHWTP not included (~$2.7M/yr).

Element 3a: DPR

1. DPR water blends with raw water near Bay Street Reservoir. Energy calculation uses very conservative estimate that existing pressure pipe will not be changed.(A pipeline improvement would decrease energy needs.)
2. It is reasonable to assume that the City would investigate pipeline improvements and a lower-pressure operating scenario might be found. This change could significantly reduce the energy cost per MG.

Element 3b: IPR to Loch Lomond

1. A very significant portion of energy use is embedded in the pumping costs to move water ~800 vertical feet up to Loch Lomond.

Element 3c: IPR for Groundwater Recharge

1. Groundwater recharge is assumed to occur near the coast.
2. Eight wells included for 3 mgd capacity scenario used here.

Element 3d: Local Desal

1. The City desalination option capacity is 3 mgd product water 365 days a year.
2. Cost now includes property rights acquisition.
3. An O&M cost element for lifting the water to Bay Street has been added (instead of into the distribution system at a lower point).

Item		Units	Quantity	Cost, dollars	
				Cost per unit	Cost
Treatment Processes					
1	Nitrification (6.1 mgd)	LS	1	1,500,000	1,500,000
2	Ozone/BAC Filters (6.1 mgd)	LS	1	9,000,000	9,000,000
3	Microfiltration (6.1 mgd)	LS	1	14,000,000	14,000,000
4	Reverse Osmosis (5.5 mgd)	LS	1	20,000,000	20,000,000
5	Advanced Oxidation (Peroxide + UV) (4.7 mgd)	LS	1	3,250,000	3,250,000
6	Conditioning Facilities (4.7 mgd)	LS	1	1,432,500	1,432,500
7	Effluent Diffuser Modification	LS	1	1,000,000	1,000,000
	Site Work Subtotal				**50,182,500**
Pumps and Pipes					
8	Pumping System (WWTP to CAT)	GPM	4,300	400	1,720,000
9	Pipeline Installation (WWTP to CAT)	LF	200	600	120,000
10	Pumping System (CAT to Bay St. Reservoir)	GPM	3,200	400	1,280,000
11	Pipeline Installation (CAT to Bay St. Reservoir)	LF	6,000	440	2,640,000
12	Equalization Basin	LS	1		500,000
Pipeline, Pumps, Dam, Appurtenances Subtotal					**6,260,000**
	Construction Subtotal				**56,442,500**
	Contingency	percent	50	---	28,221,250
Subtotal					**84,663,750**
	Engineering and Administration	percent	20	---	16,932,750
	Legal	percent	5	---	4,233,188
	Geotechnical Investigation	percent	1	---	846,638
	Permitting - CEQA/NEPA	percent	5	---	4,233,188
	Other	percent	0	---	0
Subtotal					**26,245,763**
	Line Maintenance Facility Relocation				**5,200,000**
Total Project Cost					**116,200,000**

Operation and Maintenance Cost for Building Block 3	
Parameter	**Value**
Nitrification Tower Rework & Pipeline capital cost ($)	$2,947,500
Nitrification Tower electricity cost ($/year)	$28,470
Nitrification Tower O&M Cost	1.5%
Annual O&M cost ($/year)	$44,212.50
Nitrification Tower Replacement	60
Nitrification Tower Replacement Cost ($/year)	$49,125
Total Nitrification Tower electricity, O&M and replacement cost ($/year)	**$121,808**
Ozone/BAC Filters	
Ozone/BAC Filter capital cost ($)	$17,685,000
Ozone/BAC electricity cost ($/year)	$48,916
Ozone/BAC O&M Cost	1.5%
Ozone/BAC Filter annual cost ($/year)	$265,275
Ozone/BAC Filter replacement	60
Ozone/BAC Filter replacement cost ($/year)	$294,750
Total Ozone/BAC Filter O&M and replacement cost ($/year)	**$608,941**
Microfiltration	
Microfiltration system installation cost ($)	$27,510,000
Electricity consumption cost ($/year)	$250,536
Microfiltration maintenance cost ($/year)	$51,429
Chemical/Cleaning Cost	$207,386
Microfiltration system replacement	60
Microfiltration system replacement cost ($/year)	$458,500
Total Microfiltration system O&M and replacement cost ($/year)	**$967,851**
Reverse Osmosis	
RO system installation cost ($)	$39,300,000
Electricity Consumption Cost ($/year)	$740,220
RO System maintenance cost ($/year)	$136,080
Chemical/cleaning cost	$193,389
RO system replacement	60
RO system replacement cost ($/year)	655,000
Total RO system O&M and replacement cost ($/year)	**$1,724,689**
Peroxide/UV Disinfection	
UV system installation cost ($)	$6,386,250
Electricity Consumption Cost ($/year)	$182,208
Maintenance/Replacement UV & Ballast cost ($/year)	$73,234
Hydrogen Peroxide	$67,634
UV system replacement	30
UV system replacement cost ($/year)	$212,875
Total UV system replacement cost ($/year)	**$535,951**

Conditioning Facilities	
Conditioning facilities installation cost ($)	$2,814,863
Electricity Consumption Cost ($/year)	$28,470
Maintenance cost ($/year)	1.5%
Maintenance cost ($/year)	$42,223
Conditioning facility replacement	30
Conditioning facility replacement cost ($/year)	$93,829
Total Conditioning facility O&M and replacement cost ($/year)	**$164,522**
Pumping System (WWTP to CAT)	
Pumping System	$3,379,800
Electricity Consumption Cost ($/year)	$64,912
Pump replacement interval	15
Pump replacement cost ($)	$250,000
Pump replacement cost ($/year)	$16,667
Pumping System Replacement	30
Pumping System Replacement cost ($/year)	$112,660
Total Pump and Pumping System O&M and Replacement cost ($/year)	**$194,238**
Pipeline (WWTP to CAT)	
Pipeline capital cost ($)	235,800
Pipeline O&M Cost	1.5%
Pipeline annual cost ($/year)	$3,537
Pipeline replacement	60
Pipeline replacement cost ($/year)	$3,930
Total Pipeline O&M and replacement cost ($/year)	**7,467**
Pumping System (CAT to Bay St. Reservoir)	
Pumping System	$2,515,200
Electricity Consumption Cost ($/year)	$580,788
Pump replacement interval	15
Pump replacement cost ($)	$250,000
Pump replacement cost ($/year)	$16,667
Pumping System Replacement	30
Pumping System Replacement cost ($/year)	$83,840
Total Pump and Pumping System O&M and Replacement cost ($/year)	**$681,295**
Pipeline (CAT to Bay St. Reservoir)	
Pipeline capital cost ($)	5,187,600
Pipeline O&M Cost	1.5%
Pipeline annual cost ($/year)	$77,814
Pipeline replacement	60
Pipeline replacement cost ($/year)	$86,460
Total Pipeline O&M and replacement cost ($/year)	**164,274**
Equalization Basin	
Steel Equalization Tank	$982,500

Operation and Maintenance	$4,913
Painting Cost ($)	$150,000
Painting interval	20
Painting Cost ($/year)	$7,500
Tank replacement	60
Tank replacement cost ($/year)	$16,375
Total tank painting, O&M, and replacement cost ($/year)	**$28,788**
Sampling/Water Quality Analysis	
Sampling/Water Quality Analysis	**$25,999.12**
Total Annual O&M Cost	**$5,200,000**

Figure 12 Gantt Chart
Implementation Plan and Timeline

Timeline columns: 2016 (Year 1) through 2024 (Year 9) by quarter (Q1–Q4); 2025 (Year 10), 2026 (Year 11), 2027 (Year 12) by half-year (Q1/2, Q3/4).

Strategy	Node	Activity	Duration (years)
strategy 1	Element 1 - In lieu	Both near term with SqCWD using North Coast & lareger project with SqCWD & SVWD using SLR water	
	1.1D	Near term: Develop Agreements, Complete CEQA, Resolve any Infra. Issues	0.5
	1.2M	Evaluate larger project(s) with other agencies; affirm return water volumes & water rights	3
	1.3W/D	Completion of agreements, water rights, planning/prelim design, siting study & CEQA.	1
	1.4W	Infrastructure Improvements (see below for potential projects) & return water to SCWD	4
	1.5D/W	Assess performance	NA
	Element 2 - ASR (City, SqCWD and/or SVWD; i.e., Purisima & SM) + shared infrastructure (in lieu & ASR)		
	Phase 1 2.1M	Complete & use groundwater model	0.5-2
	Higher-level Feasibility	Identify/select existing wells for potential pilot testing	0.25
		Perform site specific injection capacity & geochemical analyses	0.5
		Develop Pilot Program & identify potential sites for new ASR well(s)	0.75
	Phase 2 2.2D	Retrofit existing wells	0.25
	Pilot Testing	Perform injection well hydraulic testing	0.25
		ISR cycle testing	1-2
		Develop ASR program	1
	Phase 3 2.3M/W	Procure properties	1
	Implementation	Design Project (includes City Administration)	1
		CEQA	0.5
		Construct	1.5
	2.4D/W	Assess performance	2
	2.5W	Storage target achieved	NA
	Infrastructure Improvements for Long term in lieu and/or ASR		
		Design/build pipeline in Santa Cruz to Beltz Wells	1.5
		Tait Street Diversion Improvements	3
		Graham Hill WTP Improvements	4
		Design & build Soquel Creek transfer (back), Scotts Valley transfer (to) infrastructure	2
		Pump Station (Soquel to City)	1.5
		Intertie No. 1 Pipeline (City to Scotts Valley)	2
		Pump Station (City to Scotts Valley) Intertie No. 1	2
strategy 2	Element 3 - Advanced Treated Recycled Water or Desalination		
	3.1M	Define Recycled Water project alternatives and status of DPR regulations	1
	3.2D	Select preferred Element 3	1
	3.3D	Prelim design, CEQA (prepare Draft EIR), permits	3
	3.4M	Complete Design , CEQA, permits, property acquistion	2
	3.5W	Complete construction/start up	2

Note on the Infrastructure Improvements rows: These items will be evaluated along with Elements 1 and 2 and implemented as needed.

Table Notes & Select Assumptions

This table approximates activities, costs, durations and sequencing of each element, all of which are subject to change.
Elements are shown to start in Q1 - 2016. This may or may not occur depending upon agreements, contracts, etc.
Rehab/replacement of the Newell Creek Pipeline is part of the existing CIP and not shown here.
Some infrastructure improvements may not be required if other pursuits are successful. E.g., evaluation of Ranney collectors may substitute GHWTP Improvements.
CEQA is used generically; implies compliance with Califorina Environmental Quality Act.
Pilot ASR work assumes major infrastructure not required. E.g., intertie to Scotts Valley or new well(s).
Element 2 includes 8 wells for in lieu plus 8 additional wells for ASR.

Legend

ASR = Aquifer Storage and Recovery
CEQA = California Environmental Quality Act
DDW = Division of Drinking Water
DPR = Direct Potable Reuse
EIR = Environmental Impact Report
GHWTP = Graham Hill Water Treatment Plant
IPR = Indirect Potable Reuse
ISR = Injection, Storage, Recovery
SCWD = Santa Cruz Water Department
SqCWD = Soquel Creek Water District
SVWD = Scotts Valley Water District

△ Decision Node
◇ Milestone Node
□ Some amount of water returned to SCWD
■ Full required amount of water returned to SCWD

Overview of Decision Nodes and Related Milestones along Adaptive Pathway Diagram

NODE	ABBREVIATED DESCRIPTION	ENDING YEAR
In-Lieu (Element 1)		
1.1D	Near Term: Initiation of near term water transfer/sale to SqCWD using North Coast water; agreements in place, and CEQA completed.	c. 2016
1.2M	Larger Project: Understanding the feasibility of a potentially larger water transfer/exchange project with SqCWD and/or SVWD using North Coast and San Lorenzo River waters. Includes quantifying return water (using groundwater models) from SqCWD and/or SVWD to Santa Cruz as well as understanding of water rights and inter-agency collaboration.	c. 2018
1.3W/D	Larger Project: Completion of agreements specifying terms of transfers to/from SqCWD and/or SVWD, water right modifications, planning/prelim design; complete assessments of cost, yield and schedule; and define CEQA. Decision point for proceeding on final design of associated infrastructure improvements.	c. 2019 c. 2020
1.4W	Larger Project: Potential for return of water from SqCWD, and/or SVWD, to SCWD with the construction of infrastructure/treatment improvements.	c. 2022
1.5D/W	Assess in-lieu performance: amount to SqCWD, SVWD, and SCWD; reduced groundwater pumping, groundwater elevations, etc.	c. 2025
Aquifer Storage and Recovery, ASR (Element 2) Includes evaluation of Purisima and Santa Margarita		
2.1M	High level feasibility work: use of groundwater model; completion of site specific injection capacity and geochemical analyses; development of pilot program.	c. 2017
2.2D	Completion of all administrative items to conduct pilot testing (e.g., CEQA/permits/agreements and well modifications), completion of pilot testing, and assessment of probable ASR system performance, cost and schedule to complete build out of ASR system.	c. 2020
2.3M/W	Develop/construct ASR wells, ready to operate.	c. 2022
2.4D/W	Assess ASR performance against projections and ability to meet project goals.	c. 2024
2.5W	Aquifer storage target attained (ability to sustain return flows to SCWD at desired levels).	c. 2027
Advanced Treated Recycled Water or Desalination (Element 3)		
3.1M	Identify recycled water alternatives; increase understanding of recycled water (regulatory framework, feasibility, funding opportunities, public outreach and education)	c. 2016
3.2D	Complete high level feasibility studies, as-needed demonstration testing, and conceptual level designs of alternatives;, define CEQA processes; and continue public outreach and education. Select preferred Element 3.	c. 2017
3.3D	Preliminary design, CEQA (including preparation of draft EIR), and apply for approvals and permits (except building permit).	c. 2020
3.4M	Complete property acquisition, final design, complete CEQA and all permits.	c. 2022

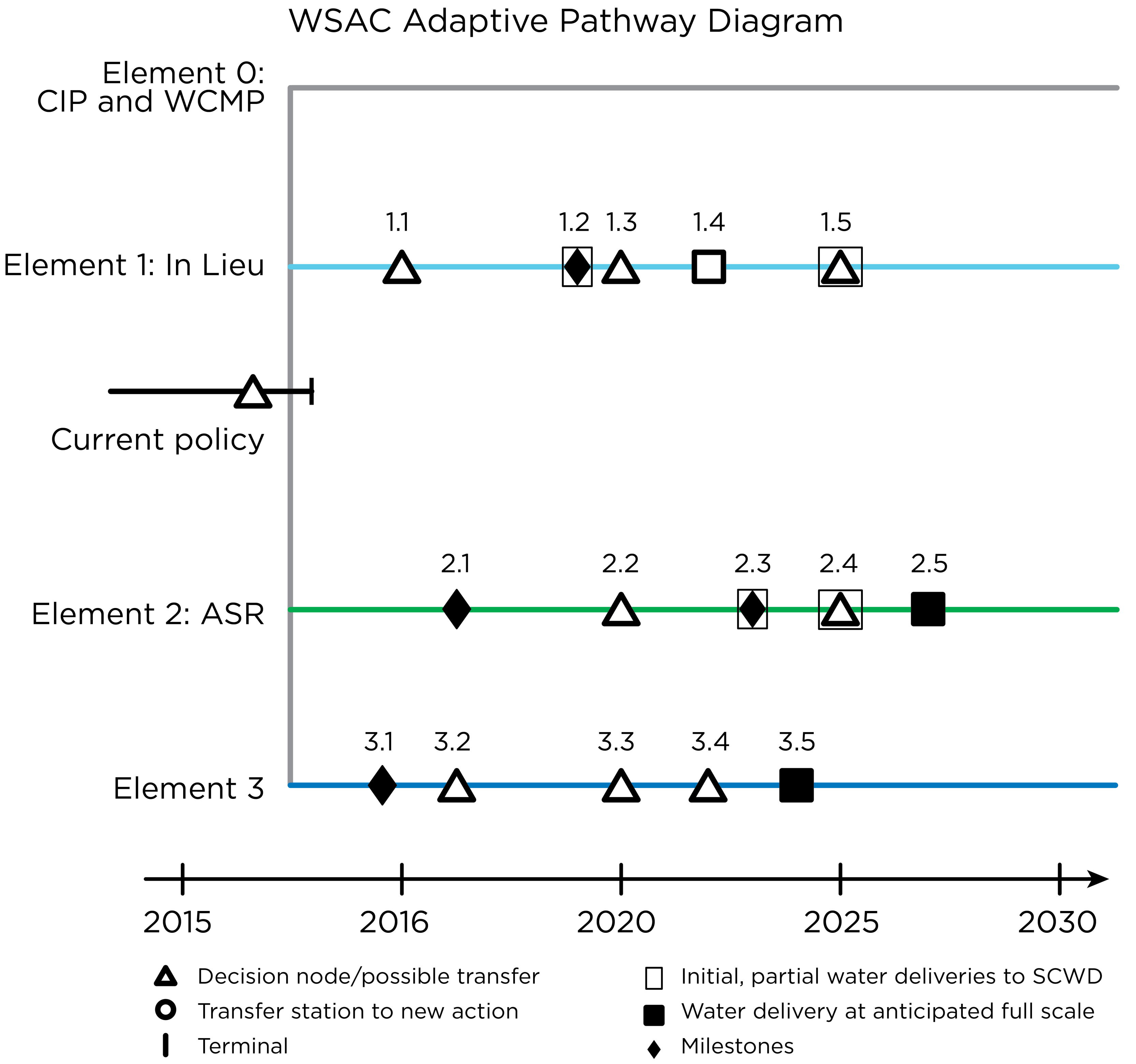
3.5W	Construction completed: plant start-up, water production begins	c. 2024

Abbreviations

ASR = Aquifer Storage and Recovery
CEQA = California Environmental Quality Act
DDW = Division of Drinking Water
DPR = Direct Potable Reuse
GHWTP = Graham Hill Water Treatment Plant
IPR = Indirect Potable Reuse
SCWD = Santa Cruz Water Department
SqCWD = Soquel Creek Water District
SVWD = Scotts Valley Water District

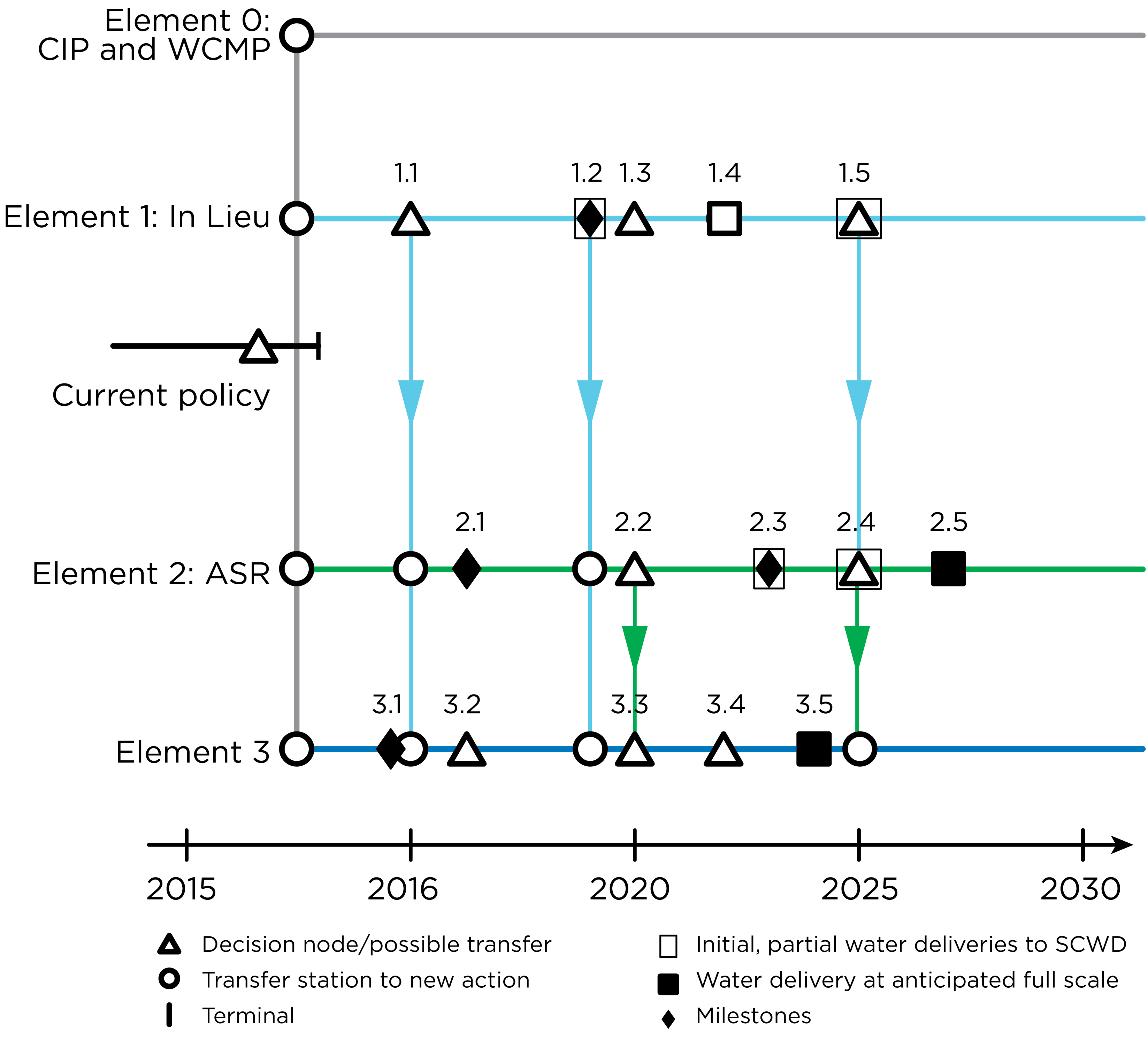
Notes

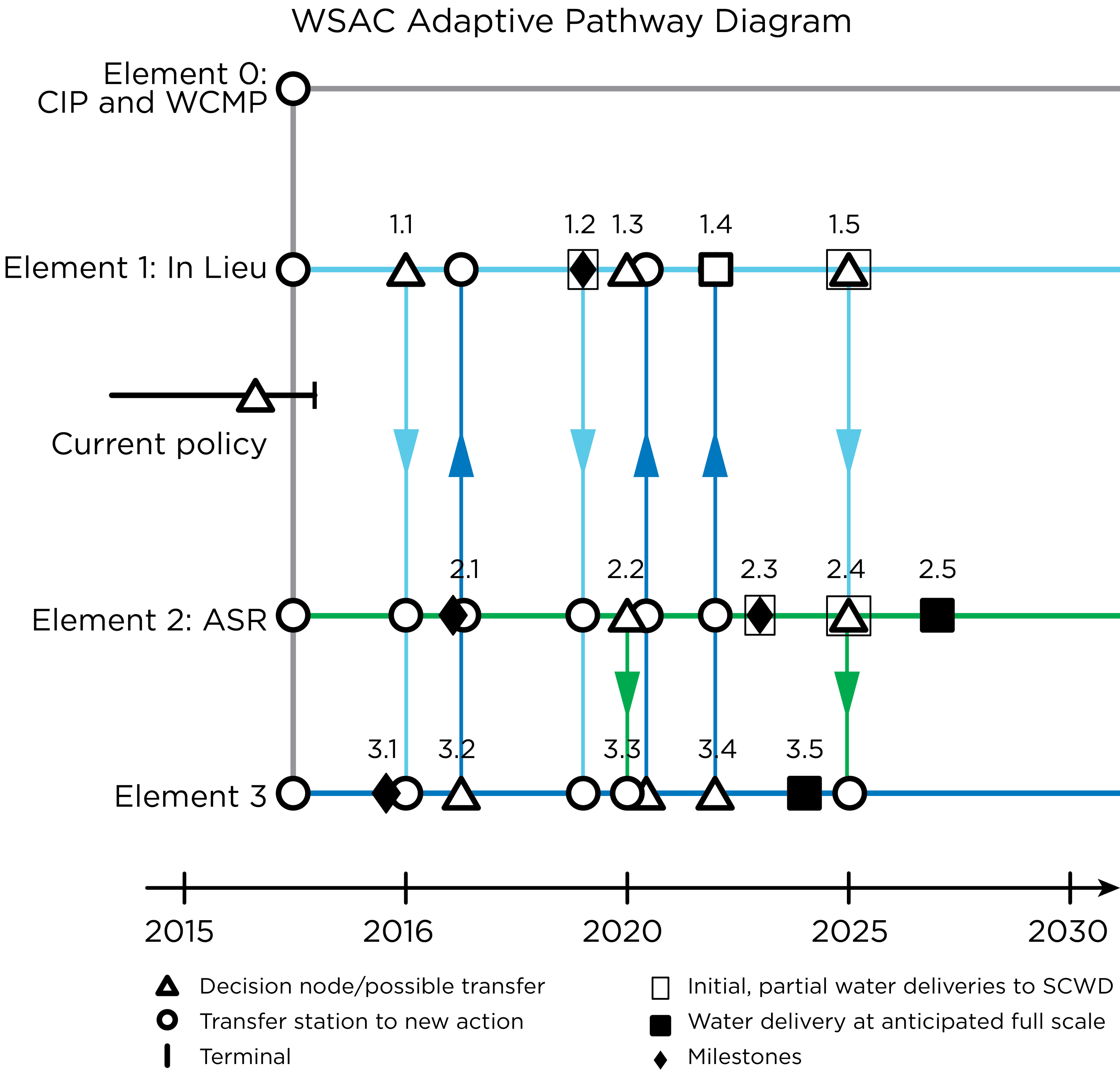
- This table is intended as a companion piece to the implementation Gantt chart and subway map. Gantt chart contains additional activity detail(s) for each node.
- Node types
  - D = decision node (triangle on subway chart)
  - M = milestone (diamond on the subway chart), furthering the understanding of feasibility.
  - W = water production potentially available (squares on the subway chart; open square indicates some water; solid square represents full goal being met).
- Node types have been assigned based on a set of assumptions as to how the implementation will proceed. However, if a threshold is being tripped, the node becomes a decision node regardless of its current designation.
- Ending Year refers to when all work associated with reaching node and/or achieving goal(s) will be accomplished. Dates shown are approximate based on current information and project understanding. Dates may adjust depending on: volumes of water available due to winter precipitation levels (which may limit amount of in-lieu and ASR); ability to establish agreements, permits, etc.; and ability to implement workload.



WSAC Adaptive Pathway Diagram
Element 0:
CIP and WCMP
Element 1: In Lieu
1.1
1.2
1.3
1.4
1.5
Current policy
Element 2: ASR
2.1
2.2
2.3
2.4
2.5
Element 3
3.1
3.2
3.3
3.4
3.5
2015
2016
2020
2025
2030
Decision node/possible transfer
Transfer station to new action
Terminal
Initial, partial water deliveries to SCWD
Water delivery at anticipated full scale
Milestones

WSAC Adaptive Pathway Diagram




WSAC Adaptive Pathway Diagram
Element 0: CIP and WCMP
Element 1: In Lieu
Current policy
Element 2: ASR
Element 3
1.1
1.2
1.3
1.4
1.5
2.1
2.2
2.3
2.4
2.5
3.1
3.2
3.3
3.4
3.5
2015
2016
2020
2025
2030
Decision node/possible transfer
Transfer station to new action
Terminal
Initial, partial water deliveries to SCWD
Water delivery at anticipated full scale
Milestones