Application to the Representative Policy Board for Approval of a Project to Construct Electrical Improvements at the Lake Gaillard Water Treatment Plant and Lake Saltonstall Water Treatment Plant

South Central Connecticut Regional Water Authority
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1. Statement of Application

This application is presented by the South Central Connecticut Regional Water Authority (RWA) to the Representative Policy Board (RPB) of the South Central Connecticut Regional Water District for approval of the Electrical Improvements at the Lake Gaillard and Lake Saltonstall Water Treatment Plants (WTP). Section 19 of Special Act 77-98, as amended, requires RPB approval before the RWA commences any capital project that will cost more than $3.5 million. The construction cost estimate for the project is approximately $14 million.

The Lake Gaillard Water Treatment Plant (LGWTP), located in North Branford, Connecticut, went online in 1986. It is a direct filtration plant that treats water from the Lake Gaillard surface water supply. Following treatment, the Lake Gaillard Pump Station provides water directly to the New Haven and Branford service areas, and indirectly to additional service areas through multiple pump stations and pressure reducing facilities. The LGWTP is an 80 MGD facility that supplies an average of 32 million gallons of water per day (MGD) to more than 265,000 customers via approximately 72,400 service connections. This represents approximately 60% of the average flow that RWA transports daily, making it the largest treatment plant operated by the RWA.

In 2015, engineering consultants developed a Capital Improvements Plan (CIP) for the LGWTP (Appendix B), which noted that many of the electrical system components were original to the facility. Based on the condition of the equipment and equipment age at that time, Tighe & Bond recommended replacing critical electrical distribution equipment at the WTP within the next five years. Additionally, the electrical equipment serving the hydroelectric building at the LGWTP is now at the end of its useful life and will be replaced during this project.

The Lake Saltonstall Water Treatment Plant (LSWTP), located in East Haven, Connecticut, was placed online in 1974 and is an integral piece of the RWA's water system. The facility treats water from Lake Saltonstall, which is fed by the Farm River Diversion. The LSWTP is a 12 MGD facility that supplies an average of 6 MGD to approximately 50,000 customers in the Saltonstall service area, which includes portions of East Haven, Branford, and New Haven.

Planning efforts in the early 2000's recommended replacement of all electrical equipment at the LSWTP as it was original to the facility. The majority of the electrical equipment was replaced by 2008, with the exception of the 2400V utility service, utility transformer, and utility service section of the main switchgear. Replacement of this equipment requires a shutdown of the LSWTP, which was not feasible at that time. Since then, the RWA completed distribution system improvements that allow for installation of a temporary pumping system to transfer water to the Saltonstall service area, facilitating shutdown of the treatment plant and replacement of this equipment. In 2013, Tighe & Bond developed a CIP for the LSWTP (Appendix C), which recommended replacement of the remaining original electrical equipment, as well as the incoming electrical service from the utility. The high service (distribution) pumps and associated discharge piping and valves require replacement since they are original to the facility and were previously refurbished over a decade ago.

This project and application are a result of project consolidation, with work of the same discipline and scale occurring at two different facilities. This resourceful approach will increase capital efficiencies by achieving economies of scale by consolidating multiple projects into one bid. The project consolidation concept also provides the RWA's management with a method to complete improvements at two water treatment plants without returning to the RPB for separate project approvals. With an increasing number of planned projects expected to exceed the $3.5 million RPB application threshold, this project consolidation method will increase the efficiency of conducting the RWA's capital program by reducing the time, expenses, and facility impacts associated with individual projects.

The project's intent, summarized in this application, is to invest capital resources into facilities that will allow the RWA to continue to provide water reliably and efficiently to its customers. Through improvements to both the Lake Gaillard and Lake Saltonstall water treatment plants electrical equipment as well as the

LSWTP high service pumps, the RWA achieves strategic goals of increasing resiliency and water supply accessibility to the major service areas within the distribution system, while also continuing to reduce emissions and our carbon footprint.

Consequently, this application is organized into two distinct sections, to allow for presentation of the proposed work, benefits, alternatives, and recommendations at each facility:

- Section 2: Electrical improvements at the Lake Gaillard Water Treatment Plant

- Section 3: Electrical improvements at the Lake Saltonstall Water Treatment Plant

Project design is provided by two engineering consulting firms – HDR and Tighe & Bond. Due to their extensive experience with hydro-generator controls, HDR is providing services for the electrical and controls upgrades associated with the work in the hydroelectric building at the LGWTP. Tighe & Bond is providing design services for the remainder of the work at the LGWTP, all design work at the LSWTP, and permitting, construction administration, and construction observation services for the entire project. The design drawings, which are 90% complete, are included in Appendix A.

2. Lake Gaillard Water Treatment Plant

2.1 Description of the Proposed Action

Electrical improvements at the LGWTP will include replacing the Motor Control Centers (MCC-1 through 3), the hydro-generator switchgear and controls, the 1500KVA transformer (T-5), as well as the 1600-amp filter plant main switchboard and automatic transfer switch (ATS). Replacement of these major pieces of equipment will involve several shutdowns of the water treatment plant, therefore requiring significant planning and coordination to minimize disruption. Additionally, temporary power facilities will be needed to complete the work.

More specifically, the work associated with the LGWTP includes:

- Filter Building
    - Replace the main switchboard and ATS controlling the filter plant
    - Replace MCC-1 through 3 with power distribution panel and wall-mounted starters
- Residuals Loading Building
    - Replace MCC-5 with power distribution panel
- Exterior
    - Replace transformer T-5
- Hydroelectric Building
    - Replace controls in hydroelectric generator control panel, including PLC, touchscreen, protective relays, and associated switches
    - Replace hydroelectric generator switchgear, including battery charger, and distribution panels internal to switchgear lineup. Replace switchgear wiring, distribution feeds, unit control wiring, and instrumentation wiring
    - Replace two panelboards and associated transformer adjacent to hydroelectric generator switchgear
    - Replace battery bank associated with the hydroelectric generator system

2.2 Need for the Proposed Action

As noted in the Statement of Application, Tighe & Bond's 2015 LGWTP CIP recommended replacement of critical electrical equipment at the LGWTP, noting that many of the electrical system components are original to the facility (circa 1986). This recommendation was based on the condition at the time as well as the equipment age. After approximately 30 years of operation, the electrical equipment poses an increased risk of catastrophic failure that could result in unexpected facility shutdowns, interruption of service to customers and safety risks to staff operating the facility.

Prior to this proposed project, electrical upgrades were completed in 2017 to replace the T-6 transformer and associated primary and secondary wiring. That project included several provisions to facilitate the future upgrades to the main switchboard and MCC replacements, and installing additional conduit and pull boxes between the transformer and the main switchboard inside the Filter Building.

As part of the evaluation for this project, Tighe & Bond reviewed current usage and operation of MCC-1, 2 and 3. It determined that each of the MCCs have become less utilized over time as the original motor starters have been replaced with remote field-mounted equipment including new motor starters, VFDs, and controls. As such, providing new MCCs is unnecessary and not cost effective. Instead, a combination of power distribution panelboards and stand-alone motor starters have been incorporated in the design. This alternative equipment helps to reduce arc flash hazards, requires less space, increases operational and construction flexibility and is less costly to install and maintain.

It has been determined that electrical upgrades at the LGWTP are necessary based on the following reasons:

- MCC-1, MCC-2, MCC-3, the filter plant main switchboard, T-5 transformer, main circuit breakers, and ATS are either nearing or have exceeded their recommended service life of 30 years. This equipment is now at an increased risk of causing damage to the surrounding equipment and employees, which may result in prolonged facility shutdowns.

- Replacing MCC-1, MCC-2 and MCC-3 with power distribution panelboards and stand-alone motor starters will reduce cost, space needed for equipment and will allow for more flexibility during construction.

- Aging electrical equipment is susceptible to breakdowns requiring numerous repairs. Replacement parts can be difficult to find, have long lead times, and can't be refurbished rather than new due to many parts being obsolete.

2.3 Analysis of the Alternatives to the Proposed Action

To evaluate the different alternatives for the proposed electrical upgrades at the LGWTP, Tighe & Bond developed a preliminary design report titled *MCC Replacement Study at the Lake Gaillard WTP,* dated June 2020 (Appendix D). This report includes alternatives for replacing the Main Switchboard, MCC-1, 2, and 3, including evaluations of equipment sizing and locations, while considering constructability issues, sequencing, and temporary provisions. The alternatives include a no action approach, replacing equipment in existing locations, and replacing equipment in new locations.

Alternative 1 – No Action: This alternative proposes taking no action and keeping the existing equipment as-is. The existing equipment has exceeded the recommended 30-year service life, and poses an increased risk of catastrophic failure, damage, and loss of service to the 265,000+ customers served by the LGWTP. The main switchboard is the central power distribution for the entire treatment plant. Keeping the main switchboard in service greatly impacts the reliability of the plant's electrical system. If a major failure were to occur, the LGWTP would be out of service for days, or potentially weeks, with the risk of impacting public health and damaging the RWA's credibility. A major failure could result in damage to surrounding equipment and poses a significant safety hazard to staff operating the facility. As such, this alternative was determined to be non-viable.

Additionally, emergency work associated with a failure would be costly and time-consuming to repair.

Alternative 2 – Replacing Equipment in Existing Locations: Alternative 2 proposes replacing the existing electrical equipment in or near the current locations. Replacing equipment in-situ is challenging because the facilities require continuous power to operate. However, this work will require short, controlled shutdowns of LGWTP. To accomplish this, RWA will restrict the necessary coordinated shutdown durations to one to two hours and will depend on the type of work being completed. Temporary provisions will be required to provide back up and temporary power when possible, during construction. In this alternative, the switchboard would be moved slightly and replaced next to the existing MCC-1 to reduce project costs and facility downtime.

MCC-1, MCC-2, and MCC-3 would be demolished, and each replaced with power distribution panelboards and stand-alone motor starters/control panels. These MCC-1, MCC-2, and MCC-3 replacements are less costly, take up less space, and add flexibility during construction. Providing a panelboard to power non-motor loads instead of powering them from an MCC will increase future flexibility, help reduce arc flash hazards at the MCC and helps to minimize costs. The wiring for all equipment replacing the MCCs would be connected to existing wiring and concealed in wire troughs mounted on the existing equipment pads, which would occupy a smaller space within the existing footprint of the MCCs.

Alternative 3 – Replacing Equipment in New Locations: This alternative proposes installing new electrical equipment in different locations, which allows the new equipment to be installed while the existing equipment is still in operation, thereby reducing shutdowns. Similar to Alternative 2, Alternative 3 assumes the main switchboard will be replaced to the south of the existing MCC-1 in the Electrical Room. This will enable the new equipment to be installed, tested, and operational while the existing switchboard maintains power to the plant.

MCC-1, MCC-2 and MCC-3 would be demolished, and each replaced with power distribution panelboards and stand-alone motor starters/control panels as proposed in Alternative 2. However, new MCC-1 and MCC-2 replacement equipment would be installed in the adjacent Pilot Plant Room, while new MCC-3 replacement equipment would be installed on the wall to the south of existing MCC-3, located near the filters.

While measures are taken to minimize conduit/wiring in this alternative, conduit installation would require numerous wall penetrations in the common wall between the Electrical Room and Pilot Plant Room. Cable trays and additional wall reinforcement may be necessary to maintain the structural integrity of the wall if the wall is loadbearing. A structural analysis would be required.

Under this alternative, the equipment is proposed to be relocated into the Pilot Plant Room. This room is currently used as general storage for RWA's Emergency Operations Center (EOC) and RWA's back up servers. This area also serves as the RWA IT Department's staging area when the EOC is activated as part of the business continuity plan. This Pilot Plant Room would be consumed by the relocated electrical facilities and would require the server equipment and IT staging area to be relocated. Additionally, equipment pads, wire troughs, and some electrical facilities would still remain in the existing electrical area, which would result in an area that would be generally unusable for other purposes.

Recommendation - The Alternatives Analysis concluded that Alternative 2 is most favorable in terms of cost, floorspace, and quantity of new wiring/conduit required. The alternative to replace equipment in existing locations was selected for the following major reasons:

- Cost is minimized due to less conduit and wiring required to connect the new equipment.
- There are no space constraints, as the new equipment is similar in size to the existing equipment,
- Minimal structural modifications are required.
- Although this alternative will require additional shutdowns than Alternative 3, advanced planning, coordination, and the use of temporary electrical facilities will help minimize shutdown durations.

A Business Case Evaluation (BCE) was performed by RWA to compare and evaluate the alternatives above and is included in Appendix I. To summarize the results, Alternative 2, was found to have the lowest total costs and lowest life cycle cost – annuitized cost stream, the greatest risk reduction effectiveness factor, and overall greatest cost benefit ratio.

Of the electrical improvement options available, the alternatives analysis concluded that Alternative No. 2 is most favorable in terms of reliability and long-term usability of the space. The alternative was selected for the following reasons:

- The alternative has the lowest capital costs as it limits relocation and extension of existing utilities.
- The alternative best utilizes the available space and maintains the Business Continuity Plan.
- The alternative limits structural modifications to the filter building.

2.4 Statement of the Cost to Be Incurred and/or Saved

2.4.1 Capital Cost

This project will result in an approximate capital expenditure of up to $3.91 million including a 10% contingency on the un-escalated estimated construction costs. The RWA has expended through February 2025 approximately $358,000 to conduct the preliminary engineering and design. A breakdown of the capital cost for this project is presented in Table 1 below and a detailed breakdown of this cost estimate is contained in Appendix G of this application. The project costs presented are based on a 90% design level of completion prepared in October 2024. In accordance with cost estimating principles, the project costs have been adjusted for inflation.

TABLE 1
Estimated Project Capital Cost for LGWTP Electrical Improvements– Including Escalation and Construction Phase Engineering

Cost Description	Estimated Cost
Previous Expenditures (from 2019 through February 2025)	$358,000
Final Design Cost	$25,000
Estimated Construction Cost	$2,548,000
Escalation to Mid-point of Construction: 5.0% per year	$262,000
Construction Total with Inflation	$2,810,000
Consultant cost During Construction	$337,200
RWA Costs During Construction (Includes temporary system)	$120,851
Engineering and Construction Oversight Sub-total	$458,051
Construction Sub-total (w/o final design)	$3,268,051
Total	**$3,651,051**
Rounded Total	**$3,650,000**
Minimum Anticipated Project Cost (-10%)	$3,324,000*
Maximum Anticipated Project Cost (+15%)	$4,141,000*
Requested Budget (+10%)	$3,906,000*

* Project costs ranges include (-10%) to (+15%) American Association of Cost Engineers (AACE) accuracy factors, on the Estimated Construction Cost only.

The project costs presented are based on a 90% design level prepared in October 2024. In accordance with cost estimating principles, the project costs have been adjusted for inflation. An inflation factor of 5.0% per year has been used in the cost estimate. This factor was calculated by Tighe & Bond from the ENR Construction Cost Index from October 2024.

For the requested budget, a 10% contingency on the Estimated Construction Cost is shown in Table 1. This is within the range recommended by the American Association of Cost Engineers (AACE) International Recommended Practices and Standards for a Class 1 estimate, which is included in Appendix H. In a Class 1 estimate, the design of the project is expected to be between 65% to 100% complete and accurate within -10% to +15%. The AACE defines contingency as a specific provision for unforeseeable elements of cost within the defined project scope, particularly where experience has shown that unforeseeable costs are likely to occur. The 10% contingency allowance is included at this design stage for uncertainty in future bid prices, and as a means to reduce the risk of possible cost overruns.

2.4.2 Operation and Maintenance Cost

Implementation of new equipment will reduce RWAs operation and maintenance costs. The electrical distribution equipment does not use significant electricity, however new distribution equipment can result in an improved efficiency of up to 1% of energy use. Additionally, it is anticipated that the RWA Operations team will experience fewer emergency calls to address malfunctioning equipment at the treatment plant. Overall reliability will be greatly improved, but the project will not add more equipment or new processes, therefore will not add new maintenance burdens for Operations staff. Newer equipment and the breaker configuration would have more available and less expensive replacement parts.

The LGWTP hydroelectric facility utilizes similar aged distribution equipment and older obsolete PLC for which parts are difficult to obtain. Failure of electrical equipment associated with the hydroelectric turbine would result in lost electricity generation valued at an average of $600 per day. It is anticipated that there will be an additional 90 days of hydroelectric facility operation over the course of 2 years.

Based on the change to existing equipment, the selected project is expected to reduce operation and maintenance costs, including energy costs, by an estimated $26,000 annually.

3. Lake Saltonstall Water Treatment Plant

3.1 Description of the Proposed Action

The proposed work at the LSWTP will include replacement of the existing 2400-volt (V) distribution equipment and utility service with new 4160V equipment and a 13,800V utility service. The high service pumps and associated motors will also be replaced. These upgrades to the electrical equipment will require a shutdown of the facility, which will be carefully sequenced by the RWA and Tighe & Bond to minimize downtime, cost, and risk.

More specifically, the work consists of:

- Electrical
  - Demolition of the LSWTP main switchgear, main utility transformer (by utility), RWA owned transformers, MCC-2 and MCC-3
  - 13.8kV overhead electrical service and associated United Illuminating (UI) service
  - 13.8kV x 4160V transformer (feeding new 4160V switchgear), located outside the Filter Building
  - 4160V switchgear located in a new electrical enclosure, outside the Filter Building
  - Three new 4160V x 480V transformers and a 480V switchboard.
  - 480V MCC-3 in the Residual Loading Building (RLB)
  - Generator modifications to convert output from 2400V to 4160V
  - Electrical wiring modifications to accommodate the new equipment and locations
  - Various site work including concrete pads, buried conduit, and a retaining wall to accommodate the new transformer and switchgear. Utility relocation to allow for new switchgear location.
- High Service Pumps
  - Remove existing and replace with three new high service sumps
  - Install three new pump control and isolation valves, discharge piping, and a surge relief valve for the upgraded high service pumps
  - Provide three 480V VFDs and motors for the high service pumps

3.2 Need for the Proposed Action

Although the LSWTP has undergone numerous upgrades to the electrical system, as recommended by Tighe & Bond in the 2013 LSWTP CIP, there is still equipment that is original to the treatment plant. Some electrical improvements were completed in 2007 (replacement of the ATS, diesel generator, three MCCs and three soft starters for the high service pumps). However, other major equipment could not be replaced without service interruptions. These upgrades, as well as distribution system improvements providing temporary pumping facilities, now allow for temporary shutdowns at the LSWTP without service interruption to customers. As such, the remaining original electrical equipment can now be replaced.

The existing LSWTP electrical system includes 2400V main distribution equipment throughout the facility. The 2400V main switchgear requires replacement as it has exceeded its recommended service life of 30 years. As stated previously, after 30 years of operation, electrical equipment poses an increased risk of failure, interruption of service to customers and poses a safety risk to RWA staff operating the facility.

The existing 13.8kV buried utility service line to the LSWTP is difficult to safely access for maintenance because it originates north of the LSWTP, adjacent to Interstate-95 and runs south underneath the Amtrak right-of-way (ROW). The RWA's electric utility provider, UI, indicated that it will be necessary to install a new electrical service to the LSWTP, which will originate from Saltonstall Parkway (Highway 1) and will be more accessible for maintenance and repair.

UI also stated that the 2400V transformers are no longer standard and will not be supported once the existing 2400V switchgear is replaced. Two voltages, 480V and 13.8kV, were considered for the new service. This alternatives analysis concluded that a 13.8kV service was preferred, which is consistent with the service voltage at other RWA water treatment plants. The analysis also recommended that the LSWTP operate at 4160V. Since the LSWTP is currently configured to operate using 2400V, additional electrical improvements are required to utilize the 4160V service, including installation of an RWA-owned transformer (13.8kV x 4160V), replacement of 2400V x 480V transformers with 4160V x 480V transformers, and electrical modifications to existing equipment.

The three high service pumps transport the treated water from LSWTP to the distribution system. Although the pumps were refurbished approximately 16 years ago, they are original to the LSWTP, and replacement is recommended by Tighe & Bond. In addition to the replacement of the high service pumps and motors, discharge piping and valves will be replaced, VFDs will be installed, and MCC-3 in the RLB will be replaced.

In summary, the electrical updates at the LSWTP are required based on the following reasons:

- The existing 2400V main switchgear dates back to 1974 and has significantly exceeded its service life. It now poses an increased risk of a major failure.
- The 2400V switchgear violates National Electrical Code workspace requirements, due to lack of sufficient space in front of the equipment and is therefore a safety hazard.
- The 2400V switchgear is a critical component of the LSWTP because it provides power to the treatment plant and Raw Water Pump Station.
- 2400V transformers are no longer standard. UI will discontinue supporting the existing utility service upon replacement of the 2400V switchgear, thus requiring a new utility service at a different voltage and the installation of a RWA-owned transformer.
- New transformers and electrical modifications to existing equipment are required to account for the voltage change of the new utility service.

- The high service pumps are past their service life, are inefficient, and have already been refurbished. The associated piping and valves are showing signs of wear and have been identified as requiring replacement.

3.3 Analysis of the Alternatives to the Proposed Action

3.3.1 Electrical Improvements

In determining the best course of action to address the aging 2400V distribution equipment at the LSWTP, Tighe & Bond prepared the *Lake Saltonstall WTP Electrical Service Upgrades Report* dated March 2020 (Appendix E). This report evaluated several different replacement alternatives, including sizing and location options, constructability concerns, sequencing considerations, and potential permitting needs. The alternatives summarized below, include a no action approach, replacing the 2400V equipment in-kind, replacing the 2400V equipment with 4160V equipment, and replacing the 2400V equipment with 480V equipment. The replacement of the existing UI utility service is considered in these alternatives.

Alternative 1 – No Action: This alternative proposes taking no action and keeping the existing equipment and electrical utility service as-is. The existing equipment has exceeded the recommended 30-year service life, posing an increased risk of catastrophic failure, damage, and loss of the LSWTP. Keeping the switchgear in service greatly impacts the reliability of the LSWTP electrical system. Aging electrical equipment is susceptible to break downs requiring numerous repairs and finding replacement parts can be difficult. If a major failure were to occur, the facility could be out of service for days or weeks. It could also result in damage to surrounding equipment and poses significant safety hazards to staff operating the treatment plant. Even with proper preventive maintenance, the main switchgear does not meet code requirements for electrical working space. Additionally, parts for 2400V equipment are not common nor readily available.

Should a failure occur, emergency repair work would be more costly and disruptive to operation of the treatment plant. Failure could result in the inability to deliver water to customers in the Saltonstall service area, until temporary pumping provisions could be set up at North High Street. As such, this alternative was determined to be non-viable.

Alternative 2 – Replace 2400V Distribution Equipment In-Kind: This alternative includes replacing the existing 2400V distribution equipment with new 2400V equipment. The proposed main switchgear would be located outdoors in a walk-in enclosure near the Filter Building to address the code violation. The relocation would allow the work to be performed while the existing switchgear is still online, thereby reducing shutdown periods and associated risk. The existing 2400V utility service would either remain as-is (Alternative 2A) or be replaced (Alternative 2B). Existing transformers at the RLB and Raw Water Pump Station would remain. The existing generator would only require new wiring and conduit to connect to the new switchgear. Much of the existing wiring and conduit would be reused; however, the RWA would continue to need a special maintenance contract to perform work on the medium voltage 2400V equipment.

> **Alternative 2A – Keep Existing Service As-Is:** UI indicated that if the existing 2400V switchgear is replaced, they would stop supporting the 2400V transformer. This alternative is therefore impracticable. The RWA is required by UI to make the necessary upgrades to accommodate a new utility service as part of any switchgear replacement project.
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> **Alternative 2B – Replace Utility Service:** UI indicated that they would install a new service to LSWTP that originates from Saltonstall Parkway (Highway 1). The UI-provided service would be at UI's standard 13.8kV, similar to RWA's other WTPs, and include installation of a RWA-owned transformer to convert from the 13.8kV service voltage to the 2400V provided to LSWTP. Since LSWTP is configured to operate at 2400V, few additional modifications would be required under this alternative.

Alternative 3 – Replace 2400V Distribution Equipment with 4160V Equipment: Alternative 3 proposes replacing the 2400V distribution equipment with new equipment at 4160V, which is a common voltage used by equipment manufacturers. This alternative requires additional work to convert existing equipment such as the generator, MCCs, and pumps, to the new voltage. Both 2400V and 4160V are considered to be medium voltage and can use the same major feeder cables and disconnect switches that are currently in place and are rated for up to 5000V. Similar to Alternative 2, a special maintenance contract would be required to perform work on the medium-voltage equipment.

The proposed 4160V main switchgear would be located outdoors in a walk-in enclosure, as with Alternative 2. This alternative would require installation of a new 4160V to 480V transformer with associated wiring to tie the new 4160V switchgear to MCC-1A and 1B. Similarly, the new 4160V switchgear would require installing a new 4160V to 480V transformer at the RLB and Raw Water Pump Station to provide power to MCC-3 and 4, respectively. Finally, the existing generator would require field-modifications to be compatible with the new 4160V system.

Alternative 3 also includes provisions to connect the LSWTP to the new 13.8kV utility service, as detailed in Alternative 2B above. The UI-provided service requires the installation of a client-owned transformer to convert from 13.8kV to 4160V.

Alternative 4 – Replace 2400V Distribution Equipment with 480V Equipment: Alternative 4 proposes replacing the 2400V distribution equipment with new equipment at 480V, which is also a common voltage used by equipment manufacturers. Like Alternative 3, installing equipment at a new voltage requires additional work. The generator, MCCs, and pumps would require replacement or modifications to accommodate a new voltage. The "low voltage" 480V equipment is generally smaller and less expensive than medium voltage; however, the existing major feeder cables and disconnect switches are sized for medium-voltage equipment and require replacement to be compatible with 480V. One advantage with installing 480V equipment is that staff electricians can perform maintenance and repair, as opposed to the need for a maintenance contract.

The proposed 480V main switchgear would be located outdoors in a walk-in enclosure, similar to Alternatives 2 and 3. Using a 480V switchgear, MCC-1A, 1B, and 3 could be powered directly without use of transformers; however, new 480V-rated wiring and conduit would be installed between the switchgear and MCC-3 as the existing wiring cannot be used at 480V. MCC-4 at the Raw Water Pump Station is nearly one-half mile from the proposed switchgear; therefore, installing an additional 480V to 2400V transformer and reusing the existing 5000V-rated wiring would be necessary. Replacing the existing wiring and conduit would be expensive, difficult to install, require extensive permitting, and carry risk since it would involve crossing the existing Amtrak ROW and Interstate 95. Finally, the existing medium-voltage generator is incompatible with a 480V system and would require a transformer, new wiring, and conduit to provide backup power to the new switchgear.

Alternative 4 includes provisions to connect the LSWTP to the new 13.8kV utility service, as detailed in Alternative 2B. The new service can be supplied at either 13.8kV or 480V via a utility-owned transformer. Alternative 4 assumes that the utility service will be supplied at 480V via a utility-owned transformer.

Recommendation - The Lake Saltonstall electrical system alternatives analysis concluded that Alternative 3 is most favorable in terms of equipment voltage and quantity of reused wiring/conduit. While this alternative is more expensive than Alternative 2B, 2400V equipment proposed by Alternative 2B is less common and could provide future challenges locating parts and equipment. The alternative to replace 2400V distribution equipment with 4160V distribution equipment was selected for the following major reasons:

- 4160V equipment is more commonly used and readily available.
- Complicated wiring and conduit installation across railroad lines between the Filter Building and Raw Water Pump Station are removed, eliminating risk.

- Existing 5000V-rated wiring can be reused, offering significant cost savings.
- Generator modifications are minimized compared to Alternative 4.
- The LSWTP will continue to be powered by a UI-provided utility service and will not propagate a non standard voltage issue into the future.

3.3.2. High Service Pump Improvements

While the replacement of high service pump motors and installation of VFDs were considered in Tighe & Bond's March 2020 report, it was ultimately decided to replace the high service pumps as well. A separate alternatives analysis was conducted in Tighe & Bond's *LSWTP High Service Pumps Preliminary Engineering Report*, dated July 2023 (Appendix F), to ensure the new pumps will allow the pumping system to reliably maintain the plant's firm capacity with the largest pump out of service. The alternatives have been summarized below and include a no-action approach, refurbishing the pumps and motors, replacing the pumps with two 8 MGD pumps and one 4 MGD pump, and replacing the pumps with three 6 MGD pumps.

Alternative 1 – No Action: This alternative proposes taking no action and keeping the existing high service pumping equipment as-is. The existing equipment associated with the high service pumps has exceeded its recommended service life, posing an increased risk of failure including the inability to provide water to the distribution system. Aging equipment is susceptible to breakdowns requiring numerous repairs and finding replacement parts can be difficult. The pumps are more than 50 years old, operate inefficiently, and cannot be expected to reliably serve and provide the required firm capacity into the future.

Alternative 2 – Refurbish Pumps and Motors: This alternative proposes rebuilding the existing high service pumps and motors. The high service pumps were refurbished at least more than 15 years ago. Rebuilding the pumps will improve their operation, but not fully restore their capacity and efficiency to original condition. The existing motors are less energy efficient than currently available motor technologies. Additionally, these pumps do not currently run on VFDs. A pumping facility process energy evaluation report, conducted by JK Muir, LLC in May 2017, also confirmed that current pumps and motors have poor efficiency making this not a desirable alternative.

Alternative 3 – Replace Pumps and Motors with Pumps, Motors, and VFDs of Similar Capacity (two 8 MGD pumps and one 4 MGD pump): This alternative proposes replacing the existing two 8 MGD and one 4 MGD high service pumps and motors with similarly sized new high service pumps and motors, with the addition of VFDs. Replacing the high service pumps and motors will provide better operating energy efficiency and more reliable operation of the LSWTP. In addition, providing VFDs will provide treatment plant staff with the ability to optimize pump operations to meet the distribution system demand in an energy-efficient manner to help further reduce operating costs. By providing two 8 MGD pumps and one 4 MGD pump, the 4 MGD pump could be utilized during low flow times in an effort to maintain tank level and an 8 MGD pump could be utilized to fill the tank overnight. This pump selection also maintains the LSWTP firm capacity of 12 MGD with one large pump out of service. In order to install the pumps and perform the associated work, the plant will be offline for a period of time. This outage will make it possible to complete upgrades that are not feasible when the plant is online.

Alternative 4 – Replace Pumps and Motors with Pumps, Motors, and VFDs of Equal Capacity (three 6 MGD pumps): Similar to Alternative 3, this alternative proposes replacing the existing two 8 MGD and one 4 MGD High Service Pumps and motors with new high service pumps and motors and adding VFDs. This alternative, however, proposes utilizing three equally sized 6 MGD pumps. This alternative will lower operating costs both from pump and motor replacement and by providing VFDs. By providing three 6 MGD pumps, plant staff may have additional operational flexibility by alternating the lead/lag operation of each pump for equal sustaining tank level and filling the tank. This pump selection also maintains the LSWTP firm capacity of 12 MGD with one pump out of service. The same upgrades to piping and valves as proposed in Alternative 3 would be performed.

Recommendation - The high service pump alternatives analysis concluded that Alternative 3 is most favorable due to lower operating and capital costs compared to Alternative 4. The alternate to replace the existing high service pumps with two 8 MGD pumps and one 4 MGD pump was selected for the following major reasons:

- The 4 MGD pump can run alone during the day and one 8 MGD pump can run alone at night to provide a cost savings, as there is a 10% reduction on electrical generation costs at night.
- Alternative 3 is a more cost-effective solution than Alternative 4 in terms of operating and capital expenses.

A Business Case Evaluation (BCE) was performed by RWA to compare and evaluate the alternatives above and is included in Appendix J. Because the two projects are interrelated, the analysis combined the LSWTP Electrical upgrades and the high service pump alternatives, and evaluated them together. To summarize the results, "Alternative 5" was determined to be most beneficial. "Alternative 5" is a combination of Alternative 3 of the electrical upgrades analysis and Alternative 3 from the high service pump analysis. Alternative 5, was found to have a higher life cycle cost – annuitized cost stream but it was most effective risk reduction and had the greatest overall cost benefit ratio.

The alternatives analysis concluded that Alternative No. 5 is most favorable in terms of benefit to cost ratio. The alternative was selected for the following reasons:

- Alternative 3, and therefore Alternative 5, reduces risk during construction by facilitating reuse of medium voltage wire and conduit, and does not require a new crossing under Amtrak property. This alternative is consistent with RWAs other treatment plants.

- High Service Pumps are original to the facility and are inefficient. Replacing the pumps will improve the reliability of the pump, reduce energy consumption, provide operational flexibility. Replacing the High Service Pumps at the same time as the Electrical Upgrades will facilitate the appropriate long-term selection of the pumps and will prevent rework.

3.4 Statement of the Cost to Be Incurred and/or Saved

3.4.1 Capital Cost

This project will result in an approximate capital expenditure of up to $10.17 million including a 10% contingency on the un-escalated estimated construction costs. The RWA has expended through February 2025 approximately $495,600 to conduct the preliminary engineering and design. A breakdown of the capital cost for this project is presented in Table 2 below and a detailed breakdown of this cost estimate is contained in Appendix G of this application. The project costs presented are based on a 90% design level of completion prepared in October 2024. In accordance with cost estimating principles, the project costs have been adjusted for inflation.

TABLE 2

Estimated Project Capital Cost for LSWTP Electrical Improvements and High Service Pump Improvements – Including Escalation and Construction Phase Engineering

Cost Description	Estimated Cost
Previous Expenditures (from 2019 through February 2025)	$495,600
Remaining Design Cost	$25,000
Estimated Construction Cost	$6,886,000
Escalation to Mid-point of Construction: 5.0% per year	$706,000
Construction total with Inflation	$7,592,000
Consultant cost During Construction	$912,000
RWA Costs during Construction	$460,000
Engineering and Construction Oversight Sub-total	$1,372,000
Construction Sub-total (w/o final design)	$8,964,000
Total	**$9,484,600**
Rounded Total	**$9,480,000**
Minimum Anticipated Project Cost (-10%)	$8,588,000*
Maximum Anticipated Project Cost (+15%)	$10,829,000*
Requested Budget (+10%)	$10,173,000*

***** Project costs ranges include (-10%) to (+15%) American Association of Cost Engineers (AACE) accuracy factors, on the Estimated Construction Cost only.

The project costs presented are based on a 90% design level prepared in October 2024. In accordance with cost estimating principles, the project costs have been adjusted for inflation. An inflation factor of 5.0% per year has been used in the cost estimate. This factor was calculated by Tighe & Bond from the ENR Construction Cost Index from October 2024.

For the requested budget, a 10% contingency on the Estimated Construction Cost is shown in Table 2. This is within the range recommended by the American Association of Cost Engineers (AACE) International Recommended Practices and Standards for a Class 1 estimate, which is included in Appendix H. In a Class 1 estimate, the design of the project is expected to be between 65% to 100% complete and accurate within -10% to +15%. The AACE defines contingency as a specific provision for unforeseeable elements of cost within the defined project scope, particularly where experience has shown that unforeseeable costs are likely to occur. The 10% contingency allowance is included at this design stage for uncertainty in future bid prices, and as a means to reduce the risk of possible cost overruns.

3.4.2 Operation and Maintenance Cost

Implementation of new equipment will reduce RWAs operation and maintenance costs. The electrical distribution equipment is not a significant user of electricity, however new distribution equipment can result in an improved efficiency of energy up to 1%. Additionally, it is anticipated that the RWA Operations team will experience fewer emergency calls to address malfunctioning equipment. The reliability will be greatly improved, but the project will not add more equipment or new processes, therefore it will not add new maintenance burdens for Operations staff. The existing equipment is older and LSWTP currently utilizes an atypical voltage, which makes obtaining new replacement parts difficult. Newer equipment and the breaker configuration would have more available and less expensive replacement parts.

Implementation of the new high service pumps and associated VFDs will result in a significant cost savings to the LSWTP operations. Pumping at LSWTP accounts for 65% of the treatment plant's total electric cost, with approximately 45% attributed to the high service pumps. In 2017, JK Muir examined the combined pump and motor efficiency, which was determined to be 65%, 78%, and 80% for the 4 MGD and two 8 MGD pumps, respectively. Independent of other efforts, upgrading to more efficient pumps will result in an annual savings of approximately $22,000 ($28,000 in 2024 dollars). These high service pumps currently operate in an on or off mode, with no mechanism for flow modulation. This requires treatment and plant flow to double to 8 MGD, once the demand has exceeded the capacity of the 4 MGD pump. By utilizing VFDs, operators will have the flexibility to adjust water production to rates that more closely reflect demands, as well as filling tanks during off-peak time periods when electric rates are lower.

Based on the change to existing equipment, the selected project is expected to reduce operation and maintenance costs, including energy costs, by an estimated $40,000 annually. Additionally, a one-time incentive from UI will be pursued.

4. Summary of Combined Project Costs

4.1 Cost Summary

The following table summarizes the combined opinion of probable construction costs for the Lake Gaillard Electrical Improvements and Lake Saltonstall Electrical Improvements and High Service Pumps.

TABLE 4
Summary of Combined Project Costs and Variability

Project	*AACE Cost Accuracy*	*Minimum Cost*	*Maximum Cost*	*Calculated Cost*	*Requested Approval*
Lake Gaillard WTP Electrical	-10% to 15%	$3,324,000	$4,141,000	$3,650,000	$3,906,000
Lake Saltonstall WTP Electrical and HSP	-10% to 15%	$8,588,000	$10,829,000	$9,480,000	$10,173,000
TOTAL		$11,912,000	$14,970,000	$13,130,000	$14,079,000

The requested approval amount is not-to-exceed $14 million and is calculated based on a 10% cost accuracy factor for the Estimated Construction Cost.

4.2 Bonds or Other Obligations the RWA Intends to Issue

The annual cost of this project to a typical residential customer using 5 ccf's a month, assuming a conservative financing assumption of RWA Bonds, would be approximately $3.78, based on the project cost of $14.0 million. For a residential customer using 8 ccf's a month, the annual cost of this project would be approximately $5.13.

However, we expect this project to be funded by a combination of funding sources. This project has the potential for funding under the Connecticut Department of Public Health's (CTDPH) Drinking Water State Revolving Fund (DWSRF), and appears in the CTDPH DWSRF Annual Intended Use Plan SFY 2024. The Lake Saltonstall Electrical Improvements component of this project is approved for $2 million in Congressional Directed Spending funds. By utilizing these funding sources, the total financing costs associated with this project will be reduced. Internally generated funds may also be used.

5. Preliminary Project Schedule and Permitting

5.1 Schedule

The anticipated project schedule is as follows:

1.	90% Design	October 2024
2.	RPB Review and Approval	April to July 2025
3.	Final Design	June 2025
4.	CT Department of Public Health Approval	September 2025
5.	Bidding/Award	October 2025 to February 2026
6.	Construction	April 2026 to April 2028

The RWA prefers to construct the LGWTP hydroelectric building improvements during winter months to avoid construction during high flow periods. Additionally, to protect the overall water supply provided by these two facilities, shutdown of both facilities at the same time is not permitted. Electrical equipment lead times and potential delays have also been considered.

5.2 Permitting

Permitting efforts for the construction of the electrical improvements at the LGWTP and LSWTP are as follows:

- The LSWTP and LGWTP are located on Class II lands. The proposed work prompts the requirement to apply for a CT Department of Public Health Water Company Owned Lands Permit, which is commonly referred to as a "Change of Use" permit due to construction of new facilities outside of existing structures.
- Federal funding through the Drinking Water State Revolving Fund (DWSRF) is being sought for this project and therefore requires a National Diversity Database Request (NDDB) for CT Department of Energy and Environmental Protection (CT DEEP) approval.
- Proposed exterior work at the LSWTP and LGWTP requires coordination with the local Planning and Zoning Commissions for site plan approvals by the Town of East Haven and the Town of North Branford, respectively.
- A Coastal Site Plan Application will be submitted to the East Haven Planning and Zoning Commission for the LSWTP.
- Proposed work at the LSWTP falls within the upland review line for East Haven and therefore requires approval by the Town of East Haven Inland Wetlands Commission for work in the upland review area of Lake Saltonstall.

- The electrical improvements at the LGWTP and LSWTP are necessary to upgrade aging electrical equipment and other equipment as necessary. For this reason, it is assumed that general permitting with the DPH is not necessary.

6. Statement of the Facts on Which the Board Is Expected to Rely in Granting the Authorization Sought

- The LGWTP is the RWA's largest and most critical water asset. The LSWTP is an integral part of the RWA's water system. Replacement of electrical equipment should be given the highest priority at critical facilities such as these water treatment plants to reduce risk and provide reliable service to over 265,000 customers in RWA's service territory.
- Only proactive replacement of electrical equipment will provide assurance of long-term reliability for RWA to provide water to its customers.
- The LSWTP's existing 2400V main switchgear is a critical component of the WTP as it provides power to the facility's motor control centers, yet it is over 45 years old and must be replaced. It poses an increased risk of failure that could result in facility shutdowns, service interruption to customers and safety hazards to treatment plant staff.
- The 2400V switchgear at LSWTP violates National Electrical Code workspace requirements due to a lack of sufficient space in front of the equipment and is therefore a safety hazard.
- With the replacement of the switchgear at the LSWTP, UI will discontinue supporting the existing utility service, thus requiring a new service. This new electric service will eliminate the need for the main service to cross the Amtrak ROW.
- 2400V transformers, similar to those at the LSWTP are no longer standard and must be replaced with more common voltage equipment to allow for proper operation and maintenance.
- The LSWTP high service pumps are more than 50 years old and no longer operate efficiently or cost effectively.
- The LGWTP's MCC-1, MCC-2, MCC-3, Filter Plant Main Switchboard, T-5 transformer, main circuit breakers, ATS, and hydro-generator equipment are either nearing or have exceeded their recommended service life. This equipment is at an increased risk of causing significant damage to the surrounding equipment and a safety risk to treatment plant employees, and have the potential to result in prolonged facility shutdowns.
- Installing power distribution panelboards and stand-alone motor starts at the LGWTP in lieu of a new MCC-1 and 3 will reduce cost, space needed for equipment, and will allow for more flexibility during construction.
- Aging electrical equipment is susceptible to breakdowns requiring numerous repairs, and replacement parts can be difficult to find, have long lead times, and cannot be easily refurbished since many parts are obsolete.

7. Explanation of Unusual Circumstances Involved in the Application

There were no unusual circumstances involved in this application.

8. Conclusion

The Lake Saltonstall Water Treatment Plant serves approximately 50,000 customers in the Saltonstall service area. The Lake Gaillard Water Treatment Plant serves more than 265,000 customers and provides approximately 60% of the average flow that the RWA transports daily, making it the largest water treatment plant. The proposed electrical improvements outlined in this application will optimize constructability sequencing, future maintenance, improve safety, and will improve the reliability of both water treatment plants.

At $14 million, the selected project maximizes the organization's cost and non-cost benefits. As such, the RWA has concluded that the proposed action is consistent with and advances the policies and goals of the South Central Connecticut Regional Water Authority.

Appendix G

Engineer's Opinion of Probable Cost for the Electrical Improvements at the Lake Gaillard WTP and Lake Saltonstall WTP

Electrical Improvements at the Lake Gaillard Water Treatment Plant and Lake Saltonstall Water Treatment Plant
Lake Gaillard WTP

90% Design Opinion of Probable Construction Cost

South Central Connecticut Regional Water Authority

October 2024 (ENR 13632.23)

ITEM	DESCRIPTION	UNITS	QTY	UNIT PRICE	SUB TOTAL	INSTALLATION	TOTAL
1.	**Demolition**						**$211,126**
	Electrical Demolition	LS	1	$122,426	$122,426	N/A	$122,426
	Concrete Equipment Pads	LS	1	$8,700	$8,700	N/A	$8,700
	Temporary Power	LS	1	$80,000	$80,000	N/A	$80,000
2.	**Architectural / Structural**						**$24,375**
	General Site Work and Restoration	LS	1	$1,500	$1,500	N/A	$1,500
	Concrete Equipment Pads	CY	12	$850	$10,200	N/A	$10,200
	Touch-Up Painting	LS	1	$1,200	$1,200	N/A	$1,200
	Vinyl Flooring Replacement	SF	200	$13	$2,550	N/A	$2,550
	Guardrail above new T-5 transformer	LF	35	$255	$8,925	N/A	$8,925
3.	**Electrical**						**$1,887,930**
	T-5 Transformer	LS	1	$192,378	$192,378	N/A	$192,378
	Filter Plant Main Switchgear and ATS	LS	1	$543,443	$543,443	N/A	$543,443
	Power Wiring and Conduit	LS	1	$72,573	$72,573	N/A	$72,573
	MCC-1 Replacement with Panelboards and Starters	LS	1	$133,306	$133,306	N/A	$133,306
	MCC-2 Replacement with Panelboards and Starters	LS	1	$89,492	$89,492	N/A	$89,492
	MCC-3 Replacement with Panelboards and Starters	LS	1	$139,510	$139,510	N/A	$139,510
	MCC-5 Replacement with Panelboard	LS	1	$55,502	$55,502	N/A	$55,502
	Misc. Electrical Costs	LS	1	$108,426	$108,426	N/A	$108,426
	Hydroelectric Generator Control Panel & Protective Relaying	LS	1	$198,000	$198,000	N/A	$198,000
	Hydroelectric Generator Switchgear	LS	1	$251,900	$251,900	N/A	$251,900
	Hydroelectric Generator Distribution Panels Replace & Refeed	LS	1	$71,500	$71,500	N/A	$71,500
	Hydroelectric Generator Batteries & Charger	LS	1	$20,900	$20,900	N/A	$20,900
	Hydroelectric Generator Combination Motor Starters	LS	1	$11,000	$11,000	N/A	$11,000
					SUBTOTAL		**$2,123,000**
4.	**General Conditions and Overhead and Profit - 20%**						**$425,000**
					SUBTOTAL		**$2,548,000**
5.	**Escalation to Mid Point of Construction (Anticipated March 2026)** **2 Years at 5% per Year (Assumed Notice to Proceed Issued March 1, 2025)**						**$2,810,000**
					CONSTRUCTION TOTAL		**$2,810,000**
					PROJECT TOTAL		**$2,810,000**
					SAY		**$2,800,000**

DISCLAIMER: This is an engineer's Opinion of Probable Construction Cost (OPCC). Tighe & Bond has no control over the cost or availability of labor, equipment or materials, or over market conditions or the Contractor's method of pricing, and that the estimates of probable construction costs are made on the basis of Tighe & Bond's professional judgment and experience. Tighe & Bond makes no guarantee nor warranty, expressed or implied, that the bids or the negotiated cost of the Work will not vary from this estimate of the Probable Construction Cost.

Electrical Improvements at the Lake Gaillard Water Treatment Plant and Lake Saltonstall Water Treatment Plant
Lake Saltonstall WTP

90% Design Opinion of Probable Construction Cost

South Central Connecticut Regional Water Authority

October 2024 (ENR 13632.23)

ITEM	DESCRIPTION	UNITS	QTY	UNIT PRICE	SUB TOTAL	INSTALLATION	TOTAL
1.	**Demolition/HBMA**						**$202,150**
	Hazardous Building Materials Abatement	LS	1	$13,200	$13,200	N/A	$13,200
	Electrical Demolition	LS	1	$124,950	$124,950	N/A	$124,950
	High Service Pump, Piping, & Valve Demolition	EA	3	$9,000	$27,000	N/A	$27,000
	Surge Relief Valve & Piping Demolition	EA	1	$3,000	$3,000	N/A	$3,000
	Concrete Equipment Pads	LS	1	$17,000	$17,000	N/A	$17,000
	Temporary Power (2 generators, etc.)	LS	2	$8,500	$17,000	N/A	$17,000
2.	**Architectural / Structural**						**$ 645,050**
	General Site Work and Restoration	LS	2	$15,000	$30,000	N/A	$30,000
	Concrete Equipment Pads (including pipe supports)	CY	59	$1,200	$70,800	N/A	$70,800
	Miscellaneous Repairs (Wall, Floor, etc.)	SF	75	$150	$11,250	N/A	$11,250
	Concrete Retaining Walls and Associated Site Preparation	CY	171	$3,000	$513,000	N/A	$513,000
	Water Main Relocation (for Retaining Wall)	LS	1	$20,000	$20,000	N/A	$20,000
3.	**Electrical**						**$ 3,280,848**
	Primary 13.8kv Service Conductors, Equipment, and Duct Bank	LS	1	$243,589	$243,589	N/A	$243,589
	13.8kV to 4.16kV Transformer (2500KVA)	LS	1	$130,672	$130,672	N/A	$130,672
	4.16kV Duct Banks	LS	1	$139,629	$139,629	N/A	$139,629
	Outdoor Switchgear	LS	1	$1,711,866	$1,711,866	N/A	$1,711,866
	4.16kV to 480V Transformer (MCC-1A/MCC-1B, incl. conduit/wire)	LS	1	$258,440	$258,440	N/A	$258,440
	4.16kV to 480V Transformer (RLB, incl. conduit/wire)	LS	1	$55,406	$55,406	N/A	$55,406
	4.16kV to 480V Transformer (Raw Water PS, incl. conduit/wire)	LS	1	$37,566	$37,566	N/A	$37,566
	Generator Modifications	LS	1	$11,337	$11,337	N/A	$11,337
	Main Switchboard	LS	1	$153,696	$153,696	N/A	$153,696
	High Service Pumps VFDs	LS	1	$318,148	$318,148	N/A	$318,148
	Misc Electrical	LS	1	$26,010	$26,010	N/A	$26,010
	RLB MCC Replacement	LS	1	$91,290	$91,290	N/A	$91,290
	Pump control valve and surge relief valve controls	EA	4	$4,000	$16,000	N/A	$16,000
	Electric Utility Allowance (United Illuminating)	LS	1	$87,200	$87,200	N/A	$87,200
4.	**Mechanical**						**$ 1,366,922**
	High Service Pump and Motor Replacement (two 8 MGD and one 4 MGD pump)	LS	1	$505,300	$505,300	$252,650	$757,950
	High Service Pump Piping Connections:	EA	3	$15,000	$45,000	N/A	$45,000
	16" Pump Control Valves	EA	3	$86,066	$258,198	$103,279	$361,477
	16" Butterfly Isolation Valves	EA	3	$20,000	$60,000	$24,000	$84,000
	3" Air/Vacuum Valve	EA	3	$5,000	$15,000	$6,000	$21,000
	12" Surge Relief Valve	EA	1	$49,639	$49,639	$19,856	$69,495
	12" Butterfly Isolation Valve	EA	1	$10,000	$10,000	$4,000	$14,000
	Surge Relief Valve Piping Connection	EA	1	$10,000	$10,000	$4,000	$14,000
5.	**Site Work**						**$243,410**
	12" DIP Water Service	LF	150	$400	$60,000	N/A	$60,000
	12" Wet Tap	EA	1	$10,000	$10,000	N/A	$10,000
	12" Gate Valve	EA	1	$6,000	$6,000	N/A	$6,000
	Testing and Chlorination	LS	1	$5,000	$5,000	N/A	$5,000
	Yard Drain	EA	2	$4,000	$8,000	N/A	$8,000
	48" Diameter Manhole	EA	1	$5,000	$5,000	N/A	$5,000
	Reset Catch Basin	EA	1	$1,200	$1,200	N/A	$1,200
	8" PVC Storm Sewer	LF	95	$130	$12,350	N/A	$12,350
	12" PVC Storm Sewer	LF	35	$150	$5,250	N/A	$5,250
	Formation of Subgrade	SY	650	$3	$1,950	N/A	$1,950
	Processed Aggregate Base	CY	150	$50	$7,500	N/A	$7,500
	Remove Existing Driveway	SY	400	$13	$5,200	N/A	$5,200
	HMA S0.5	Ton	150	$200	$30,000	N/A	$30,000
	Gravel Driveway	CY	100	$85	$8,500	N/A	$8,500
	Sawcut Bituminous Concrete Pavement	LF	40	$4	$160	N/A	$160
	Stone Lined Swale	LF	175	$100	$17,500	N/A	$17,500
	Steel Bollard	EA	7	$1,000	$7,000	N/A	$7,000
	Silt Fence	LF	1200	$7	$8,400	N/A	$8,400
	Construction Entrance	SY	65	$40	$2,600	N/A	$2,600
	Erosion Control Blanket	SY	400	$7	$2,800	N/A	$2,800
	Silt Sack	EA	2	$500	$1,000	N/A	$1,000
	Haybale Inlet Protection	EA	5	$500	$2,500	N/A	$2,500
	Straw Wattle	LF	200	$10	$2,000	N/A	$2,000
	Haybale Check Dam	EA	5	$700	$3,500	N/A	$3,500
	Clearing and Grubbing	LS	1	$11,000	$11,000	N/A	$11,000
	Mobilization and Closeout	LS	1	$14,000	$14,000	N/A	$14,000
	Construction Staking and Surveying	LS	1	$5,000	$5,000	N/A	$5,000
					SUBTOTAL		**$5,738,000**
6.	**General Conditions and Overhead and Profit - 20%**						**$1,148,000**
					SUBTOTAL		**$6,886,000**
7.	**Escalation to Mid Point of Construction (Anticipated March 2026) 2 Years at 5% per Year (Assumed Notice to Proceed Issued March 1, 2025)**						**$7,592,000**
					CONSTRUCTION TOTAL		**$7,592,000**
					PROJECT TOTAL		**$7,592,000**
					SAY		**$7,600,000**

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Appendix H

American Association of Cost Engineers (AACE) Cost Estimate Classification System – As Applied in Engineering, Procurement, and Construction for the Process Industries, August 2020

AACE INTERNATIONAL RECOMMENDED PRACTICE

18R-97

COST ESTIMATE CLASSIFICATION SYSTEM - AS APPLIED IN ENGINEERING, PROCUREMENT, AND CONSTRUCTION FOR THE PROCESS INDUSTRIES

AACE

INTERNATIONAL

INTERNATIONAL

AACE International Recommended Practice No. 18R-97

COST ESTIMATE CLASSIFICATION SYSTEM – AS APPLIED IN ENGINEERING, PROCUREMENT, AND CONSTRUCTION FOR THE PROCESS INDUSTRIES

TCM Framework: 7.3 – Cost Estimating and Budgeting

Rev. August 7, 2020

Note: As AACE International Recommended Practices evolve over time, please refer to web.aacei.org for the latest revisions.

Any terms found in AACE Recommended Practice 10S-90, *Cost Engineering Terminology*, supersede terms defined in other AACE work products, including but not limited to, other recommended practices, the *Total Cost Management Framework*, and *Skills & Knowledge of Cost Engineering*.

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AACE® International Recommended Practice No. 18R-97

COST ESTIMATE CLASSIFICATION SYSTEM – AS APPLIED IN ENGINEERING, PROCUREMENT, AND CONSTRUCTION FOR THE PROCESS INDUSTRIES

TCM Framework: 7.3 – Cost Estimating and Budgeting

August 7, 2020

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1. PURPOSE

As a recommended practice (RP) of AACE International, the *Cost Estimate Classification System* provides guidelines for applying the general principles of estimate classification to project cost estimates (i.e., cost estimates that are used to evaluate, approve, and/or fund projects). The *Cost Estimate Classification System* maps the phases and stages of project cost estimating together with a generic project scope definition maturity and quality matrix, which can be applied across a wide variety of industries and scope content.

This recommended practice provides guidelines for applying the principles of estimate classification specifically to project estimates for engineering, procurement, and construction (EPC) work for the process industries. It supplements the generic cost estimate classification RP 17R-97[1] by providing:

- A section that further defines classification concepts as they apply to the process industries.
- A chart that maps the extent and maturity of estimate input information (project definition deliverables) against the class of estimate.

As with the generic RP, the intent of this document is to improve communications among all the stakeholders involved with preparing, evaluating, and using project cost estimates specifically for the process industries.

The overall purpose of this recommended practice is to provide the process industry with a project definition deliverable maturity matrix that is not provided in 17R-97. It also provides an approximate representation of the relationship of specific design input data and design deliverable maturity to the estimate accuracy and methodology used to produce the cost estimate. The estimate accuracy range is driven by many other variables and risks, so the maturity and quality of the scope definition available at the time of the estimate is not the sole determinate of accuracy; risk analysis is required for that purpose.

This document is intended to provide a guideline, not a standard. It is understood that each enterprise may have its own project and estimating processes, terminology, and may classify estimates in other ways. This guideline provides a generic and generally acceptable classification system for the process industries that can be used as a basis to compare against. This recommended practice should allow each user to better assess, define, and communicate their own processes and standards in the light of generally-accepted cost engineering practice.

2. INTRODUCTION

For the purposes of this document, the term *process industries* is assumed to include firms involved with the manufacturing and production of chemicals, petrochemicals, and hydrocarbon processing. The common thread among these industries (for the purpose of estimate classification) is their reliance on process flow diagrams (PFDs), piping and instrument diagrams (P&IDs), and electrical one-line drawings as primary scope defining documents. These documents are key deliverables in determining the degree of project definition, and thus the extent and maturity of estimate input information. This RP applies to a variety of project delivery methods such as traditional design-bid-build (DBB), design-build (DB), construction management for fee (CM-fee), construction management at risk (CM-at risk), and private-public partnerships (PPP) contracting methods.

Estimates for process facilities center on mechanical and chemical process equipment, and they have significant amounts of piping, instrumentation, and process controls involved. As such, this recommended practice may apply to portions of other industries, such as pharmaceutical, utility, water treatment, metallurgical, converting, and similar industries.

Most plants also have significant electrical power equipment (e.g., transformers, switchgear, etc.) associated with them. As such, this RP also applies to electrical substation projects, either associated with the process plant, as part of power transmission or distribution infrastructure, or supporting the power needs of other facilities. This RP excludes power generating facilities and high-voltage transmission.

This RP specifically does not address cost estimate classification in non-process industries such as commercial building construction, environmental remediation, transportation infrastructure, hydropower, "dry" processes such as assembly and manufacturing, "soft asset" production such as software development, and similar industries. It also does not specifically address estimates for the exploration, production, or transportation of mining or hydrocarbon materials, although it may apply to some of the intermediate processing steps in these systems.

The cost estimates covered by this RP are for engineering, procurement, and construction (EPC) work only. It does not cover estimates for the products manufactured by the process facilities, or for research and development work in support of the process industries. This guideline does not cover the significant building construction that may be a part of process plants.

This guideline reflects generally-accepted cost engineering practices. This recommended practice was based upon the practices of a wide range of companies in the process industries from around the world, as well as published references and standards. Company and public standards were solicited and reviewed, and the practices were found to have significant commonalities. [4,5,6,7] These classifications are also supported by empirical process industry research of systemic risks and their correlation with cost growth and schedule slip [8].

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3. COST ESTIMATE CLASSIFICATION MATRIX FOR THE PROCESS INDUSTRIES

A purpose of cost estimate classification is to align the estimating process with project stage-gate scope development and decision-making processes.

Table 1 provides a summary of the characteristics of the five estimate classes. The maturity level of project definition is the sole determining (i.e., primary) characteristic of class. In Table 1, the maturity is roughly indicated by a percentage of complete definition; however, it is the maturity of the defining deliverables that is the determinant, not the percent. The other characteristics are secondary and are generally correlated with the maturity level of project definition deliverables, as discussed in the generic RP [1]. The specific deliverables, and their maturity or status are provided in Table 3. The post sanction (post funding authorization) classes (Class 1 and 2) are only indirectly covered where new funding is indicated. Again, the characteristics are typical but may vary depending on the circumstances.

	Primary Characteristic	***Secondary Characteristic***		
ESTIMATE CLASS	**MATURITY LEVEL OF PROJECT DEFINITION DELIVERABLES** Expressed as % of complete definition	**END USAGE** Typical purpose of estimate	**METHODOLOGY** Typical estimating method	**EXPECTED ACCURACY RANGE** Typical variation in low and high ranges at an 80% confidence interval
Class 5	0% to 2%	Concept screening	Capacity factored, parametric models, judgment, or analogy	L: -20% to -50% H: +30% to +100%
Class 4	1% to 15%	Study or feasibility	Equipment factored or parametric models	L: -15% to -30% H: +20% to +50%
Class 3	10% to 40%	Budget authorization or control	Semi-detailed unit costs with assembly level line items	L: -10% to -20% H: +10% to +30%
Class 2	30% to 75%	Control or bid/tender	Detailed unit cost with forced detailed take-off	L: -5% to -15% H: +5% to +20%
Class 1	65% to 100%	Check estimate or bid/tender	Detailed unit cost with detailed take-off	L: -3% to -10% H: +3% to +15%

Table 1 – Cost Estimate Classification Matrix for Process Industries

This matrix and guideline outline an estimate classification system that is specific to the process industries. Refer to Recommended Practice 17R-97 [1] for a general matrix that is non-industry specific, or to other cost estimate classification RPs for guidelines that will provide more detailed information for application in other specific industries. These will provide additional information, particularly the *Estimate Input Checklist and Maturity Matrix* which determines the class in those industries. See Professional Guidance Document 01, *Guide to Cost Estimate Classification.* [16]

Table 1 illustrates typical ranges of accuracy ranges that are associated with the process industries. The +/- value represents typical percentage variation at an 80% confidence interval of actual costs from the cost estimate after application of appropriate contingency (typically to achieve a 50% probability of project cost overrun versus underrun) for given scope. Depending on the technical and project deliverables (and other variables) and risks associated with each estimate, the accuracy range for any particular estimate is expected to fall into the ranges identified. However, this does not preclude a specific actual project result from falling outside of the indicated range of ranges identified in Table 1. In fact, research indicates that for weak project systems and complex or otherwise risky projects, the high ranges may be two to three times the high range indicated in Table 1. [17]

In addition to the degree of project definition, estimate accuracy is also driven by other systemic risks such as:

- Level of familiarity with technology.
- Unique/remote nature of project locations and conditions and the availability of reference data for those.
- Complexity of the project and its execution.
- Quality of reference cost estimating data.
- Quality of assumptions used in preparing the estimate.
- Experience and skill level of the estimator.
- Estimating techniques employed.
- Time and level of effort budgeted to prepare the estimate.
- Market and pricing conditions.
- Currency exchange.
- The accuracy of the composition of the input and output process streams.

Systemic risks such as these are often the primary driver of accuracy, especially during the early stages of project definition. As project definition progresses, project-specific risks (e.g. risk events and conditions) become more prevalent and also drive the accuracy range. Another concern in estimates is potential organizational pressure for a predetermined value that may result in a biased estimate. The goal should be to have an unbiased and objective estimate both for the base cost and for contingency. The stated estimate ranges are dependent on this premise and a realistic view of the project. Failure to appropriately address systemic risks (e.g. technical complexity) during the risk analysis process, impacts the resulting probability distribution of the estimated costs, and therefore the interpretation of estimate accuracy.

Figure 1 illustrates the general relationship trend between estimate accuracy and the estimate classes (corresponding with the maturity level of project definition). Depending upon the technical complexity of the project, the availability of appropriate cost reference information, the degree of project definition, and the inclusion of appropriate contingency determination, a typical Class 5 estimate for a process industry project may have an accuracy range as broad as -50% to +100%, or as narrow as -20% to +30%. However, note that this is dependent upon the contingency included in the estimate appropriately quantifying the uncertainty and risks associated with the cost estimate. Refer to Table 1 for the accuracy ranges conceptually illustrated in Figure 1. [18]

Figure 1 also illustrates that the estimating accuracy ranges overlap the estimate classes. There are cases where a Class 5 estimate for a particular project may be as accurate as a Class 3 estimate for a different project. For example, similar accuracy ranges may occur if the Class 5 estimate of one project that is based on a repeat project with good cost history and data and, whereas the Class 3 estimate for another is for a project involving new technology. It is for this reason that Table 1 provides ranges of accuracy values. This allows consideration of the specific circumstances inherent in a project and an industry sector to provide realistic estimate class accuracy range percentages. While a target range may be expected for a particular estimate, the accuracy range should always be determined through risk analysis of the specific project and should never be pre-determined. AACE has recommended practices that address contingency determination and risk analysis methods. [19]

If contingency has been addressed appropriately approximately 80% of projects should fall within the ranges shown in Figure 1. However, this does not preclude a specific actual project result from falling inside or outside of the indicated range of ranges identified in Table 1. As previously mentioned, research indicates that for weak project systems, and/or complex or otherwise risky projects, the high ranges may be two to three times the high range indicated in Table 1.

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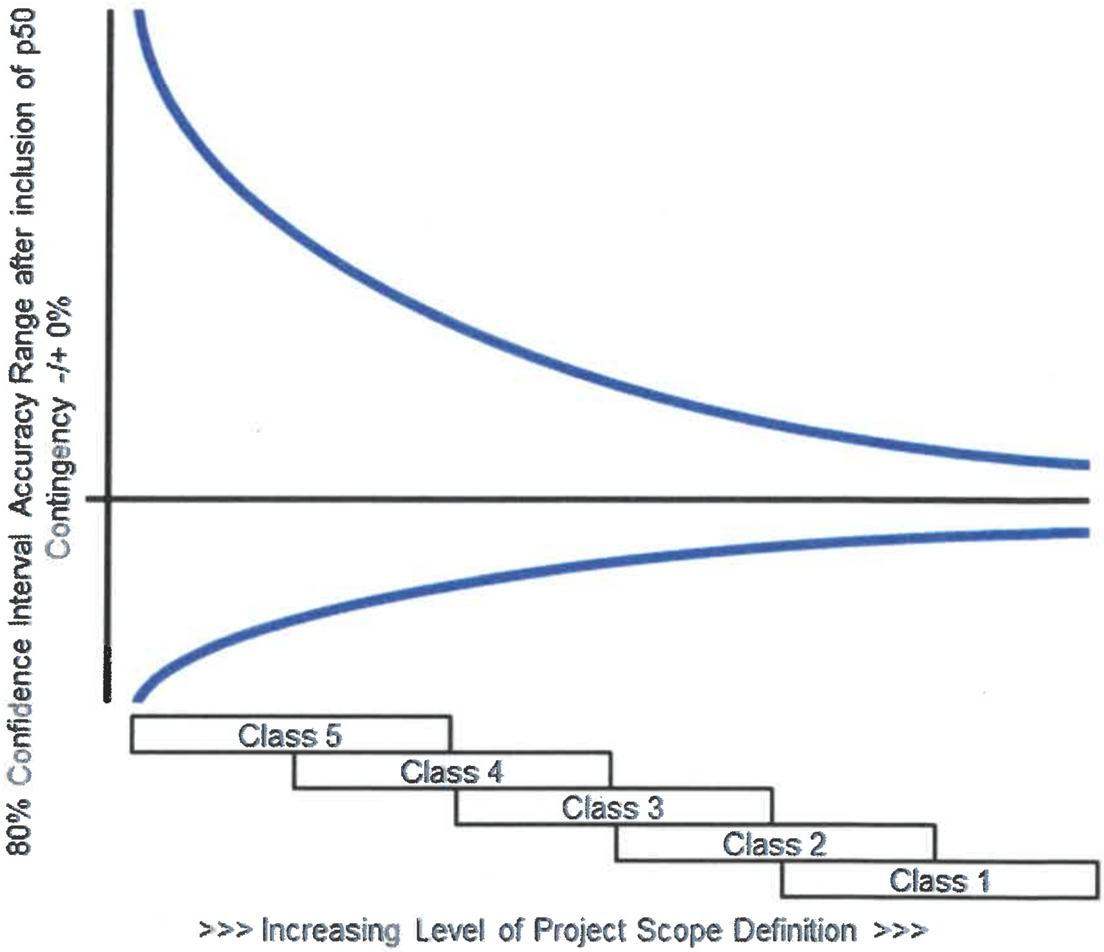

Figure 1 – Illustration of the Variability in Accuracy Ranges for Process Industry Estimates

4. DETERMINATION OF THE COST ESTIMATE CLASS

For a given project, the determination of the estimate class is based upon the maturity level of project definition based on the status of specific key planning and design deliverables. The percent design completion may be correlated with the status, but the percentage should not be used as the class determinate. While the determination of the status (and hence the estimate class) is somewhat subjective, having standards for the design input data, completeness and quality of the design deliverables will serve to make the determination more objective.

5. CHARACTERISTICS OF THE ESTIMATE CLASSES

The following tables (2a through 2e) provide detailed descriptions of the five estimate classifications as applied in the process industries. They are presented in the order of least-defined estimates to the most-defined estimates. These descriptions include brief discussions of each of the estimate characteristics that define an estimate class.

For each table, the following information is provided:

- **Description:** A short description of the class of estimate, including a brief listing of the expected estimate inputs based on the maturity level of project definition deliverables.

- **Maturity Level of Project Definition Deliverables (Primary Characteristic):** Describes a particularly key deliverable and a typical target status in stage-gate decision processes, plus an indication of approximate percent of full definition of project and technical deliverables. Typically, but not always, maturity level correlates with the percent of engineering and design complete.

- **End Usage (Secondary Characteristic):** A short discussion of the possible end usage of this class of estimate.

- **Estimating Methodology (Secondary Characteristic):** A listing of the possible estimating methods that may be employed to develop an estimate of this class.

- **Expected Accuracy Range (Secondary Characteristic):** Typical variation in low and high ranges after the application of contingency (determined at a 50% level of confidence). Typically, this represents about 80% confidence that the actual cost will fall within the bounds of the low and high ranges if contingency appropriately forecasts uncertainty and risks.

- **Alternate Estimate Names, Terms, Expressions, Synonyms:** This section provides other commonly used names that an estimate of this class might be known by. These alternate names are not endorsed by this recommended practice. The user is cautioned that an alternative name may not always be correlated with the class of estimate as identified in Tables 2a-2e.

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CLASS 5 ESTIMATE	
Description: Class 5 estimates are generally prepared based on very limited information, and subsequently have wide accuracy ranges. As such, some companies and organizations have elected to determine that due to the inherent inaccuracies, such estimates cannot be classified in a conventional and systematic manner. Class 5 estimates, due to the requirements of end use, may be prepared within a very limited amount of time and with little effort expended—sometimes requiring less than an hour to prepare. Often, little more than proposed plant type, location, and capacity are known at the time of estimate preparation. **Maturity Level of Project Definition Deliverables:** Key deliverable and target status: Block flow diagram agreed by key stakeholders. List of key design basis assumptions. 0% to 2% of full project definition. **End Usage:** Class 5 estimates are prepared for any number of strategic business planning purposes, such as but not limited to market studies, assessment of initial viability, evaluation of alternate schemes, project screening, project location studies, evaluation of resource needs and budgeting, long-range capital planning, etc.	**Estimating Methodology:** Class 5 estimates generally use stochastic estimating methods such as cost/capacity curves and factors, scale of operations factors, Lang factors, Hand factors, Chilton factors, Peters-Timmerhaus factors, Guthrie factors, and other parametric and modeling techniques. **Expected Accuracy Range:** Typical accuracy ranges for Class 5 estimates are -20% to -50% on the low side, and +30% to +100% on the high side, depending on the technological complexity of the project, appropriate reference information and other risks (after inclusion of an appropriate contingency determination). Ranges could exceed those shown if there are unusual risks. **Alternate Estimate Names, Terms, Expressions, Synonyms:** Ratio, ballpark, blue sky, seat-of-pants, ROM, idea study, prospect estimate, concession license estimate, guesstimate, rule-of-thumb.

Table 2a – Class 5 Estimate

CLASS 4 ESTIMATE	
Description: Class 4 estimates are generally prepared based on limited information and subsequently have fairly wide accuracy ranges. They are typically used for project screening, determination of feasibility, concept evaluation, and preliminary budget approval. Typically, engineering is from 1% to 15% complete, and would comprise at a minimum the following: plant capacity, block schematics, indicated layout, process flow diagrams (PFDs) for main process systems, and preliminary engineered process and utility equipment lists. **Maturity Level of Project Definition Deliverables:** Key deliverable and target status: Process flow diagrams (PFDs) issued for design. 1% to 15% of full project definition. **End Usage:** Class 4 estimates are prepared for a number of purposes, such as but not limited to, detailed strategic planning, business development, project screening at more developed stages, alternative scheme analysis, confirmation of economic and/or technical feasibility, and preliminary budget approval or approval to proceed to next stage.	**Estimating Methodology:** Class 4 estimates generally use factored estimating methods such as equipment factors, Lang factors, Hand factors, Chilton factors, Peters-Timmerhaus factors, Guthrie factors, the Miller method, gross unit costs/ratios, and other parametric and modeling techniques. **Expected Accuracy Range:** Typical accuracy ranges for Class 4 estimates are -15% to -30% on the low side, and +20% to +50% on the high side, depending on the technological complexity of the project, appropriate reference information, and other risks (after inclusion of an appropriate contingency determination). Ranges could exceed those shown if there are unusual risks. **Alternate Estimate Names, Terms, Expressions, Synonyms:** Screening, top-down, feasibility (pre-feasibility for metals processes), authorization, factored, pre-design, pre-study.

Table 2b – Class 4 Estimate

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CLASS 3 ESTIMATE	
Description: Class 3 estimates are generally prepared to form the basis for budget authorization, appropriation, and/or funding. As such, they typically form the initial control estimate against which all actual costs and resources will be monitored. Typically, engineering is from 10% to 40% complete, and would comprise at a minimum the following: process flow diagrams, utility flow diagrams, preliminary piping and instrument diagrams, plot plan, developed layout drawings, and essentially complete engineered process and utility equipment lists. Remedial action plan resulting from HAZOPs is identified. **Maturity Level of Project Definition Deliverables:** Key deliverable and target status: Piping and instrumentation diagrams (P&IDs) issued for design. 10% to 40% of full project definition. **End Usage:** Class 3 estimates are typically prepared to support full project funding requests, and become the first of the project phase control estimates against which all actual costs and resources will be monitored for variations to the budget. They are used as the project budget until replaced by more detailed estimates. In many owner organizations, a Class 3 estimate is often the last estimate required and could very well form the only basis for cost/schedule control.	**Estimating Methodology:** Class 3 estimates generally involve more deterministic estimating methods than conceptual methods. They usually involve predominant use of unit cost line items, although these may be at an assembly level of detail rather than individual components. Factoring methods may be used to estimate less-significant areas of the project. **Expected Accuracy Range:** Typical accuracy ranges for Class 3 estimates are -10% to -20% on the low side, and +10% to +30% on the high side, depending on the technological complexity of the project, appropriate reference information, and other risks (after inclusion of an appropriate contingency determination). Ranges could exceed those shown if there are unusual risks. **Alternate Estimate Names, Terms, Expressions, Synonyms:** Budget, scope, sanction, semi-detailed, authorization, preliminary control, concept study, feasibility (for metals processes) development, basic engineering phase estimate, target estimate.

Table 2c – Class 3 Estimate

CLASS 2 ESTIMATE	
Description: Class 2 estimates are generally prepared to form a detailed contractor control baseline (and update the owner control baseline) against which all project work is monitored in terms of cost and progress control. For contractors, this class of estimate is often used as the bid estimate to establish contract value. Typically, engineering is from 30% to 75% complete, and would comprise at a minimum the following: process flow diagrams, utility flow diagrams, piping and instrument diagrams, heat and material balances, final plot plan, final layout drawings, complete engineered process and utility equipment lists, single line diagrams for electrical, electrical equipment and motor schedules, vendor quotations, detailed project execution plans, resourcing and work force plans, etc. **Maturity Level of Project Definition Deliverables:** Key deliverable and target status: All specifications and datasheets complete including for instrumentation. 30% to 75% of full project definition. **End Usage:** Class 2 estimates are typically prepared as the detailed contractor control baseline (and update to the owner control baseline) against which all actual costs and resources will now be monitored for variations to the budget, and form a part of the change management program. Some organizations may choose to make funding decisions based on a Class 2 estimate.	**Estimating Methodology:** Class 2 estimates generally involve a high degree of deterministic estimating methods. Class 2 estimates are prepared in great detail, and often involve tens of thousands of unit cost line items. For those areas of the project still undefined, an assumed level of detail takeoff (forced detail) may be developed to use as line items in the estimate instead of relying on factoring methods. **Expected Accuracy Range:** Typical accuracy ranges for Class 2 estimates are -5% to -15% on the low side, and +5% to +20% on the high side, depending on the technological complexity of the project, appropriate reference information, and other risks (after inclusion of an appropriate contingency determination). Ranges could exceed those shown if there are unusual risks. **Alternate Estimate Names, Terms, Expressions, Synonyms:** Detailed control, forced detail, execution phase, master control, engineering, bid, tender, change order estimate.

Table 2d – Class 2 Estimate

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CLASS 1 ESTIMATE	
Description: Class 1 estimates are generally prepared for discrete parts or sections of the total project rather than generating this level of detail for the entire project. The parts of the project estimated at this level of detail will typically be used by subcontractors for bids, or by owners for check estimates. The updated estimate is often referred to as the current control estimate and becomes the new baseline for cost/schedule control of the project. Class 1 estimates may be prepared for parts of the project to comprise a fair price estimate or bid check estimate to compare against a contractor's bid estimate, or to evaluate/dispute claims. Typically, overall engineering is from 65% to 100% complete (some parts or packages may be complete and others not), and would comprise virtually all engineering and design documentation of the project, and complete project execution and commissioning plans. **Maturity Level of Project Definition Deliverables:** Key deliverable and target status: All deliverables in the maturity matrix complete. 65% to 100% of full project definition. **End Usage:** Generally, owners and EPC contractors use Class 1 estimates to support their change management process. They may be used to evaluate bid checking, to support vendor/contractor negotiations, or for claim evaluations and dispute resolution. Construction contractors may prepare Class 1 estimates to support their bidding and to act as their final control baseline against which all actual costs and resources will now be monitored for variations to their bid. During construction, Class 1 estimates may be prepared to support change management.	**Estimating Methodology:** Class 1 estimates generally involve the highest degree of deterministic estimating methods, and require a great amount of effort. Class 1 estimates are prepared in great detail, and thus are usually performed on only the most important or critical areas of the project. All items in the estimate are usually unit cost line items based on actual design quantities. **Expected Accuracy Range:** Typical accuracy ranges for Class 1 estimates are -3% to -10% on the low side, and +3% to +15% on the high side, depending on the technological complexity of the project, appropriate reference information, and other risks (after inclusion of an appropriate contingency determination). Ranges could exceed those shown if there are unusual risks. **Alternate Estimate Names, Terms, Expressions, Synonyms:** Full detail, release, fall-out, tender, firm price, bottoms-up, final, detailed control, forced detail, execution phase, master control, fair price, definitive, change order estimate.

Table 2e – Class 1 Estimate

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6. ESTIMATE INPUT CHECKLIST AND MATURITY MATRIX

Table 3 maps the extent and maturity of estimate input information (deliverables) against the five estimate classification levels. This is a checklist of basic deliverables found in common practice in the process industries. The maturity level is an approximation of the completion status of the deliverable. The completion is indicated by the following descriptors:

General Project Data:

- **Not Required (NR):** May not be required for all estimates of the specified class, but specific project estimates may require at least preliminary development.
- **Preliminary (P):** Project definition has begun and progressed to at least an intermediate level of completion. Review and approvals for its current status has occurred.
- **Defined (D):** Project definition is advanced, and reviews have been conducted. Development may be near completion with the exception of final approvals.

Technical Deliverables:

- **Not Required (NR):** Deliverable may not be required for all estimates of the specified class, but specific project estimates may require at least preliminary development.
- **Started (S):** Work on the deliverable has begun. Development is typically limited to sketches, rough outlines, or similar levels of early completion.
- **Preliminary (P):** Work on the deliverable is advanced. Interim, cross-functional reviews have usually been conducted. Development may be near completion except for final reviews and approvals.
- **Complete (C):** The deliverable has been reviewed and approved as appropriate.

MATURITY LEVEL OF PROJECT DEFINITION DELIVERABLES	ESTIMATE CLASSIFICATION				
	CLASS 5	CLASS 4	CLASS 3	CLASS 2	CLASS 1
	0% to 2%	1% to 15%	10% to 40%	30% to 75%	65% to 100%
GENERAL PROJECT DATA:					
A. SCOPE:					
Non-Process Facilities (Infrastructure, Ports, Pipeline, Power Transmission, etc.)	P	P	D	D	D
Project Scope of Work Description	P	P	D	D	D
Byproduct and Waste Disposal	NR	P	D	D	D
Site Infrastructure (Access, Construction Power, Camp etc.)	NR	P	D	D	D
B. CAPACITY:					
Plant Production / Facility (includes power facilities)	P	P	D	D	D
Electrical Power Requirements (when not the primary capacity driver)	NR	P	D	D	D

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MATURITY LEVEL OF PROJECT DEFINITION DELIVERABLES	ESTIMATE CLASSIFICATION				
	CLASS 5	CLASS 4	CLASS 3	CLASS 2	CLASS 1
	0% to 2%	1% to 15%	10% to 40%	30% to 75%	65% to 100%
C. PROJECT LOCATION:					
Plant and Associated Facilities	P	P	D	D	D
D. REQUIREMENTS:					
Codes and/or Standards	NR	P	D	D	D
Communication Systems	NR	P	D	D	D
Fire Protection and Life Safety	NR	P	D	D	D
Environmental Monitoring	NR	NR	P	P	D
E. TECHNOLOGY SELECTION:					
Process Technology	P	P	D	D	D
F. STRATEGY:					
Contracting / Sourcing	NR	P	D	D	D
Escalation	NR	P	D	D	D
G. PLANNING:					
Logistics Plan	P	P	P	D	D
Integrated Project Plan[1]	NR	P	D	D	D
Project Code of Accounts	NR	P	D	D	D
Project Master Schedule	NR	P	D	D	D
Regulatory Approval & Permitting	NR	P	D	D	D
Risk Register	NR	P	D	D	D
Stakeholder Consultation / Engagement / Management Plan	NR	P	D	D	D
Work Breakdown Structure	NR	P	D	D	D
Startup and Commissioning Plan	NR	P	P/D	D	D
H. STUDIES:					
Environmental Impact / Sustainability Assessment	NR	P	D	D	D
Environmental / Existing Conditions	NR	P	D	D	D
Soils and Hydrology	NR	P	D	D	D
TECHNICAL DELIVERABLES:					
Block Flow Diagrams	S/P	C	C	C	C
Equipment Datasheets	NR/S	P	C	C	C
Equipment Lists: Electrical	NR/S	P	C	C	C

[1] The integrated project plan (IPP), project execution plan (PEP), project management plan (PMP), or more broadly the project plan, is a high-level management guide to the means, methods and tools that will be used by the team to manage the project. The term integration emphasizes a project life cycle view (the term execution implying post-sanction) and the need for alignment. The IPP covers all functions (or phases) including engineering, procurement, contracting strategy, fabrication, construction, commissioning and startup within the scope of work. However, it also includes stakeholder management, safety, quality, project controls, risk, information, communication and other supporting functions. In respect to estimate classification, to be rated as *defined*, the IPP must cover all the relevant phases/functions in an integrated manner aligned with the project charter (i.e., objectives and strategies); anything less is *preliminary*. The overall IPP cannot be rated as *defined* unless all individual elements are defined and integrated.

MATURITY LEVEL OF PROJECT DEFINITION DELIVERABLES	ESTIMATE CLASSIFICATION				
	CLASS 5	CLASS 4	CLASS 3	CLASS 2	CLASS 1
	0% to 2%	1% to 15%	10% to 40%	30% to 75%	65% to 100%
Equipment Lists: Process / Utility / Mechanical	NR/S	P	C	C	C
Heat & Material Balances	NR	C	C	C	C
Process Flow Diagrams (PFDs)	NR	C	C	C	C
Utility Flow Diagrams (UFDs)	NR	C	C	C	C
Design Specifications	NR	S/P	C	C	C
Electrical One-Line Drawings	NR	S/P	C	C	C
General Equipment Arrangement Drawings	NR	S/P	C	C	C
Instrument List	NR	S/P	C	C	C
Piping & Instrument Diagrams (P&IDs)	NR	S/P	C	C	C
Plot Plans / Facility Layouts	NR	S/P	C	C	C
Construction Permits	NR	S/P	P/C	C	C
Civil / Site / Structural / Architectural Discipline Drawings	NR	S/P	P	C	C
Demolition Plan and Drawings	NR	S/P	P	C	C
Erosion Control Plan and Drawings	NR	S/P	P	C	C
Fire Protection and Life Safety Drawings and Details	NR	S/P	P	C	C
Electrical Schedules	NR	NR/S	P	P/C	C
Instrument and Control Schedules	NR	NR/S	P	P/C	C
Instrument Datasheets	NR	NR/S	P	P/C	C
Piping Schedules	NR	NR/S	P	P/C	C
Piping Discipline Drawings	NR	NR/S	S/P	C	C
Spare Parts Listings	NR	NR	P	P/C	C
Electrical Discipline Drawings	NR	NR	S/P	P/C	C
Facility Emergency Communication Plan and Drawings	NR	NR	S/P	P/C	C
Information Systems / Telecommunication Drawings	NR	NR	S/P	P/C	C
Instrumentation / Control System Discipline Drawings	NR	NR	S/P	P/C	C
Mechanical Discipline Drawings	NR	NR	S/P	P/C	C

Table 3 – Estimate Input Checklist and Maturity Matrix (Primary Classification Determinate)

7. BASIS OF ESTIMATE DOCUMENTATION

The basis of estimate (BOE) typically accompanies the cost estimate. The basis of estimate is a document that describes how an estimate is prepared and defines the information used in support of development. A basis document commonly includes, but is not limited to, a description of the scope included, methodologies used, references and defining deliverables used, assumptions and exclusions made, clarifications, adjustments, and some indication of the level of uncertainty.

The BOE is, in some ways, just as important as the estimate since it documents the scope and assumptions; and provides a level of confidence to the estimate. The estimate is incomplete without a well-documented basis of estimate. See AACE Recommended Practice 34R-05 *Basis of Estimate* for more information [12].

8. PROJECT DEFINITION RATING SYSTEM

An additional step in documenting the maturity level of project definition is to develop a project definition rating system. This is another tool for measuring the completeness of project scope definition. Such a system typically provides a checklist of scope definition elements and a scoring rubric to measure maturity or completeness for each element. A better project definition rating score is typically associated with a better probability of achieving project success.

Such a tool should be used in conjunction with the AACE estimate classification system; it does not replace estimate classification. A key difference is that a project definition rating measures overall maturity across a broad set of project definition elements, but it usually does not ensure completeness of the key project definition deliverables required to meet a specific class of estimate. For example, a good project definition rating may sometimes be achieved by progressing on additional project definition deliverables, but without achieving signoff or completion of a key deliverable.

AACE estimate classification is based on ensuring that key project deliverables have been completed or met the required level of maturity. If a key deliverable that is indicated as needing to be complete for Class 3 (as an example) has not actually been completed, then the estimate cannot be regarded as Class 3 regardless of the maturity or progress on other project definition elements.

An example of a project definition rating system is the *Project Definition Rating Index* developed by the Construction Industry Institute. It has developed several indices for specific industries, such as IR113-2 [13] for the process industry and IR115-2 [14] for the building industry. Similar systems have been developed by the US Department of Energy [15].

9. CLASSIFICATION FOR LONG-TERM PLANNING AND ASSET LIFE CYCLE COST ESTIMATES

As stated in the Purpose section, classification maps the phases and stages of project cost estimating. Typically, in a phase-gate project system, scope definition and capital cost estimating activities flow from framing a business opportunity through to a capital investment decision and eventual project completion in a more-or-less steady, short-term (e.g., several years) project life-cycle process.

Cost estimates are also prepared to support long-range (e.g., perhaps several decades) capital budgeting and/or asset life cycle planning. Asset life cycle estimates are also prepared to support net present value (e.g., estimates for initial capital project, sustaining capital, and decommissioning projects), value engineering and other cost or economic studies. These estimates are necessary to address sustainability as well. Typically, these long-range estimates are based on minimal scope definition as defined for *Class 5*. However, these asset life cycle "conceptual" estimates are prepared so far in advance that it is virtually assured that the scope will change from even the minimal level of definition assumed at the time of the estimate. Therefore, the expected estimate accuracy values reported in Table 1 (percent that actual cost will be over or under the estimate including contingency) are not meaningful because the Table 1 accuracy values explicitly *exclude scope change*. For long-term estimates, one of the following two classification approaches is recommended:

- If the long-range estimate is to be updated or maintained periodically in a controlled, documented life cycle process that addresses scope and technology changes in estimates over time (e.g., nuclear or other licensing may require that future decommissioning estimates be periodically updated), the estimate is rated as *Class 5* and the Table 1 accuracy ranges are assumed to apply for the specific scope included in the estimate at the time of estimate preparation. Scope changes are explicitly excluded from the accuracy range.

- If the long-range estimate is performed as part of a process or analysis where scope and technology change is not expected to be addressed in routine estimate updates over time, the estimate is rated as *Unclassified* or as *Class 10* (if a class designation is required to meet organizational procedures), and the Table 1 accuracy ranges cannot be assumed to apply. The term *Class 10* is specifically used to distinguish these long-range estimates from the relatively short time-frame *Class 5* through *Class 1* capital cost estimates identified in Table 1 and this RP; and to indicate the order-of-magnitude difference in potential expected estimate accuracy due to the infrequent updates for scope and technology. Unclassified (or Class 10) estimates are not associated with indicated expected accuracy ranges.

In all cases, a *Basis of Estimate* should be documented so that the estimate is clearly understood by those reviewing and/or relying on them later. Also, the estimating methods and other characteristics of Class 5 estimates generally apply. In other words, an *Unclassified* or *Class 10* designation must not be used as an excuse for unprofessional estimating practice.

REFERENCES

1. AACE International, Recommended Practice 17R-97, *Cost Estimate Classification System*, AACE International, Morgantown, WV, (latest revision).
2. Stephenson, H. Lance, CCP, Editor, *Total Cost Management Framework: An Integrated Approach to Portfolio, Program and Project Management*, AACE International, Morgantown, WV (latest revision).
3. AACE International, Recommended Practice 10S-90, *Cost Engineering Terminology*, AACE International, Morgantown, WV (latest revision).
4. John R. Heizelman, *Estimating Factors for Process Plants*, 1988 AACE Transactions, V.3, AACE International, Morgantown, WV, 1988.
5. K.T. Yeo, The Cost Engineer Journal, UK Vol. 27, No. 6, 1989.
6. Stevens, G. and T. Davis, How Accurate are Capital Cost Estimates?, 1988 AACE Transactions, B.4, AACE International. Morgantown, WV, 1988. (* Class 3 is inferred)
7. Behrenbruch, Peter, article in Journal of Petroleum Technology, Vol. 45, No. 8, Society of Petroleum Engineers, August 1993.
8. AACE International, Recommended Practice 42R-08, *Risk Analysis and Contingency Determination Using Parametric Estimating*, AACE International, Morgantown, WV (latest revision).
9. AACE International, Recommended Practice 40R-08, *Contingency Estimating - General Principles*, AACE International, Morgantown, WV (latest revision).
10. AACE International, Recommended Practice 41R-08, *Risk Analysis and Contingency Determination Using Range Estimating*, AACE International, Morgantown, WV (latest revision).
11. AACE International, Recommended Practice 44R-08, *Risk Analysis and Contingency Determination Using Expected Value*, AACE International, Morgantown, WV (latest revision).
12. AACE International, Recommended Practice 34R-05, Basis of Estimate, AACE International, Morgantown, WV (latest revision).
13. Construction Industry Institute (CII), PDRI: Project Definition Rating Index – Building Projects, Version 3.2 (115-2), Austin, TX, December 1, 2009.
14. Construction Industry Institute (CII), PDRI: Project Definition Rating Index – Industrial Projects, Version 3.2 (113-2), Austin, TX, December 1, 2009.

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15. U.S. Department of Energy (DOE), *Project Definition Rating Index Guide for Traditional Nuclear and Non-Nuclear Construction Projects*, DOE G 413.3-12, July 22, 2010.
16. AACE International, Professional Guidance Document PGD 01, *Guide to Cost Estimate Classification*, AACE International, Morgantown, WV (latest revision).
17. J. K. Hollmann, Project Risk Quantification, Sugarland, TX: Probabilistic Publishing, 2016.
18. AACE International Recommended Practice No. 104R-19, Understanding Estimate Accuracy, Morgantown, WV: AACE International, Latest revision.
19. AACE International, Professional Guidance Document (PGD) 02, Guide to Quantitative Risk Analysis, Morgantown, WV: AACE International, Latest revision.

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APPENDIX: UNDERSTANDING ESTIMATE CLASS AND COST ESTIMATE ACCURACY

Despite the verbiage included in the RP, often, there are still misunderstandings that the class of estimate, as defined in the RP above, defines an expected accuracy range for each estimate class. This is incorrect. The RP clearly states that "while a target range may be expected for a particular estimate, the accuracy range should always be determined through risk analysis of the specific project and should never be predetermined." Table 1 and Figure 1 in the RP are intended to illustrate only the general relationship between estimate accuracy and the level of project definition. For the process industries, typical estimate ranges described in RP 18R-97 above are shown as a range of ranges:

- Class 5 Estimate:
  - High range typically ranges from +30% to +100%
  - Low range typically ranges from -20% to -50%
- Class 4 Estimate:
  - High range typically ranges from +20% to +50%
  - Low range typically ranges from -15% to -30%
- Class 3 Estimate:
  - High range typically ranges from +10% to +30%
  - Low range typically ranges from -10% to -20%
- Class 2 Estimate:
  - High range typically ranges from +5% to +20%
  - Low range typically ranges from -5% to -15%
- Class 1 Estimate:
  - High range typically ranges from +3% to +15%
  - Low range typically ranges from -3% to -10%

As indicated in the RP, these +/- percentage members associated with an estimate class are intended as rough indicators of the accuracy relationship. They are merely a useful simplification given the reality that every individual estimate will be associated with a unique probability distribution correlated with its specific level of uncertainty. As indicated in the RP, estimate accuracy should be determined through a risk analysis for each estimate.

It should also be noted that there is no indication in the RP of contingency determination being based on the class of estimate. AACE has recommended practices that address contingency determination and risk analysis methods (for example RP 40R-08, *Contingency Estimating – General Principles* [9]). Furthermore, the level of contingency required for an estimate is not the same as the upper limits of estimate accuracy (as determined by a risk analysis).

The results of the estimating process are often conveyed as a single value of cost or time. However, since estimates are predications of an uncertain future, it is recommended that all estimate results should be presented as a probabilistic distribution of possible outcomes in consideration of risk.

Every estimate is a prediction of the expected final cost or duration of a proposed project or effort (for a given scope of work). By its nature, an estimate involves assumptions and uncertainties. Performing the work is also subject to risk conditions and events that are often difficult to identify and quantify. Therefore, every estimate presented as a single value of cost or duration will likely deviate from the final outcome (i.e., statistical error). In simple terms, this means that every point estimate value will likely prove to be wrong. Optimally, the estimator will analyze the uncertainty and risks and produce a probabilistic estimate that provides decision makers with the probabilities of over-running or under-running any particular cost or duration value. Given this probabilistic nature of an estimate, an estimate should not be regarded as a single point cost or duration. Instead, an estimate actually reflects a range of potential outcomes, with each value within this range associated with a probability of occurrence.

Individual estimates should always have their accuracy ranges determined by a quantitative risk analysis study that results in an estimate probability distribution. The estimate probability distribution is typically skewed. Research shows the skew is typically to the right (positive skewness with a longer tail to the right side of the distribution) for large and complex projects. In part, this is because the impact of risk is often unbounded on the high side.

High side skewness implies that there is potential for the high range of the estimate to exceed the median value of the probability distribution by a higher absolute value than the difference between the low range of the estimate and the median value of the distribution.

Figure A1 shows a positively skewed distribution for a sample cost estimate risk analysis that has a point base estimate (the value before adding contingency) of $89.5. In this example, a contingency of $4.5 (approximately 5%) is required to achieve a 50% probability of underrun, which increases the final estimate value after consideration of risk to $93. Note that this example is intended to describe the concepts but not to recommend specific confidence levels for funding contingency or management reserves of particular projects; that depends on the stakeholder risk attitude and tolerance.

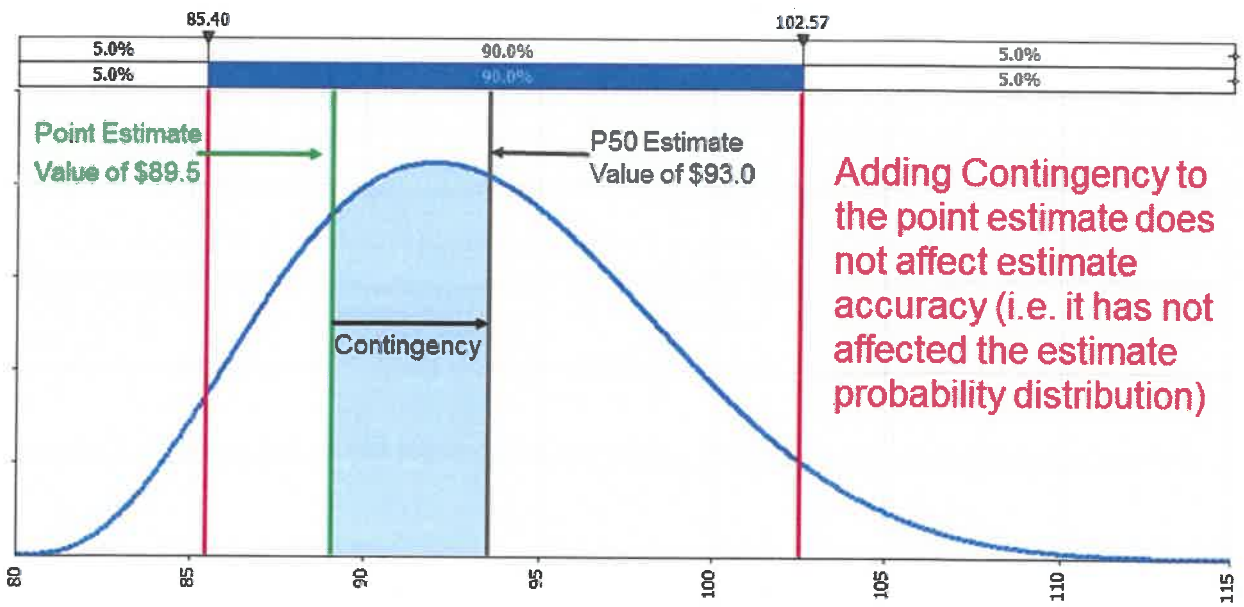

Figure – A1: Example of an Estimate Probability Distribution at a 90% Confidence Interval

Note that adding contingency to the base point estimate does not affect estimate accuracy in absolute terms as it has not affected the estimate probability distribution (i.e., high and low values are the same). Adding contingency simply increases the probability of underrunning the final estimate value and decreases the probability of overrunning the final estimate value. In this example, the estimate range with a 90% confidence interval remains between approximately $85 and $103 regardless of the contingency value.

As indicated in the RP, expected estimate accuracy tends to improve (i.e., the range of probable values narrows) as the level of project scope definition improves. In terms of the AACE International estimate classifications, increasing levels of project definition are associated with moving from Class 5 estimates (lowest level of scope definition) to Class 1 estimates (highest level of scope definition), as shown in Figure 1 of the RP. Keeping in mind that accuracy is an expression of an estimate's predicted closeness to the final actual value; anything included in that final actual cost, be it the result of general uncertainty, risk conditions and events, price escalation, currency or anything else within the project scope, is something that estimate accuracy measures must communicate in some manner. With that in mind, it should be clear why standard accuracy range values are not applicable to individual estimates.

The level of project definition reflected in the estimate is a key risk driver and hence is at the heart of estimate classification, but it is not the only driver of estimate risk and uncertainty. Given all the potential sources of risk and uncertainty that will vary for each specific estimate, it is simply not possible to define a range of estimate accuracy solely based on the level of project definition or class of estimate.