RegionalWaterAuthority

South Central Connecticut Regional Water Authority
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December 16, 2021

Members of the Representative Policy Board
South Central Connecticut Regional Water District
90 Sargent Drive
New Haven, CT 06511-5966

Subject: Application to the Representative Policy Board for Approval of the Lake Gaillard Water Treatment Plant Clarifiers, Recycle Pump Station, and Concrete Restoration Project and the HVAC and Electrical Improvements Located in North Branford, CT

Ladies and Gentlemen:

The South Central Connecticut Regional Water Authority requests that the Representative Policy Board (RPB) accept the following enclosed document as complete:

> Application for Approval to the Representative Policy Board of the Lake Gaillard Water Treatment Plant Clarifiers, Recycle Pump Station, and Concrete Restoration Project and the HVAC and Electrical Improvements Located in North Branford, CT

Based on our conclusion that the proposed actions are consistent with the policies and advance the goals of the South Central Connecticut Regional Water Authority, are in the best interests of our customers, and will have no significant adverse impact on the environment, we are further requesting that the RPB approve this action following a public hearing.

Section 1-210(b)(19) of the Connecticut General Statues provides that documents describing critical infrastructure and related operational details of water supply and distribution systems are exempt from public disclosure. This application contains materials that fall within the category of confidential protected information. This material is contained in Appendices A, B, C, D, G and H of the Application, and is attached separately herein.

To protect this material from public disclosure during Application processing, including public hearings, contemplated by Sections 10 and 19 of the Authority's enabling legislation we are requesting that the RPB take the following protective measures:

- Grant the protective order that accompanies the application.

- Conduct any part of the public hearing on this application that includes detailed discussion of the protected material in a special session closed to the public, including keeping the recording of that session confidential.

Regional Water Authority

Counsel to the Authority and RPB recommends that the procedures put in place for the closed public hearing follow closely the procedures followed by the Public Utilities Regulatory Authority in similar circumstances. You should feel free to follow up regarding details of these procedures directly with counsel.

Any questions regarding this Application may be directed to Ted Norris, Vice President - Asset Management.

Sincerely,

SOUTH CENTRAL CONNECTICUT REGIONAL WATER AUTHORITY

DocuSigned by:
David Borowy
BC99015B3EC142F...

David Borowy, Chair
Kevin Curseaden
Anthony DiSalvo
Catherine LaMarr
Suzanne Sack

Enclosures

TN/lm

Application to the Representative Policy Board for Approval of the Lake Gaillard Water Treatment Plant Clarifiers, Recycle Pump Station, and Concrete Restoration Project and HVAC and Electrical Improvements at the Lake Gaillard Water Treatment Plant

South Central Connecticut Regional Water Authority
December 16, 2021

Application for Approval to the Representative Policy Board of the Lake Gaillard Water Treatment Plant Clarifiers, Recycle Pump Station, and Concrete Restoration Project and the Heating, Ventilation, and Air Conditioning (HVAC) and Electrical Improvements at the Lake Gaillard Water Treatment Plant Project

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1. Statement of Application

In accordance with Section 19 of Special Act 77-98, as amended, the South Central Connecticut Regional Water Authority (RWA) is pleased to present this application for the Lake Gaillard Water Treatment Plant (LGWTP) Clarifiers, Recycle Pump Station (RPS), and Heating, Ventilation, and Air Conditioning (HVAC) with Electrical Lighting Upgrades to the Representative Policy Board (RPB) for review and approval. Section 19 of Special Act 77-98, as amended, requires the RPB approval before the RWA commences any capital project that will cost more than $2 million. The proposed project cost is a not-to-exceed amount of $14.79 million. The proposed upgrades will improve treatment plant filter performance, water quality, increase efficiency, reliability, safety, and maintainability of the plant.

This application is a multi-project application consisting of two distinct projects as discussed below. The multi-project concept provides the RWA's management with a method to complete more than one project at a time at a water treatment plant or within a distribution system without returning to the RPB for separate project approvals. With an increasing number of planned projects expected to exceed the $2 million RPB application threshold, this multi-project method will increase the efficiency of conducting the RWA's capital program by reducing the time, expenses, and facility impacts associated with individual project applications. Importantly, this method will also increase capital efficiencies by achieving economies of scale for multiple project bids as a combined project.

Multi-project applications may include projects that are at the conceptual stage versus applications based on more complete designs. The HVAC and Electrical Lighting Replacement Project in this application is an example of a project at the conceptual stage. The design of this project is at an early juncture and the cost estimate developed without detailed engineering data and therefore its contingency is relatively high at (+)30%. The inclusion of conceptual stage project(s) in multi-project applications will result in total project cost estimates that are in terms of a 'not-to-exceed' dollar amounts, as is the case with this application. The inclusion of conceptual stage projects in multi-project applications provides a method to incorporate evolving projects into applications that are anchored on a well-developed large project, and allows for the development of RPB applications to be completed sooner than if fully developed projects were included. This results in expediency in conducting the capital program and captures the associated efficiencies. The conceptual project included in a multi-project application will be brought to full design after the project approval, if so granted by the RPB. This project will be bid separately to ensure the work is performed by a specialty qualified general contractor.

The LGWTP, located in North Branford, Connecticut, became operational in 1986. It is a direct filtration plant that treats water from Lake Gaillard. The Lake Gaillard Pump Station, which pumps water from the Lake Gaillard Water Treatment Plant, with a rated capacity of 80 million gallons per day (MGD), provides water directly to the New Haven and Branford Service Areas and provides water indirectly to many more service areas through other pump stations and pressure reducing stations. On average, the LGWTP and pump station supply approximately 61% of the total water to the RWA's system. The LGWTP is a typical campus style facility with the Treatment Building housing all the filters, chemical feed systems, control room, laboratory, and various HVAC, electrical, and storage rooms. Flocculation basins are located outside of the Treatment Building, accessible via the filter gallery. The storage tanks, pump station, Residuals Loading Building, Recycle Pump Station, underflow pump station, Hydroelectric Building, lagoons, and various chambers are located within the LGWTP grounds.

A Capital Improvements Plan (CIP) was completed for the LGWTP in 2004, which evaluated the civil, architectural/structural, process, instrumentation, electrical, and HVAC components of the LGWTP. Since that time, the RWA has completed various improvements projects throughout the treatment plant. Despite the significant upgrades completed over the last 15+ years, many components of the LGWTP remain original and are approaching the end of their service life. An additional CIP was completed in 2015 to revisit and expand upon the 2004 CIP. This update identified those systems and infrastructure that required upgrading or replacement due to condition, and expanded the scope of the CIP to identify additional items which improve reliability, safety, and security. The results of the CIP, which is included as Appendix C, were used to develop the two projects presented in this application.

The RPS and associated structures, including the clarifiers, control chambers, and Washwater Equalization Basin, are used for treating and dewatering the plant's filter backwash water. The RPS, Clarifiers 1 and 2, Control Chamber 1, and the Washwater Equalization Basin were constructed in 1982. The facilities were later expanded in 1991 to add Clarifiers 3 and 4 and Control Chamber No. 2.

The HVAC equipment in the Treatment Building includes indoor air handling units, an indoor water-cooled chiller, chilled water pumps, boilers, hot water pumps, fans, a domestic water heater, mobile air conditioner, and a passive solar system. In general, the equipment is original or was purchased during the upgrade in 1991, with the exception of the indoor water cooled chiller, boilers, domestic water heater and solar system, which were replaced between 1998 and 2014.

The Treatment Building contains a passive solar system known as a Trombe Wall. This wall requires significant maintenance and is in very poor condition. The Trombe Wall System has been non-functioning for many years. The panels have yellowed and none of the associated dampers are operational. Rather than expending more effort and money to rebuild the wall, the abandonment of the wall is proposed in this application.

This application is organized into two distinct sections:

- Section 2: Lake Gaillard Water Treatment Plant Clarifiers, Recycle Pump Station, and Concrete Restoration Project
- Section 3: HVAC and Electrical Improvements at the Lake Gaillard Water Treatment Plant Project

Each section of this application will provide a description of the proposed work, an explanation of why it is necessary, a discussion of the alternatives considered, and the estimated cost. The accuracy and completeness of this document are critical to the RPB's ability to make an informed decision on behalf of the RWA's customers and member communities. Tighe & Bond is providing design and construction administration services for the projects.

2. Lake Gaillard Water Treatment Plant Clarifiers, Recycle Pump Station, and Concrete Restoration Project

2.1 Description of the Proposed Action

This project will include upgrades to the washwater clarifiers and RPS with associated piping, electrical, and instrumentation work. The clarifier mechanisms, recycle pumps, and sludge pumps will be replaced. Concrete restoration throughout the facility will also be completed.

The clarifiers' primary function is to remove solids from the backwash water, which is created when filters are cleaned. The clarified water is then pumped (recycled) back to the beginning of the treatment process for re-use, making the plant's operation more sustainable. The clarifiers also help to thicken the residuals, reducing the amount of water pumped to the drying beds, reducing pumping and disposal costs.

The primary equipment in the four clarifiers includes inclined plate settlers, sludge scrapers and sludge rake drives, and an effluent channel equipped with mud valves. The sludge scrapers and drives are original, with heavy corrosion on the drives and drive support plates for Clarifiers 3 and 4. The treatment operators noted that deterioration has also been an issue for the clarifier drives and motors for Clarifiers 1 and 2. The plate settlers and frames are original, as well. Due to the age, the plate settlers have become rough, causing solids to stick to them instead of sliding down. To remove this buildup of solids, current practices require each clarifier to be drained and cleaned every 2 months. This equates to Treatment staff draining and manually cleaning a clarifier every 2 weeks. This is a labor-intensive process in addition to a safety concern due to the frequent confined space entries. Replacement of all aging mechanisms in the clarifiers would result in significantly less maintenance and a much higher treatment efficiency.

The RPS houses four recycle water pumps, two unthickened residuals (sludge) pumps, one trash pump, and a recycle polymer system. The four recycle pumps and two sludge pumps were replaced when the facilities were upgraded in 1991 and Recycle Pump No. 1 has since received a new motor. The 2004 CIP report noted that the recycle pumps had been rebuilt twice and have had a loss in pumping capacity and efficiency over time. The average design life for pumps is approximately 20 to 30 years. Pumps can be rebuilt one or two times; however, following the second rebuild, the pumps should be replaced due to a loss in operating efficiency. While the failure of all four recycle pumps would not result in the inability to operate the plant, it would result in overflow of the supernatant wet well, an environmental permit violation as a result of the spill, and would exacerbate downstream drainage issues. The existing sludge pumps have had continuous maintenance issues with rocks, sand and debris making its way into the basins and ultimately to the pumps. Replacing the pumps with positive displacement progressive cavity pumps will eliminate these issues as these pumps can handle a much higher solids content, and will allow for more efficient residuals removal from the clarifiers. Similar pumps used at the Lake Whitney WTP and Lake Saltonstall WTP have been found to require significantly less maintenance and are more durable.

Tighe & Bond is providing design consulting services for the Lake Gaillard Water Treatment Plant Clarifier, Recycle Pump Station, and Concrete Restoration Project. Appendix A contains the 90% design drawings for the project.

Specifically, the upgrades and rehabilitation consist of:

- Clarifiers
    - Clarifiers 1 & 2: Demolish and replace the existing frames, lamella plates, effluent troughs, sludge scrapers and drives, and all associated appurtenances within the basins.
    - Clarifiers 3 & 4: Demolish and replace the existing lamella plates, effluent troughs, sludge scrapers and drives, and all associated appurtenances within the basins. The existing frames will be reused. Replace existing metal covers with walk-on Fiberglass Reinforced Plastic (FRP) covers.
    - Demolish and replace walkways and railings.
    - Associated electrical work.
- Recycle Pump Station
    - Demolish recycle pumps, base plates, motors, variable frequency drives (VFDs), and associated electrical equipment.
    - Demolish sludge pumping system including pumps, pads, piping, instruments, pipe supports, and associated electrical equipment.
    - Replacement of four existing vertical turbine recycle pumps, motors, and VFDs.
    - Replacement of existing sludge system including new progressive cavity pumps, new piping, and valves.
    - Associated electrical work.
    - Concrete pads for new equipment.
- Concrete Restorations
    - Chemical grout injection for cracks in the Pipe Gallery and Recycle Building.
    - Repair spalled concrete surfaces in the Pipe Gallery

2.2 Need for the Proposed Action

Due to the degraded condition of the clarifiers the RWA currently shuts down, drains, and cleans one clarifier every two weeks because of decreased performance of the clarifier's inclined plates. In order to perform maintenance on the clarifiers over 150,000 - gallons of water needs to be discharged to the drying beds for each clarifier cleaning. This is a labor intensive effort that would be drastically reduced with the replacement of equipment. Given that the LGWTP is the RWA's largest water treatment facility, the time and manpower it takes to clean the clarifiers can be better utilized on other maintenance activities. Reducing the cleaning frequency will result in a significant safety improvement by minimizing the regularity with which staff and contractors need to make confined space entries into the clarifiers for maintenance and repairs. Inspections of the clarifiers have revealed degraded rake arms, which have been welded to maintain their structural integrity and failing mounting hardware. The frequent clarifier draining also impacts plant operation by limiting plant performance during cleaning. Backwashes must be manually initiated early to ensure a minimal number of backwashes during the clarifier cleaning, which means more staff time and less efficient water treatment plant operation. More efficient clarifiers will also incrementally improve finished water quality (color and turbidity) and reduce disinfectant by products (DBPs) by incrementally reducing the amount of organic recycled to the head of the plant. The proposed clarifiers are able to process 25% more flow and will allow staff to take one clarifier out of service for maintenance without manually manipulating backwashes and avoid impacts to normal plant operation.

Replacing the four recycle water pumps in the RPS will reduce the risk of pump failure and increase pumping efficiency, and therefore, reduce electrical cost. Recycle pump failure would result in overflow of the supernatant wet well, an environmental permit violation, and would exacerbate downstream drainage issues.

Replacing the sludge pumps will also result in decreased labor effort. Currently, the RWA is performing significantly intense maintenance on the sludge pumps, which are not well suited for use with liquids with a high solids content. By upgrading the sludge pumps with positive displacement pumps which are better suited to pump sludge and piping that is more streamlined, the efficiency, reliability, and maintainability of the residuals processing system will be increased. In addition, by pumping higher concentrations of residuals to Lake Gaillard's drying beds, we will effectively reduce the amount of water discharged to the sanitary sewer system, saving an estimated $30,000 annually.

Specifically, it has been determined that new clarifier mechanisms, recycle pumps, and sludge pumps and concrete restoration are necessary based on the following reasons:

- New clarifiers will increase the reliability, resiliency and ability to maintain the LGWTP while incrementally improving water quality.
- Most of the recycle system equipment are original and approximately 30 years old. Pumps have a service life of 20-30 years.
- The recycle pumps have been rebuilt twice and are now operating at a lower efficiency and capacity.
- It is increasingly more difficult to find replacement parts for old equipment. Parts may not fit a rebuilt pump correctly, potentially causing failure in the future.
- A significant amount of labor is currently used to clean the clarifier basins.
- Reliability of the recycle system will improve. The risk of all recycle pumps failing and resulting in overflow of the supernatant wet well, a possible environmental permit violation, and exacerbation of downstream drainage issues would be removed.
- Minimizing cleaning and maintenance would be a significant safety improvement.
- Concrete restoration will improve walking surfaces, and reestablish structural integrity of filter walls inside the treatment building, as well as the clarifier basins.

2.3 Analysis of the Alternatives to the Proposed Action

In determining the best course of action to address upgrading aging equipment and reducing labor effort needed at the LGWTP, Tighe & Bond evaluated several different alternatives. The alternatives include replacing the existing equipment with upgraded models, rebuilding the pumps, installing an alternative sludge management system, and taking no action.

Alternative 1 – No Action: Not completing any upgrades to the existing clarifiers and recycle pump station is inefficient and risky in terms of reliability. The clarifiers would continue to need cleaning every 2 months, the recycle pumps would remain operating at a lower capacity and would likely break in the future as they pass their service life. The sludge pumps would still need to be replaced upon breaking. Replacement parts for outdated equipment would be more expensive and difficult to find. This alternative will result in continued excessive maintenance work and inefficient pumping, costing the RWA time and money.

Alternative 2 – Rebuild Recycle Pumps: Given that the recycle pumps have already been rebuilt twice and are therefore operating at a lower capacity, this alternative is not recommended. There is no guarantee that spare parts inevitably needed in the future will fit the refurbished pumps as well as the original. With another rebuild, the pumps are likely to lose even more efficiency.

Alternative 3 – Convert System to An Alternative Thickening Technology: Installation of an alternative sludge management system in lieu of the existing clarifier design is feasible. For example, the clarifiers could be replaced with thickening centrifuges. Technically, an alternative thickening technology would provide similar performance. However, an alternative thickening technology would not allow for beneficial use of the existing clarifier tanks, would require construction of new building space to house new equipment, and would require purchase of new thickening equipment. While technically feasible, conversion to an alternative thickening technology would be too cost-prohibitive to be practical at the LGWTP.

Alternative 4 – Replace with Upgraded Equipment: Installing new clarifier plate settlers, frames, sludge scrapers and drives, recycle pumps, and sludge pumps provides a more efficient recycle system. The clarifier plate settlers would have a 25% higher capacity, meaning that the maintenance requirements for the clarifiers will be drastically reduced. The recycle pumps, which are at the end of their service life, would be replaced with new, more efficient models. The new sludge pumps would be able handle a higher solids content to combat the issue of sand and rocks getting stuck in the pumps. This alternative addresses the aging infrastructure and labor concerns.

The alternatives analysis concluded that Alternative 4 is most favorable in terms of efficiency, reliability, and labor. Replacing aging equipment with upgraded equipment was selected for the following reasons:

- The newer models of the equipment being replaced will be more energy and process efficient.
- The recycle and sludge pumps are at the end of their useful lives.
- Labor for maintaining the clarifiers will be significantly reduced. Additionally, with a 25% higher loading capacity, the clarifiers will need to be shut down for maintenance less frequently.
- Safety concerns regarding confined space entry when maintaining the clarifiers will be reduced due to the lower maintenance demand.
- New sludge pumps can handle a higher solids content.

2.3.1 Business Case Evaluation

A Business Case Evaluation (BCE) on the two most feasible alternatives was performed by RWA to further compare and evaluate Alternatives 3 and 4, and is included in Appendix G, along with the BCE introductory memo with a definition of terms. The BCE was conducted using the comprehensive Triple

Bottom Line (TBL) approach, that evaluates life-cycle costs, cost-benefit ratio, risk and social factors (including environmental) to determine the best long-term solution to a problem. The following summarizes the results of the BCE.

1. Life Cycle Cost Projection (LCCP): the Life Cycle Costs Annuitized Cost Stream is the least for Alternative 4. The life cycle costs over the analysis period (33 years) show a significant decrease in the present value of annual operating and maintenance costs for both alternatives (over the Status Quo).
2. Risk Reduction: The Risk Reduction Effectiveness Factor is the highest for Alternative 4. Both of the alternatives were evaluated to reduce the Risk Cost from the Status Quo. The Risk Cost (annual basis) of the Status Quo is about $13 million. The overall Residual Risk Cost (annual basis) is about $175,000 for each Alternative evaluated.
3. Benefit/Cost: The Benefit/Cost Ratio is a ratio of the benefit value over the cost value. A higher result demonstrates that the project is more cost effective than the other alternatives for the benefits it delivers. This calculation allows for the quantification of factors such as environmental and social impact of a project (both during construction and long-term). The Benefit/Cost Ratio is highest for Alternative 4, with a result of 69.38; followed by Alternative 3, with a result of 48.36.

Based on the results of the BCE, Alternative 4, the Clarifier Plate Settler Replacement with Upgraded Equipment was determined to best address all aspects of the need for proposed action while balancing the impact of the work as it relates to the TBL concerns.

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

2.4.1 Capital Cost

This project will result in a capital expenditure of up to $8.66 million including a 15% contingency. The RWA has expended approximately $118,006 through November 2021 to conduct preliminary design 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 E of this application. The project costs presented are based on a 90% design level of completion prepared in August 2021. In accordance with cost estimating principles, the project costs have been adjusted for inflation.

Due to the escalation of prices and part/equipment shortages that have occurred as a result of the COVID-19 pandemic, additional material and bidding contingencies have been factored into the estimated cost provided by our consultant Tighe & Bond.

TABLE 1
Estimated Project Capital Cost for Clarifiers, Recycle Pump Station, and Concrete Restoration

Cost Description	Estimated Cost
Previous Expenditures (from 2019 through November 2021)	$118,006
Demolition	$86,000
Mechanical	$3,754,000
Structural	$247,500
Electrical	$181,500
Construction Subtotal in 2021 dollars:	**$4,269,000**
Escalation to Mid-Point of Construction – 4% per year	$171,000
Construction Total With Inflation	**$4,440,000**
General Conditions, Overhead and Profit (20%)	$888,000
Contingency (15%)	$799,200
Construction Phase Services Engineering (12%)	$735,264
RWA Cost during Construction (8%)	$548,997
PROJECT TOTAL:	**$7,529,467**
ROUNDED TOTAL:	**$7,530,000**
Minimum Anticipated Project Cost (-10%)	$6,777,000*
Maximum Anticipated Project Cost (+15%)	$8,659,500*

* Minimum and Maximum project costs includes (-10%) to (+15%) American Association of Cost Engineers (AACE) accuracy factors respectively on construction subtotal.

In accordance with cost estimating principles, the project costs have been adjusted for inflation forward 12 months from the date of the cost estimate, September 2021, to the mid-point of construction, which is anticipated to be January 2023. An inflation factor of 4.0% per year has been used in the cost estimate. This factor was calculated by Tighe & Bond from the ENR Construction Cost Index from August 2015 through August 2021.

For the construction cost estimate at the 90% completion level, a 15% contingency is included. This is consistent with the American Association of Cost Engineers (AACE) International Recommended Practices and Standards for a Class 1 estimate, which is included in Appendix I. In a Class 1 estimate, the design of the project is expected to be between 50% to 100% complete and accurate within -10% to +15%. This implies that there is a high probability that the final project cost will fall within the specified range. 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 15% contingency allowance of $800,000 is included at this design stage in anticipation of items that will be further defined in subsequent phases of the design process, as well as 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

The clarifier and recycle pump station upgrades include the following mechanical equipment that will require routine maintenance:

- Recycle pumps
- Sludge pumps
- Incline settler plates

Maintenance of equipment will vary depending upon the manufacturer. However, the basic maintenance activities can be expected, including equipment rotation, greasing, and routine monitoring of rotating components. In addition, periodic cleaning of the inclined plate settlers should be expected.

It is anticipated that the maintenance of the upgraded systems equipment will require less maintenance than what is currently required. The clarifiers will not need to be drained and cleaned as frequently. The new pumps will not need to be replaced, rebuilt, or cleaned as frequently.

Pumps require minimal maintenance. Operators should inspect the pumps weekly for leakage, bearing noises, or broken couplings. Bearings should be checked and lubricated at least twice per year, or as recommended by the manufacturer.

Based on the change to existing equipment, which is at the end of its useful life, requires frequent shutdowns for cleaning, and results in excess water discharged from the plant, the project is expected to reduce operation and maintenance costs by an estimated $111,000 annually. These costs are demonstrated by the Life Cycle Cost Calculations in the BCE. They are comprised of staff time savings, decreased materials for repair, reduced wastewater discharge costs, and filter performance increases.

3. HVAC and Electrical Improvements at the Lake Gaillard Water Treatment Plant

3.1 Description of the Proposed Action

The HVAC and Electrical Improvements at the Lake Gaillard Water Treatment Plant include upgrades to the existing HVAC, electric, and lighting systems. Additionally, the existing Trombe Wall will be taken out of service.

As detailed in the 2015 Tighe & Bond CIP, the major pieces of HVAC equipment at the LGWTP are expected to have a useful life expectancy of approximately 35 years or more, depending upon their duty cycle and exposure to corrosive elements. For HVAC, electrical, and automatic control systems, the design life is driven more by technological advancements rather than failure, so replacement is typically based on age instead of condition. Electrical wiring, under the best conditions, has a typical life expectancy of 50 years. Wet/corrosive atmospheres or exposure to flooding may further reduce the recommended service life for a particular piece of equipment. The Pipe Gallery in the Treatment Building is extremely humid, causing equipment, lighting fixtures, and conduit to corrode and need replacement sooner than anticipated.

Much of the HVAC equipment and associated electrical power wiring located in the Treatment Building is near or past its expected service life and should therefore be replaced. Updated equipment will provide higher efficiencies and reliability for the LGWTP. New electrical wiring will also be appropriately sized to accommodate these HVAC upgrades. Fluorescent bulbs will be replaced with LED bulbs for higher efficiency. In the Pipe Gallery, where the light fixtures are showing signs of rusting, the fluorescent light fixtures can be replaced with LED light fixtures suitable for the humid environment.

Tighe & Bond is providing design consulting services for the HVAC and Electrical Improvements at the Lake Gaillard Water Treatment Plant. Appendix B contains the conceptual design drawings for the project.

Specifically, this work includes:

- HVAC
    - Replace air handling units (HV-1, HV-2, HV 3, HV-5, AC-1, AC-2)
    - Install a new dehumidification air handling unit to replace the air handler (HV-4) serving the pipe gallery
    - Replace all seven return and 15 exhaust fans associated with the air handling systems noted above
    - Replace the condenser serving air handling unit AC-3
    - Install a new condensing hot water boiler plant, including new building hot water pumps
    - Replace the chilled water pumps
    - Install a control system, known as a Building Management System (BMS) to serve all HVAC equipment, including new control devices for proposed equipment and existing equipment to remain. The proposed system would upgrade the BMS to be standardized with all other RWA facilities that utilize the Johnson Controls system.
    - Install a new cooling system for the Control Room
    - Replace variable air volume (VAV) boxes serving the first floor office areas of the Chemical Building
- Electrical/Lighting - In accordance with the Contract Documents
    - Replace light fixtures where necessary, including conduit and wiring
    - Replace fluorescent light bulbs with LEDs
    - Install motion sensors
    - Replace power wiring for HVAC equipment
    - Replace conduit for HVAC equipment where needed
- Trombe Wall
    - Demolish/abandon the existing Trombe Wall in place. The existing wall is approximately 200 feet long by 10 feet high
    - Remove vegetation from inside the wall cavity
    - Seal duct openings
    - Cover the wall with an architectural façade

The proposed improvements will provide the facility with updated equipment, improved reliability/efficiency, improved longevity of building systems and equipment due to enhanced ventilation and humidity control, improved workplace comfort, and safety.

3.2 Need for the Proposed Action

The existing HVAC and electrical equipment is in fair to poor condition and are past their useful lives. Finding replacement parts for this equipment will continue to become more difficult and time consuming. Replacing existing equipment with new HVAC equipment, controls, and appropriately sized wiring will make the system more efficient and easier to maintain. Lighting upgrades and the installation of motion sensors throughout the plant will improve safety and efficiency. Based on energy production calculations, it was determined that the cost savings provided by the Trombe Wall does not outweigh the maintenance it requires. Current conditions require that the yellowing panels would need to be replaced and vegetation growing within the system removed if the system remains in place

Specifically, the existing HVAC and electrical systems require upgrades based on the following reasons:

- Air handling units (HV-1, HV-2, HV 3, HV-5, AC-1, AC-2) are in poor condition and nearing the end of their service life.
- The pipe gallery is extremely humid, causing quicker deterioration of piping and electrical equipment located inside. Air handling unit HV-4 cannot adequately meet dehumidification demands. Excessive pipe sweating causes a safety hazard, increasing the risk of slip, trips and falls.
- Exhaust fans and return fans have outlived their useful service life of approximately 25 years.
- The condenser that serves AC-3 is in poor condition and the refrigerant R-22 that it uses is no longer manufactured.
- The boilers were installed in 1998 and are reaching the end of their useful life. The design is inefficient compared to current models of condensing boilers.
- The chilled water pumps are 40 years old and approaching the end of their service life.
- Existing ventilation cannot adequately cool the Control Room due to new equipment within the space. The RWA is currently using a temporary air conditioner (AC) that requires water from condensate to be manually drained.
- Much of the existing Johnson Controls HVAC controls system is from the original construction or 1990 addition. These controls are obsolete. Some portions have been discontinued, and other portions are in the process of being discontinued.
- The Trombe Wall has been infiltrated by plant growth and the panels have yellowed. The energy savings from this passive solar system does not justify the amount of maintenance it requires, and the RWA would like to decommission it.

3.3 Analysis of the Alternatives to the Proposed Action

In determining the best course of action to address the issue of aging HVAC and electrical equipment in poor condition, several different alternatives were evaluated. The alternatives evaluated include taking no action, replacing all equipment in kind, and replacing all equipment with updated models.

Alternative H1 – No Action: The existing air handlers, boilers, chilled water pumps, ventilation fans, controls, lighting, and Trombe Wall would remain in operation. The equipment that has passed its service life would eventually break and may cause loss of temperature control or ventilation at the LGWTP. The lighting is not as energy efficient, and the original lighting fixtures may break. The RWA would continue to expend effort on keeping the Trombe Wall running with little to no payoff.

This alternative has the lowest cost, but also presents no solution to aging equipment, building environment concerns, and safety concerns.

Alternative H2 – Replace in Kind: The existing equipment mentioned above would be replaced with identically sized equipment. The HVAC load calculations would not be utilized to correctly upsize the equipment and electrical wiring, and the systems would remain at the same efficiency level. Fluorescent light bulbs would still be used even though they are not as efficient as alternatives. The Trombe Wall panels and equipment would be replaced and the plant growth would be removed from within the wall to have the system function correctly. This expense has a long payback period and the panels will need to be replaced when they turn yellow again.

Alternative H3 – Replace with Upgraded Solutions: The existing air handlers, boilers, chilled water pumps, fans, and controls would be replaced with modern models that are more efficient and sized correctly for the building loads. The temporary AC unit being used in the Control Room would be replaced with a permanent solution that can sufficiently cool the space. Light bulbs and fixtures would be updated with higher efficiency LED bulbs, and motion sensors would be installed throughout the treatment plant to be consistent with past upgrades and increase the safety of working within the plant. Energy efficiency would also be increased as motion sensors would prevent lights from being accidentally left on. The control system would be replaced for consistency across all equipment. The Trombe Wall would be taken out of service and potentially replaced with a renewable energy alternative which will reduce the amount of effort the RWA must put into maintenance. The Trombe Wall replacement alternatives are as follows:

Trombe Wall Alternative T1 – Architectural Façade: The existing polycarbonate window panels would be demolished, the duct openings would be sealed up, and the vegetation growing in the wall cavity would be removed. An architectural façade, using insulated metal panels, would be installed in place of the Trombe Wall that would require essentially zero maintenance. This alternative has the lowest cost and maintenance requirements.

Trombe Wall Alternative T2 – Solar Panels to Purchase, Operate, and Maintain: The same steps to remove the Trombe Wall as above would be followed, but solar panels would be installed in place of the insulated metal panels. The RWA would pay to install, operate, and maintain the solar panels. The electric output of the panels would reduce the amount of electricity purchased by the facility. Additional solar panels on the roof may also be combined with those on the wall for an even greater economic benefit if desired.

Trombe Wall Alternative T3 – Solar Panels through Power Purchase Agreement: This alternative would also include the installation of solar panels on the wall and possibly the roof, but the system would be constructed and operated under a power purchase agreement (PPA). In this case, a third party would install, maintain, and operate the solar panels and then sell the power under a long-term contract. This alternative can provide additional benefits to the RWA as a alternate approach to obtaining a “green” solution. There would be zero upfront capital costs and no responsibility for maintaining or operating the system. Because the third party will accrue tax benefits associated with renewable energy, the PPA will provide electricity at a lower cost to the RWA.

The most cost-effective approach to meet the operational reliability needs of the RWA, avoid losses resulting from unplanned equipment failure, increase efficiency and safety, and reduce maintenance is to replace equipment with new models and upgraded solutions and install insulated metal panels in place of the Trombe Wall (Alternative H3 and Trombe Wall Alternative T1). While the cost for installing and maintaining solar panels is not included as part of this project in the application, we recommend the RWA further evaluate solar energy alternatives outside of this construction contract. If the RWA is interested in further evaluating solar energy, we believe Trombe Wall Alternative T3 is likely the most beneficial solution, assuming a third party can provide the electric output at a beneficial rate. However, this will likely require that the system be larger in size and would also use space on the roof.

This alternative was selected for the following reasons:

- Reduces the amount of maintenance the RWA must perform on equipment and the Trombe Wall.
- Increases the efficiency of the HVAC and electrical systems.
- Provides current control systems with the ability to integrate both existing and new equipment.

- Significantly increases reliability of the entire LGWTP, the RWA's largest water treatment plant.
- Reduces the risk of possible failure of electrical and HVAC equipment.
- Increases the safety of operators working within the facility.

3.3.1 Business Case Evaluation

A Business Case Evaluation (BCE) on the alternatives was performed by RWA to further compare and evaluate Alternatives H2 and H3 and is included in Appendix H, along with the BCE introductory memo with a definition of terms. The BCE was conducted using the comprehensive Triple Bottom Line (TBL) approach, that evaluates life-cycle costs, cost-benefit ratio, risk and social factors (including environmental) to determine the best long-term solution to a problem. The following summarizes the results of the BCE.

1. Life Cycle Cost Projection (LCCP): the Life Cycle Costs Annuitized Cost Stream is the least for Alternative H3. The life cycle costs over the analysis period (25 years) show a significant decrease in the present value of annual operating and maintenance costs for both alternatives (over the Status Quo).
2. Risk Reduction: The Risk Reduction Effectiveness Factor is the highest for Alternative H3 at 1.01. Both of the alternatives were evaluated to reduce the Risk Cost from the Status Quo. The Risk Cost (annual basis) of the Status Quo is about $275,500. The overall Residual Risk Cost (annual basis) is $69,329 for Alternative H2 and $5,546 for Alternative H3.
3. Benefit/Cost: The Benefit/Cost Ratio is a ratio of the benefit value over the cost value. A higher result demonstrates that the project is more cost effective than the other alternatives for the benefits it delivers. This calculation allows for the quantification of factors such as environmental and social impact of a project (both during construction and long-term). The Benefit/Cost Ratio is highest for Alternative H3, with a result of 1.90; followed by Alternative 2, with a result of 1.25.

Based on the results of the BCE, Alternative H3, the HVAC Replacement with Upgraded Solutions was determined to best address all aspects of the need for proposed action while balancing the impact of the work as it relates to the TBL concerns

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 $6.13 million including a 30% contingency. The RWA has expended through November 2021 approximately $73,400 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 F of this application. The project costs presented are based on a conceptual design level prepared in August 2021.

Due to the escalation of prices and part/equipment shortages that have occurred as a result of the COVID-19 pandemic, additional material and bidding contingencies have been factored into the estimated cost provided by our consultant Tighe & Bond.

TABLE 2
Estimated Project Capital Cost for HVAC and Electrical Improvements at the Lake Gaillard Water Treatment Plant

Cost Description	Estimated Cost
Previous Expenditures through November 2021)	$73,400
Demolition/HBMA	$146,000
HVAC	$1,926,300
Plumbing	$15,940
Architectural/Structural	$117,000
Electrical	$306,760
Construction Subtotal in 2021 dollars:	**$2,512,000**
Escalation to Mid-Point of Construction – 4% per year	$153,000
Construction Total With Inflation	**$2,665,000**
General Conditions and Overhead and Profit (20%)	$533,000
Equipment Commissioning	$30,000
Contingency (20%)	$645,600
Construction Phase Engineering Services (12%)	$464,832
RWA Cost during Construction (7%)	$303,690
PROJECT TOTAL:	**$4,715,522**
ROUNDED TOTAL:	**$4,716,000**
Minimum Anticipated Project Cost (-20%)	$3,772,800*
Maximum Anticipated Project Cost (+30%)	$6,130,800*

* Minimum and Maximum project costs includes (-20%) to (+30%) American Association of Cost Engineers (AACE) accuracy factors respectively on construction subtotal.

In accordance with cost estimating principles, the project costs have been adjusted for inflation forward 12 months from the date of the cost estimate, September 2021, to the mid-point of construction, which is anticipated to be April 2023. An inflation factor of 4.0% per year has been used in the cost estimate. This factor was calculated by Tighe & Bond from the ENR Construction Cost Index from August 2015 through August 2021.

For the construction cost estimate, a 30% contingency is included. This is consistent with the American Association of Cost Engineers (AACE) International Recommended Practices and Standards for a Class 3 estimate, which is included in Appendix I. In a Class 3 estimate, the design of the project is expected to be between 10% to 40% complete and accurate within -20% to +30%. 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 20% contingency allowance of $640,000 is included at this design stage in anticipation of items that will be further defined in subsequent phases of the design process, as well as 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

The HVAC equipment includes the following major mechanical equipment that will require routine maintenance:

- Return and exhaust fans
- Air handling units
- Boilers
- Condensers
- Pumps

Maintenance of equipment will vary depending upon the manufacturer. However, the following basic maintenance activities can be expected.

The HVAC exhaust fans should be initially checked after the first month and then every three months if there are no issues during the first check. Twice a year, operators should inspect the bolts and setscrews, belts, bearings, and fan for cleanliness.

In general, air handling units do not require special maintenance other than routine cleaning and maintenance work. Once a week, the air filters should be checked. Once a month, the fan belt tension, spray nozzle condition, drain condition, and the access door hinge condition should be checked. Twice a year, the condition of the motor running current, function controls, fan and motor bearings, inlet strainers, and chilled/hot water control valves should be checked. In addition, the condensate drain piping should be flushed twice a year. Once a year, the operation of the dampers, condition of filter frame, access doors, controls, coils and fin condition, insulation, motor and fan lubrication, and wiring, controls, isolation devices, and terminal connections should be checked. Once a year, the belts on the air handling unit should be replaced.

Boilers should be inspected by a manufacturer authorized boiler service contractor at least once per year. During the heating season, operators should inspect the boilers at least weekly and note any errors, lockouts, leakage, or unusual noises during operation. In addition, the hot water system chemistry should be checked and adjusted at least twice per year, generally at the start of the heating season and after the boilers are shut down for the season.

Pumps require minimal maintenance. Operators should inspect the pumps weekly for leakage, bearing noises, or broken couplings. Bearings should be checked and lubricated at least twice per year, or as recommended by the manufacturer.

Based on the change to existing equipment, the project is expected to reduce operation and maintenance costs by an estimated $34,500 annually. Additionally, a one-time incentive from the energy utility will be pursued, for an approximate amount of $50,000.

4. Summary of Combined Project Costs

4.1 Cost Summary

The following table summarizes the combined opinion of probable construction costs for the Clarifier, Recycle Pump Station, and Concrete Restoration and HVAC and Electrical Improvements.

TABLE 4
Summary of Combined Project Costs and Variability

Project	*AACE Estimate Type*	*Accuracy*	*Minimum Cost*	*Maximum Cost*	*Calculated Cost*
Clarifiers, Recycle Pump Station, and Concrete Restoration	Class 1	-10% to +15%	$6,777,000	$8,659,500	$7,530,000
HVAC and Electrical Improvements	Class 3	-20% to +30%	$3,772,800	$6,130,800	$4,716,000
TOTAL			$10,549,800	$14,790,300	$12,246,000

The requested approval amount is not-to-exceed $14.79 million and is based upon the higher range of the AACE cost accuracy factors.

4.2 Bonds or Other Obligations the SCCRWA Intends to Issue

"As a result, the annual cost of this project to an average residential customer, assuming a conservative financing assumption of RWA Bonds, would be approximately $4.94, based on the project cost of $14.79 million and existing rates.

However, we expect this project to be funded by a combination of multiple funding sources. The construction component of the clarifier project is anticipated to be funded through the Connecticut Department of Public Health's (CTDPH) Drinking Water State Revolving Fund (DWSRF). By utilizing DWSRF funding, the total financing costs associated with this project will be reduced. The HVAC component of this project is expected to be at least partially funded by RWA Green Bonds. Internally generated funds are also expected to be used."

4.3 Value Engineering

Value engineering was inherent to the design process and alternatives analysis for the proposed actions. The clarifiers' project includes Lamella Plate Settler and Moyno Pumps that are standardized for the RWA treatment facilities. The costs associated with the HVAC portion of the project are predominately driven by equipment costs as determined by the physical criteria that the equipment is required to meet. All equipment associated with the proposed actions was selected to minimize overall life cycle costs. Also, both these projects have significant cost associated with the equipment which is being standardized across the RWA.

4.4 Expenditures in the FY2022 Capital Budget versus this application

Since the initial FY 2022 budget was developed, there has been a significant increase in required funds. The current costs for the Clarifiers, Recycle Pump Station, and Concrete Restoration and HVAC with Electrical Improvements Project have increased since they were initially planned. The cost increases are largely due to increased material and construction costs as a result of supply chain issues, market volatility, labor shortages, and high contractor workloads, all of which resulted in unusually high construction cost escalation. Contractors and suppliers are now holding quoted prices for only a few days instead of the typical 30 days. The high uncertainty and high material costs in the current market have been leading to higher bids from contractors. The opinions of probable construction costs for these two projects were updated to reflect higher pricing and higher contingency. Additionally, the scope of both projects has increased since their initial conception. The clarifier project scope now includes new covers on all four clarifiers, and replacing the effluent troughs for all four clarifiers. In addition, a preliminary budgetary quote from the clarifier vendor did not clearly indicate that it only included equipment pricing for two clarifiers when all four clarifiers were intended, so the most recent vendor quote for the clarifier equipment is significantly higher. The HVAC and Electrical project scope now includes additional lighting fixture replacements due to the corrosive environment in the pipe gallery, lighting motion sensors throughout the water treatment plant, and Trombe Wall modifications.

5. Preliminary Project Schedule and Permitting

5.1 Schedule

The project schedules presented below are estimated based on the current level of design development.

Lake Gaillard Water Treatment Plant Clarifiers, Recycle Pump Station, and Concrete Restoration Project

1. 90% Design: September 2021
2. RPB Application: Submitted December 2021
3. Assuming RPB approval, Final Design, & Permit: March to April 2022
4. Bidding: May to July 2022
5. Construction: August 2022 to July 2023
6. Start-up, Optimization and Punch List: August 2023 to November 2023

HVAC and Electrical Improvements at the Lake Gaillard Water Treatment Plant

1. Conceptual Design: September 2021
2. RPB Application: Submitted December 2021
3. Assuming RPB approval, Final Design, & Permit: March to June 2022
4. Bidding: August to October 2022
5. Construction: December 2022 to February 2024
6. Start-up, Optimization and Punch List: March 2024 to May 2024

5.2 Permitting

Permitting/agency considerations for construction of the Lake Gaillard Water Treatment Plant Clarifiers, Recycle Pump Station, and Concrete Repairs Project and HVAC and Electrical Improvements at the Lake Gaillard Water Treatment Plant are as follows:

- DWSRF Loan Application – For Clarifiers, Recycle Pump Station, and Concrete Restoration Project only.

- State of Connecticut Department of Public Health (DPH) Public Water System General Application for Approval or Permit

- State of Connecticut Department of Public Health (DPH) Water Company Owned Lands Permit – Change in Use

- State of Connecticut Department of Administrative Services (DAS) - The DAS will require a boiler inspection and signoff at the end of the HVAC and Electrical Improvements at the Lake Gaillard Water Treatment Plant project.

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

- The clarifier system is severely degraded, limiting the Treatment Plant operation especially during backwashes. The current frequency of clarifier maintenance limits the production capacity of the plant on high demand days. The new larger more efficient clarifiers will increase operational flexibility, restore capacity by increasing clarifier uptime, and incrementally improve finished water quality by reducing the amount of organic recycled back to the head of the plant.
- LGWTP employees currently shut down, drain, and clean one clarifier every two weeks. This time and effort from the facility staff could be better utilized, especially considering that the LGWTP is the RWA's largest water treatment facility.
- Most of the recycle system equipment is original and approximately 30 years old and reaching the end of their useful lives. The pumps have been rebuilt twice and are now operating at a lower efficiency. Replacement parts are becoming difficult to find and may not always fit correctly.
- New progressive cavity sludge pumps will work more efficiently and reliably than the existing pumps as they are intended to pump liquids with a high solids content.
- Concrete restoration is necessary to maintain the structural integrity and reliability of the facility.
- The HVAC equipment being replaced is nearing or past its useful life. New equipment is more efficient, appropriately sized, and requires less maintenance.
- The new HVAC equipment will be sized to adequately cool the Pipe Gallery space and reduce the humidity. This will minimize corrosion of equipment and lead to less frequent replacement of equipment in the Pipe Gallery in the future.
- A permanent solution will be implemented to adequately cool the Control Room with its modernized equipment. The new system will be sized for the current and future use of the Treatment Building.
- A new BMS would allow both new and existing equipment to be integrated. Some of the existing controls are already obsolete, which will only continue in future years.
- The Trombe Wall is a complex system that is difficult for the RWA to maintain and is not efficient. Currently, the wall has been infiltrated by plant growth and the panels have yellowed. The energy savings from this passive solar system does not justify the amount of maintenance it requires, and the RWA would like to replace it with a low-maintenance alternative.

- New lighting with LEDs and motion sensors will increase the electrical efficiency of the lighting system.

7. Explanation of Unusual Circumstances Involved with the Application

There were no unusual circumstances involved in this application other than those discussed above in 4.4.

8. Conclusion

The Lake Gaillard Water Treatment Plant is the RWA's largest water treatment plant and provides water directly to the New Haven and Branford Service Areas and indirectly to many more service areas through pump stations and pressure reducing stations. The proposed upgrades and improvements will significantly reduce the amount of time and labor the RWA will need to spend maintaining equipment throughout the facility. The new equipment will be more efficient and easier to maintain, saving the RWA money in the long run.

At $14.79 million, the selected projects maximize the cost and non-cost benefits for the RWA. The time of the LGWTP staff is prioritized with the construction and implementation of these improvements.

As such, the Regional Water Authority has concluded that the proposed action is consistent with and advances the policies and goals of the South Central Connecticut Regional Water Authority.

Appendix E

Engineer’s Opinion of Probable Cost for Lake Gaillard Water Treatment Plant Clarifiers, Recycle Pump Station, and Concrete Restoration Project

Lake Gaillard Water Treatment Plant Clarifiers, Recycle Pump Station, and Concrete Repairs Project

Opinion of Probable Construction Cost

South Central Connecticut Regional Water Authority

August 2021 (ENR 12464)

ITEM	DESCRIPTION	UNITS	QTY	UNIT PRICE	SUB TOTAL	INSTALLATION	TOTAL
1.	**Demolition**						**$86,000**
	Demolish Plate Settlers and Covers	EA	4	$3,000	$12,000	N/A	$12,000
	Demolish Support Racks for Clarifiers 1 and 2	EA	2	$2,000	$4,000	N/A	$4,000
	Demolish Effluent Troughs	EA	8	$2,000	$16,000	N/A	$16,000
	Demolish Support Beams, Walkway, and Railing	EA	4	$2,000	$8,000	N/A	$8,000
	Demolish Sludge Rakes	EA	4	$2,000	$8,000	N/A	$8,000
	Demolish Rake Drives/Electrical	EA	4	$2,000	$8,000	N/A	$8,000
	Demolish Recycle Pumps/Electrical	EA	4	$3,000	$12,000	N/A	$12,000
	Demolish Sludge Pumps & Piping	EA	3	$2,000	$6,000	N/A	$6,000
	Pressure Wash Clarfiier Interiors	EA	4	$3,000	$12,000	N/A	$12,000
2.	**Mechanical**						**$3,161,800**
	Lamella Clarifiers including plates, frames, rakes, drives	LS	1	$1,470,000	$1,470,000	$588,000	$2,058,000
	New Effluent Troughs	LA	4	$100,000	$400,000	$160,000	$560,000
	Recycle Pumps	EA	4	$38,000	$152,000	$60,800	$212,800
	Recycle Pump piping painting	LS	1	$10,000	$10,000		$10,000
	Sludge Pumps, Install, Startup	EA	2	$35,000	$70,000	$35,000	$105,000
	Sludge Pump Seal Water System	EA	2	$10,000	$20,000		$20,000
	Sludge Pumps - Spare Parts	LS	1	$25,000	$25,000	N/A	$25,000
	Trash Pump - Relocate/Reinstall	EA	1	$10,000	$10,000	N/A	$10,000
	4" Plug Valves	EA	18	$2,500	$45,000	$22,500	$67,500
	4" Check Valves	EA	3	$3,000	$9,000	$4,500	$13,500
	Piping - Sludge Pumps (4" PVC)	LS	1	$30,000	$30,000	$15,000	$45,000
	Chemical Piping extensions and tie-ins	EA	4	$5,000	$20,000		$20,000
	Motor Operator for Plug Valves	EA	6	$2,500	$15,000	$7,500	$15,000
3.	**Structural**						**$247,500**
	Concrete Repairs - Clarifier Basin (Allowance)	LS	1	$10,000	$10,000	$4,000	$14,000
	FRP Basin Covers and Access Hatches	LS	1	$110,000	$110,000	$66,000	$176,000
	Welding Studs to the Bridge Beams	LS	1	$10,000	$10,000	$6,000	$16,000
	Misc. Struct/Bldg Mods - Recycle Pumps	LS	1	$10,000	$10,000	N/A	$10,000
	Filter Pipe Gallery Scaffolding	LS	1	$5,000	$5,000	N/A	$5,000
	Exterior crack repairs - Filter 11	LF	100	$110	$11,000	N/A	$11,000
	Exterior crack repairs - Filter 14	LF	100	$110	$11,000	N/A	$11,000
	Field touch-up bridge beam paint	LS	1	$3,000	$3,000	N/A	$3,000
	Equipment Pads	CY	1	$1,500	$1,500	N/A	$1,500
4	**Electrical**						**$181,500**
	Recycle Pumps VFDs and Wiring	LS	1	$105,116	$105,116	N/A	$105,116
	Sludge Pump VFD and Wiring	LS	1	$24,758	$24,758	N/A	$24,758
	Elec Support for Clarifier Drive Replacement	LS	1	$30,074	$30,074	N/A	$30,074
	Elec Support for Motorized Valves for Sludge Pumps	LS	1	$6,504	$6,504	N/A	$6,504
	Misc. Electrical	LS	1	$5,000	$5,000	N/A	$5,000
	Temp Equipment and Demo	LS	1	$10,000	$10,000	N/A	$10,000
					SUBTOTAL		**$3,677,000**
	Escalation to Mid-Point of Construction - 1 Year at 4%						**$3,824,000**
	General Conditions, Overhead and Profit - 20%						**$765,000**
					SUBTOTAL		**$4,589,000**
	Contingency - 15%						**$689,000**
					CONSTRUCTION TOTAL		**$5,278,000**
	Construction Phase Services Engineering - 12%						**$633,360**
					PROJECT TOTAL		**$5,911,360**
					SAY		**$5,900,000**

Appendix F

Engineer's Opinion of Probable Cost for HVAC and Electrical Improvements Lake Gaillard Water Treatment Plant

HVAC and Electrical Improvements at the Lake Gaillard Water Treatment Plant

Conceptual Design Opinion of Probable Construction Cost

South Central Connecticut Regional Water Authority

August 2021 (ENR 12464)

ITEM	DESCRIPTION	UNITS	QTY	UNIT PRICE	SUB TOTAL	INSTALLATION	TOTAL
1.	**Demolition/HBMA**						**$146,000**
	HBMA	LS	1	$30,000	$30,000	N/A	$30,000
	HVAC Demolition	LS	1	$100,000	$100,000	N/A	$100,000
	Trombe Wall Demolition	LS	1	$13,000	$13,000	N/A	$13,000
	Trombe Wall Vegetation Removal	LS	1	$3,000	$3,000	N/A	$3,000
2.	**HVAC**						**$1,926,300**
	Exhaust and Supply Fans (14)	LS	1	$36,250	$36,250	$43,400	$79,650
	Return Fans (7)	LS	1	$64,100	$64,100	$27,300	$91,400
	HV-1	EA	1	$48,300	$48,300	$4,000	$52,300
	HV-2	EA	1	$141,000	$141,000	$4,000	$145,000
	HV-3	EA	1	$54,700	$54,700	$9,200	$63,900
	HV-4 Dehumidification Unit	EA	1	$147,400	$147,400	$4,600	$152,000
	AC-1	EA	1	$67,000	$67,000	$4,000	$71,000
	AC-2	EA	1	$18,700	$18,700	$2,200	$20,900
	AC-3 Replacement DX Cooling Coil and Condensor	LS	1	$9,500	$9,500	$3,800	$13,300
	Split Air Conditioner for Control Room	LS	1	$4,500	$4,500	$6,900	$11,400
	Boilers	EA	3	$25,743	$77,229	$15,600	$92,829
	Hot Water Pumps	EA	2	$2,611	$5,222	$3,000	$8,222
	Chilled Water Pumps	EA	2	$2,374	$4,748	$3,000	$7,748
	Boiler Venting	LS	1	$5,823	$5,823	$8,900	$14,723
	Boiler/ Pump Hot Water Piping	LS	1	$5,410	$5,410	$38,300	$43,710
	Boiler Piping System Accessories	LS	1	$16,399	$16,399	$11,400	$27,799
	Pump Piping Accessories	LS	1	$18,338	$18,338	$8,400	$26,738
	AC/HV Unit Water Piping	LS	1	$12,365	$12,365	$42,500	$54,865
	AC/HV Unit Refrigerant Piping	LS	1	$9,795	$9,795	$31,500	$41,295
	AHU Piping System Accessories	LS	1	$20,860	$20,860	$6,700	$27,560
	AHU/Fan Ductwork	LS	1	$1,701	$1,701	$66,000	$67,701
	Louvers, 48x48	EA	4	$500	$2,000	$600	$2,600
	Pipe Insulation	LS	1	$7,150	$7,150	$21,300	$28,450
	Duct Insulation	LS	1	$2,010	$2,010	$19,200	$21,210
	Complete Control System Replacement for New and Existing Systems	LS	1	$705,000	$705,000	N/A	$705,000
	Testing and Balancing	LS	1	$55,000	$55,000	N/A	$55,000
3.	**Plumbing**						**$ 15,940**
	Boiler Gas Piping and Accessories	LS	1	$5,040	$5,040	$10,900	$15,940
4.	**Architectural / Structural**						**$ 117,000**
	Roof Penetrations and Patching (Boilers)	LS	1	$10,000	$10,000	N/A	$10,000
	Trombe Wall Insulated Metal Panels	LS	1	$25,000	$25,000	N/A	$25,000
	Louver Penetrations	EA	4	$2,500	$10,000	N/A	$10,000
	Concrete Equipment Pads	CY	8	$1,500	$12,000	N/A	$12,000
	Touch-Up Painting	LS	1	$10,000	$10,000	N/A	$10,000
	Equipment Hangers and Supports	LS	1	$20,000	$20,000	N/A	$20,000
	Miscellaneous Repairs (Wall, Roof, Floor, etc.)	LS	1	$20,000	$20,000	N/A	$20,000
	Steel Supports for HV-3	LS	1	$10,000	$10,000	N/A	$10,000
5.	**Electrical**						**$306,400**
	HVAC Power Conduit & Wire	EA	1	$104,900	$104,900	N/A	$104,900
	Lighting Upgrades - Misc	EA	1	$125,500	$125,500	N/A	$125,500
	Lighting - Motion Sensors (Inc. Conduit & Wire)	EA	1	$51,500	$51,500	N/A	$51,500
	Misc. Electrical Costs	EA	1	$24,500	$24,500	N/A	$24,500
					SUBTOTAL		**$2,512,000**
6.	**Escalation to Mid Point of Construction (Anticipated April 2023) 1.5 Years at 4% per Year**						**$2,665,000**
7.	**General Conditions and Overhead and Profit - 20%**						**$533,000**
					SUBTOTAL		**$3,198,000**
	Equipment Commissioning						**$30,000**
	Contingency - 20%						**$640,000**
					CONSTRUCTION TOTAL		**$3,868,000**
8.	**Construction Phase Services Engineering (12%)**						**$464,160**
					PROJECT TOTAL		**$4,332,160**
					SAY		**$4,300,000**

Appendix I

American Association of Cost Engineers (AACE) standards

aace 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

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

TCM Framework: 7.3 – Cost Estimating and Budgeting

February 2, 2005

PURPOSE

As a recommended practice 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 maturity and quality matrix, which can be applied across a wide variety of industries.

This addendum to the generic 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. This addendum supplements the generic recommended practice (17R-97) by providing:

- a section that further defines classification concepts as they apply to the process industries;
- charts that compare existing estimate classification practices in the process industry; and
- a chart that maps the extent and maturity of estimate input information (project definition deliverables) against the class of estimate.

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

It is understood that each enterprise may have its own project and estimating processes and terminology, and may classify estimates in particular ways. This guideline provides a generic and generally acceptable classification system for process industries that can be used as a basis to compare against. It is hoped that this addendum will allow each user to better assess, define, and communicate their own processes and standards in the light of generally-accepted cost engineering practice.

INTRODUCTION

For the purposes of this addendum, 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) and piping and instrument diagrams (P&IDs) as primary scope defining documents. These documents are key deliverables in determining the level of project definition, and thus the extent and maturity of estimate input information.

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 addendum may apply to portions of other industries, such as pharmaceutical, utility, metallurgical, converting, and similar industries. Specific addendums addressing these industries may be developed over time.

This addendum specifically does not address cost estimate classification in nonprocess industries such as commercial building construction, environmental remediation, transportation infrastructure, "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 addendum 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. Building construction will be covered in a separate addendum.

This guideline reflects generally-accepted cost engineering practices. This addendum 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 by the AACE International Cost Estimating Committee. The practices were found to have significant commonalities that are conveyed in this addendum.

COST ESTIMATE CLASSIFICATION MATRIX FOR THE PROCESS INDUSTRIES

The five estimate classes are presented in figure 1 in relationship to the identified characteristics. Only the level of project definition determines the estimate class. The other four characteristics are secondary characteristics that are generally correlated with the level of project definition, as discussed in the generic standard. The characteristics are typical for the process industries but may vary from application to application.

This matrix and guideline provide an estimate classification system that is specific to the process industries. Refer to the generic standard for a general matrix that is non-industry specific, or to other addendums for guidelines that will provide more detailed information for application in other specific industries. These will typically provide additional information, such as input deliverable checklists to allow meaningful categorization in those particular industries.

	Primary Characteristic	*Secondary Characteristic*			
ESTIMATE CLASS	**LEVEL OF PROJECT DEFINITION** 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 [a]	**PREPARATION EFFORT** Typical degree of effort relative to least cost index of 1 [b]
Class 5	0% to 2%	Concept Screening	Capacity Factored, Parametric Models, Judgment, or Analogy	L: -20% to -50% H: +30% to +100%	1
Class 4	1% to 15%	Study or Feasibility	Equipment Factored or Parametric Models	L: -15% to -30% H: +20% to +50%	2 to 4
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%	3 to 10
Class 2	30% to 70%	Control or Bid/ Tender	Detailed Unit Cost with Forced Detailed Take-Off	L: -5% to -15% H: +5% to +20%	4 to 20
Class 1	50% to 100%	Check Estimate or Bid/Tender	Detailed Unit Cost with Detailed Take-Off	L: -3% to -10% H: +3% to +15%	5 to 100

Notes: [a] The state of process technology and availability of applicable reference cost data affect the range markedly. The +/- value represents typical percentage variation of actual costs from the cost estimate after application of contingency (typically at a 50% level of confidence) for given scope.

[b] If the range index value of "1" represents 0.005% of project costs, then an index value of 100 represents 0.5%. Estimate preparation effort is highly dependent upon the size of the project and the quality of estimating data and tools.

Figure 1. – Cost Estimate Classification Matrix for Process Industries
CHARACTERISTICS OF THE ESTIMATE CLASSES

The following charts (figures 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 chart, 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 level of project definition.
- **Level of Project Definition Required:** expressed as a percent of full definition. For the process industries, this correlates with the percent of engineering and design complete.
- **End Usage:** a short discussion of the possible end usage of this class of estimate.
- **Estimating Methods Used:** a listing of the possible estimating methods that may be employed to develop an estimate of this class.
- **Expected Accuracy Range:** typical variation in low and high ranges after the application of contingency (determined at a 50% level of confidence). Typically, this results in a 90% confidence that the actual cost will fall within the bounds of the low and high ranges.
- **Effort to Prepare:** this section provides a typical level of effort (in hours) to produce a complete estimate for a US$20,000,000 plant. Estimate preparation effort is highly dependent on project size, project complexity, estimator skills and knowledge, and on the availability of appropriate estimating cost data and tools.
- **ANSI Standard Reference (1989) Name:** this is a reference to the equivalent estimate class in the existing ANSI standards.
- **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 the chart.

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 systemic 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. **Level of Project Definition Required:** 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 Methods Used:** Class 5 estimates virtually always 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 the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances. **Effort to Prepare (for US$20MM project):** As little as 1 hour or less to perhaps more than 200 hours, depending on the project and the estimating methodology used. **ANSI Standard Reference Z94.2-1989 Name:** Order of magnitude estimate (typically -30% to +50%). **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.

Figure 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. **Level of Project Definition Required:** 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 Methods Used:** Class 4 estimates virtually always use stochastic 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 the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances. **Effort to Prepare (for US$20MM project):** Typically, as little as 20 hours or less to perhaps more than 300 hours, depending on the project and the estimating methodology used. **ANSI Standard Reference Z94.2-1989 Name:** Budget estimate (typically -15% to + 30%). **Alternate Estimate Names, Terms, Expressions, Synonyms:** Screening, top-down, feasibility, authorization, factored, pre-design, pre-study.

Figure 2b. – Class 4 Estimate

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. **Level of Project Definition Required:** 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 may be the last estimate required and could well form the only basis for cost/schedule control.	**Estimating Methods Used:** Class 3 estimates usually involve more deterministic estimating methods than stochastic methods. They usually involve a high degree of unit cost line items, although these may be at an assembly level of detail rather than individual components. Factoring and other stochastic 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 the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances. **Effort to Prepare (for US$20MM project):** Typically, as little as 150 hours or less to perhaps more than 1,500 hours, depending on the project and the estimating methodology used. **ANSI Standard Reference Z94.2-1989 Name:** Budget estimate (typically -15% to + 30%). **Alternate Estimate Names, Terms, Expressions, Synonyms:** Budget, scope, sanction, semi-detailed, authorization, preliminary control, concept study, development, basic engineering phase estimate, target estimate.

Figure 2c. – Class 3 Estimate

CLASS 2 ESTIMATE	
Description: Class 2 estimates are generally prepared to form a detailed 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 70% 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. **Level of Project Definition Required:** 30% to 70% of full project definition. **End Usage:** Class 2 estimates are typically prepared as the detailed 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/variation control program.	**Estimating Methods Used:** Class 2 estimates always 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 the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances. **Effort to Prepare (for US$20MM project):** Typically, as little as 300 hours or less to perhaps more than 3,000 hours, depending on the project and the estimating methodology used. Bid estimates typically require more effort than estimates used for funding or control purposes. **ANSI Standard Reference Z94.2-1989 Name:** Definitive estimate (typically -5% to + 15%). **Alternate Estimate Names, Terms, Expressions, Synonyms:** Detailed control, forced detail, execution phase, master control, engineering, bid, tender, change order estimate.

Figure 2d. – Class 2 Estimate

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, engineering is from 50% to 100% complete, and would comprise virtually all engineering and design documentation of the project, and complete project execution and commissioning plans. **Level of Project Definition Required:** 50% to 100% of full project definition. **End Usage:** Class 1 estimates are typically prepared to form a current control estimate to be used as the final 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/variation control program. They may be used to evaluate bid checking, to support vendor/contractor negotiations, or for claim evaluations and dispute resolution.	**Estimating Methods Used:** Class 1 estimates 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 the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances. **Effort to Prepare (for US$20MM project):** Class 1 estimates require the most effort to create, and as such are generally developed for only selected areas of the project, or for bidding purposes. A complete Class 1 estimate may involve as little as 600 hours or less, to perhaps more than 6,000 hours, depending on the project and the estimating methodology used. Bid estimates typically require more effort than estimates used for funding or control purposes. **ANSI Standard Reference Z94.2 Name:** Definitive estimate (typically -5% to + 15%). **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.

Figure 2e. – Class 1 Estimate

COMPARISON OF CLASSIFICATION PRACTICES

Figures 3a through 3c provide a comparison of the estimate classification practices of various firms, organizations, and published sources against one another and against the guideline classifications. These tables permits users to benchmark their own classification practices.

INCREASING PROJECT DEFINITION

AACE Classification Standard	ANSI Standard Z94.0	AACE Pre-1972	Association of Cost Engineers (UK) ACostE	Norwegian Project Management Association (NFP)	American Society of Professional Estimators (ASPE)
Class 5	Order of Magnitude Estimate -30/+50	Order of Magnitude Estimate	Order of Magnitude Estimate Class IV -30/+30	Concession Estimate Exploration Estimate Feasibility Estimate	Level 1
Class 4	Budget Estimate -15/+30	Study Estimate	Study Estimate Class III -20/+20	Authorization Estimate	Level 2
Class 3		Preliminary Estimate	Budget Estimate Class II -10/+10	Master Control Estimate	Level 3
Class 2	Definitive Estimate -5/+15	Definitive Estimate	Definitive Estimate Class I -5/+5	Current Control Estimate	Level 4
Class 1		Detailed Estimate			Level 5 Level 6

Figure 3a. – Comparison of Classification Practices

INCREASING PROJECT DEFINITION

AACE Classification Standard	Major Consumer Products Company (Confidential)	Major Oil Company (Confidential)	Major Oil Company (Confidential)	Major Oil Company (Confidential)
Class 5	Class S Strategic Estimate	Class V Order of Magnitude Estimate	Class A Prospect Estimate Class B Evaluation Estimate	Class V
Class 4	Class 1 Conceptual Estimate	Class IV Screening Estimate	Class C Feasibility Estimate Class D Development Estimate	Class IV
Class 3	Class 2 Semi-Detailed Estimate	Class III Primary Control Estimate	Class E Preliminary Estimate	Class III
Class 2	Class 3 Detailed Estimate	Class II Master Control Estimate	Class F Master Control Estimate	Class II
Class 1		Class I Current Control Estimate	Current Control Estimate	Class I

Figure 3b. – Comparison of Classification Practices

INCREASING PROJECT DEFINITION

AACE Classification Standard	J.R. Heizelman, 1988 AACE Transactions [1]	K.T. Yeo, The Cost Engineer, 1989 [2]	Stevens & Davis, 1988 AACE Transactions [3]	P. Behrenbruck, Journal of Petroleum Technology, 1993 [4]
Class 5	Class V	Class V Order of Magnitude	Class III*	Order of Magnitude
Class 4	Class IV	Class IV Factor Estimate		Study Estimate
Class 3	Class III	Class III Office Estimate	Class II	
Class 2	Class II	Class II Definitive Estimate		Budget Estimate
Class 1	Class I	Class I Final Estimate	Class I	Control Estimate

[1] John R. Heizelman, ARCO Oil & Gas Co., 1988 AACE Transactions, Paper V3.7
[2] K.T. Yeo, The Cost Engineer, Vol. 27, No. 6, 1989
[3] Stevens & Davis, BP International Ltd., 1988 AACE Transactions, Paper B4.1 (* Class III is inferred)
[4] Peter Behrenbruck, BHP Petroleum Pty., Ltd., article in Petroleum Technology, August 1993

Figure 3c. – Comparison of Classification Practices

ESTIMATE INPUT CHECKLIST AND MATURITY MATRIX

Figure 4 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 degree of completion of the deliverable. The degree of completion is indicated by the following letters.

- None (blank): development of the deliverable has not begun.
- 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.

	ESTIMATE CLASSIFICATION				
General Project Data:	**CLASS 5**	**CLASS 4**	**CLASS 3**	**CLASS 2**	**CLASS 1**
Project Scope Description	General	Preliminary	Defined	Defined	Defined
Plant Production/Facility Capacity	Assumed	Preliminary	Defined	Defined	Defined
Plant Location	General	Approximate	Specific	Specific	Specific
Soils & Hydrology	None	Preliminary	Defined	Defined	Defined
Integrated Project Plan	None	Preliminary	Defined	Defined	Defined
Project Master Schedule	None	Preliminary	Defined	Defined	Defined
Escalation Strategy	None	Preliminary	Defined	Defined	Defined
Work Breakdown Structure	None	Preliminary	Defined	Defined	Defined
Project Code of Accounts	None	Preliminary	Defined	Defined	Defined
Contracting Strategy	Assumed	Assumed	Preliminary	Defined	Defined
Engineering Deliverables:					
Block Flow Diagrams	S/P	P/C	C	C	C
Plot Plans		S	P/C	C	C
Process Flow Diagrams (PFDs)		S/P	P/C	C	C
Utility Flow Diagrams (UFDs)		S/P	P/C	C	C
Piping & Instrument Diagrams (P&IDs)		S	P/C	C	C
Heat & Material Balances		S	P/C	C	C
Process Equipment List		S/P	P/C	C	C
Utility Equipment List		S/P	P/C	C	C
Electrical One-Line Drawings		S/P	P/C	C	C
Specifications & Datasheets		S	P/C	C	C
General Equipment Arrangement Drawings		S	P/C	C	C
Spare Parts Listings			S/P	P	C
Mechanical Discipline Drawings			S	P	P/C
Electrical Discipline Drawings			S	P	P/C
Instrumentation/Control System Discipline Drawings			S	P	P/C
Civil/Structural/Site Discipline Drawings			S	P	P/C

Figure 4. – Estimate Input Checklist and Maturity Matrix

REFERENCES

ANSI Standard Z94.2-1989. **Industrial Engineering Terminology: Cost Engineering**.
AACE International Recommended Practice No.17R-97, **Cost Estimate Classification System**.

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Recommended Practice No. 17R-97

Cost Estimate Classification System

August 12, 1997

PURPOSE

As a recommended practice of AACE International, the Cost Estimate Classification System provides guidelines for applying the general principles of estimate classification to asset project cost estimates. Asset project cost estimates typically involve estimates for capital investment, and exclude operating and life-cycle evaluations. The Cost Estimate Classification System maps the phases and stages of asset cost estimating together with a generic maturity and quality matrix that can be applied across a wide variety of industries.

This guideline and its addenda have been developed in a way that:

- provides common understanding of the concepts involved with classifying project cost estimates, regardless of the type of enterprise or industry the estimates relate to;
- fully defines and correlates the major characteristics used in classifying cost estimates so that enterprises may unambiguously determine how their practices compare to the guidelines;
- uses degree of project definition as the primary characteristic to categorize estimate classes; and
- reflects generally-accepted practices in the cost engineering profession.

An intent of the guidelines is to improve communication among all of the stakeholders involved with preparing, evaluating, and using project cost estimates. The various parties that use project cost estimates often misinterpret the quality and value of the information available to prepare cost estimates, the various methods employed during the estimating process, the accuracy level expected from estimates, and the level of risk associated with estimates.

This classification guideline is intended to help those involved with project estimates to avoid misinterpretation of the various classes of cost estimates and to avoid their misapplication and misrepresentation. Improving communications about estimate classifications reduces business costs and project cycle times by avoiding inappropriate business and financial decisions, actions, delays, or disputes caused by misunderstandings of cost estimates and what they are expected to represent.

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 and terminology, and may classify estimates in particular ways. This guideline provides a generic and generally-acceptable classification system that can be used as a basis to compare against. If an enterprise or organization has not yet formally documented its own estimate classification scheme, then this guideline may provide an acceptable starting point.

INTRODUCTION

An AACE International guideline for cost estimate classification for the process industries was developed in the late 1960s or early 1970s, and a simplified version was adopted as an ANSI Standard Z94.0 in 1972. Those guidelines and standards enjoy reasonably broad acceptance within the engineering and construction communities and within the process industries. This recommended practice guide and its addenda improves upon these standards by:

1. providing a classification method applicable across all industries; and
2. unambiguously identifying, cross-referencing, benchmarking, and empirically evaluating the multiple characteristics related to the class of cost estimate.

This guideline is intended to provide a generic methodology for the classification of project cost estimates in any industry, and will be supplemented with addenda that will provide extensions and additional detail for specific industries.

CLASSIFICATION METHODOLOGY

There are numerous characteristics that can be used to categorize cost estimate types. The most significant of these are degree of project definition, end usage of the estimate, estimating methodology, and the effort and time needed to prepare the estimate. The "primary" characteristic used in this guideline to define the classification category is the degree of project definition. The other characteristics are "secondary."

Categorizing cost estimates by degree of project definition is in keeping with the AACE International philosophy of Total Cost Management, which is a quality-driven process applied during the entire project life cycle. The discrete levels of project definition used for classifying estimates correspond to the typical phases and gates of evaluation, authorization, and execution often used by project stakeholders during a project life cycle.

Five cost estimate classes have been established. While the level of project definition is a continuous spectrum, it was determined from benchmarking industry practices that three to five discrete categories are commonly used. Five categories are established in this guideline as it is easier to simplify by combining categories than it is to arbitrarily split a standard.

The estimate class designations are labeled Class 1, 2, 3, 4, and 5. A Class 5 estimate is based upon the lowest level of project definition, and a Class 1 estimate is closest to full project definition and maturity. This arbitrary "countdown" approach considers that estimating is a process whereby successive estimates are prepared until a final estimate closes the process.

	Primary Characteristic	Secondary Characteristic			
ESTIMATE CLASS	LEVEL OF PROJECT DEFINITION Expressed as % of complete definition	END USAGE Typical purpose of estimate	METHODOLOGY Typical estimating method	EXPECTED ACCURACY RANGE Typical +/- range relative to best index of 1 [a]	PREPARATION EFFORT Typical degree of effort relative to least cost index of 1 [b]
Class 5	0% to 2%	Screening or Feasibility	Stochastic or Judgment	4 to 20	1
Class 4	1% to 15%	Concept Study or Feasibility	Primarily Stochastic	3 to 12	2 to 4
Class 3	10% to 40%	Budget, Authorization, or Control	Mixed, but Primarily Stochastic	2 to 6	3 to 10
Class 2	30% to 70%	Control or Bid/ Tender	Primarily Deterministic	1 to 3	5 to 20
Class 1	50% to 100%	Check Estimate or Bid/Tender	Deterministic	1	10 to 100

Notes: [a] If the range index value of "1" represents +10/-5%, then an index value of 10 represents +100/-50%.
[b] If the cost Index value of "1" represents 0.005% of project costs, then an index value of 100 represents 0.5%.

Figure 1 – Generic Cost Estimate Classification Matrix

DEFINITIONS OF COST ESTIMATE CHARACTERISTICS

The following are brief discussions of the various estimate characteristics used in the estimate classification matrix. For the secondary characteristics, the overall trend of how each characteristic varies with the degree of project definition (the primary characteristic) is provided.

Level of Project Definition (Primary Characteristic)

This characteristic is based upon percent complete of project definition (roughly corresponding to percent complete of engineering). The level of project definition defines maturity or the extent and types of input information available to the estimating process. Such inputs include project scope definition, requirements documents, specifications, project plans, drawings, calculations, learnings from past projects, reconnaissance data, and other information that must be developed to define the project. Each industry will have a typical set of deliverables that are used to support the type of estimates used in that industry. The set of deliverables becomes more definitive and complete as the level of project definition (i.e., project engineering) progresses.

End Usage (Secondary Characteristic)

The various classes (or phases) of cost estimates prepared for a project typically have different end uses or purposes. As the level of project definition increases, the end usage of an estimate typically progresses from strategic evaluation and feasibility studies to funding authorization and budgets to project control purposes.

Estimating Methodology (Secondary Characteristic)

Estimating methodologies fall into two broad categories: stochastic and deterministic. In stochastic methods, the independent variable(s) used in the cost estimating algorithms are generally something other than a direct measure of the units of the item being estimated. The cost estimating relationships used in stochastic methods often are somewhat subject to conjecture. With deterministic methods, the independent variable(s) are more or less a definitive measure of the item being estimated. A deterministic methodology is not subject to significant conjecture. As the level of project definition increases, the estimating methodology tends to progress from stochastic to deterministic methods.

Expected Accuracy Range (Secondary Characteristic)

Estimate accuracy range is in indication of the degree to which the final cost outcome for a given project will vary from the estimated cost. Accuracy is traditionally expressed as a +/- percentage range around the point estimate after application of contingency, with a stated level of confidence that the actual cost outcome would fall within this range (+/- measures are a useful simplification, given that actual cost outcomes have different frequency distributions for different types of projects). As the level of project definition increases, the expected accuracy of the estimate tends to improve, as indicated by a tighter +/- range.

Note that in figure 1, the values in the accuracy range column do not represent + or - percentages, but instead represent an index value relative to a best range index value of 1. If, for a particular industry, a Class 1 estimate has an accuracy range of +10/-5 percent, then a Class 5 estimate in that same industry may have an accuracy range of +100/-50 percent.

Effort to Prepare Estimate (Secondary Characteristic)

The level of effort needed to prepare a given estimate is an indication of the cost, time, and resources required. The cost measure of that effort is typically expressed as a percentage of the total project costs for a given project size. As the level of project definition increases, the amount of effort to prepare an estimate increases, as does its cost relative to the total project cost. The effort to develop the project deliverables is not included in the effort metrics; they only cover the cost to prepare the cost estimate itself.

RELATIONSHIPS AND VARIATIONS OF CHARACTERISTICS

There are a myriad of complex relationships that may be exhibited among the estimate characteristics within the estimate classifications. The overall trend of how the secondary characteristics vary with the level of project definition was provided above. This section explores those trends in more detail. Typically, there are commonalties in the secondary characteristics between one estimate and the next, but in any given situation there may be wide variations in usage, methodology, accuracy, and effort.

The level of project definition is the "driver" of the other characteristics. Typically, all of the secondary characteristics have the level of project definition as a primary determinant. While the other characteristics are important to categorization, they lack complete consensus. For example, one estimator's "bid" might be another's "budget." Characteristics such as "accuracy" and "methodology" can vary markedly from one industry to another, and even from estimator to estimator within a given industry.

Level of Project Definition

Each project (or industry grouping) will have a typical set of deliverables that are used to support a given class of estimate. The availability of these deliverables is directly related to the level of project definition achieved. The variations in the deliverables required for an estimate are too broad to cover in detail here; however, it is important to understand what drives the variations. Each industry group tends to focus on a defining project element that "drives" the estimate maturity level. For instance, chemical industry projects are "process equipment-centric"—i.e., the level of project definition and subsequent estimate maturity level is significantly determined by how well the equipment is defined. Architectural projects tend to be "structure-centric," software projects tend to be "function-centric," and so on. Understanding these drivers puts the differences that may appear in the more detailed industry addenda into perspective.

End Usage

While there are common end usages of an estimate among different stakeholders, usage is often relative to the stakeholder's identity. For instance, an owner company may use a given class of estimate to support project funding, while a contractor may use the same class of estimate to support a contract bid or tender. It is not at all uncommon to find stakeholders categorizing their estimates by usage-related headings such as "budget," "study," or "bid." Depending on the stakeholder's perspective and needs, it is important to understand that these may actually be all the same class of estimate (based on the primary characteristic of level of project definition achieved).

Estimating Methodology

As stated previously, estimating methodologies fall into two broad categories: stochastic and deterministic. These broad categories encompass scores of individual methodologies. Stochastic methods often involve simple or complex modeling based on inferred or statistical relationships between costs and programmatic and/or technical parameters. Deterministic methods tend to be straightforward counts or measures of units of items multiplied by known unit costs or factors. It is important to realize that any combination of methods may be found in any given class of estimate. For example, if a stochastic method is known to be suitably accurate, it may be used in place of a deterministic method even when there is sufficient input information based on the level of project definition to support a deterministic method. This may be due to the lower level of effort required to prepare an estimate using stochastic methods.

Expected Accuracy Range

The accuracy range of an estimate is dependent upon a number of characteristics of the estimate input information and the estimating process. The extent and the maturity of the input information as measured by percentage completion (and related to level of project definition) is a highly-important determinant of accuracy. However, there are factors besides the available input information that also greatly affect estimate accuracy measures. Primary among these are the state of technology in the project and the quality of reference cost estimating data.

State of technology—technology varies considerably between industries, and thus affects estimate accuracy. The state of technology used here refers primarily to the programmatic or technical uniqueness and complexity of the project. Procedurally, having "full extent and maturity" in the estimate basis deliverables is deceptive if the deliverables are based upon assumptions regarding uncertain technology. For a "first-of-a-kind" project there is a lower level of confidence that the execution of the project will be successful (all else being equal). There is generally a higher confidence for projects that repeat past practices. Projects for which research and development are still under way at the time that the estimate is prepared are particularly subject to low accuracy expectations. The state of technology may have an order of magnitude (10 to 1) effect on the accuracy range.

Quality of reference cost estimating data—accuracy is also dependent on the quality of reference cost data and history. It is possible to have a project with "common practice" in technology, but with little cost history available concerning projects using that technology. In addition, the estimating process typically employs a number of factors to adjust for market conditions, project location, environmental considerations, and other estimate-specific conditions that are often uncertain and difficult to assess. The accuracy of the estimate will be better when verified empirical data and statistics are employed as a basis for the estimating process, rather than assumptions.

In summary, estimate accuracy will generally be correlated with estimate classification (and therefore the level of project definition), all else being equal. However, specific accuracy ranges will typically vary by industry. Also, the accuracy of any given estimate is not fixed or determined by its classification category. Significant variations in accuracy from estimate to estimate are possible if any of the determinants of accuracy, such as technology, quality of reference cost data, quality of the estimating process, and skill and knowledge of the estimator vary. Accuracy is also not necessarily determined by the methodology used or the effort expended. Estimate accuracy must be evaluated on an estimate-by-estimate basis, usually in conjunction with some form of risk analysis process.

Effort to Prepare Estimate

The effort to prepare an estimate is usually determined by the extent of the input information available. The effort will normally increase as the number and complexity of the project definition deliverables that are produced and assessed increase. However, with an efficient estimating methodology on repetitive projects, this relationship may be less defined. For instance, there are combination design/estimating tools in the process industries that can often automate much of the design and estimating process. These tools can often generate Class 3 deliverables and estimates from the most basic input parameters for repetitive-type projects. There may be similar tools in other industry groupings.

It also should be noted that the estimate preparation costs as a percentage of total project costs will vary inversely with project size in a nonlinear fashion. For a given class of estimate, the preparation cost percentage will decrease as the total project costs increase. Also, at each class of estimate, the preparation costs in different industries will vary markedly. Metrics of estimate preparation costs normally exclude the effort to prepare the defining project deliverables.

ESTIMATE CLASSIFICATION MATRIX

The five estimate classes are presented in figure 1 in relationship to the identified characteristics. Only the level of project definition determines the estimate class. The other four characteristics are secondary characteristics that are generally correlated with the level of project definition, as discussed above.

This generic matrix and guideline provide a high-level estimate classification system that is nonindustry specific. Refer to subsequent addenda for further guidelines that will provide more detailed information for application in specific industries. These will provide additional information, such as input deliverable checklists, to allow meaningful categorization in that industry.

REFERENCES

ANSI Standard Z94.2-1989. **Industrial Engineering Terminology: Cost Engineering.**