Application for Approval to the Representative Policy Board for the North Branford Water Storage Tank Replacement Project

South Central Connecticut Regional Water Authority
July 29, 2025

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1. Statement of Application

This application is presented by the South Central Connecticut Regional Water Authority (SCCRWA) to the Representative Policy Board of the South Central Connecticut Regional Water District for approval of the North Branford Water Storage Tank Replacement Project. Section 19 of Special Act 77-98, as amended, requires the Representative Policy Board approval before the SCCRWA commences any capital project that will cost more than $3.5 million. The proposed project will cost approximately $10.2 million.

The existing North Branford Water Storage Tank is a 3.3 million gallon (MG) welded steel tank constructed in 1977. It is fed by the Lake Gaillard Water Treatment Plant through the North Branford Pump Station, providing storage for the North Branford, Cherry Hill and Stony Creek service areas. Other infrastructure at the site includes a below grade valve vault and water main constructed at the same time as the existing tank; a bituminous concrete driveway; and stormwater drainage system that connects to the municipal system.

During an interior and exterior recoating project in 2016, structural issues were identified on the interior roof. At that time, short-term repairs were made due to the risk associated with keeping the tank offline and the higher summertime demands. The repairs made were designed to maintain structural stability for a 3-5 year period. Since that time, the tank condition has been monitored through regular inspections. A project to address the larger repairs was bid in early 2020 but not advanced due to the stability of the short term repairs and operational concerns. In 2024, an interior inspection was performed while the tank was in-service to observe any changes in the condition of the internal steel. Both a remote operated vehicle and a boroscope were utilized to capture photographs. While still stable, the condition of the tank is continuing to decline with age. Appendix A contains the North Branford Tank Interior Roof 2024 Inspection. While the repairs have lasted longer than expected, a permanent solution must be executed in the next few years to continue providing a reliable supply for customers, as well as emergency storage for fire protection, main breaks and other emergencies.

For this application, the SCCRWA has engaged Tighe & Bond as the consulting engineer for hydraulic modeling, engineering design associated with the proposed 1.76 MG prestressed concrete water storage tank, valve vault and associated site improvements, as well as development of a project cost estimate. Appendix B, entitled ‘North Branford, Cherry Hill, and Stony Creek Service Area Storage Capacity Analysis’, rev. June 2025, evaluated the need for water storage within the service areas and was utilized as the basis of design. Appendix C contains the 90% complete design drawings for the North Branford Water Storage Tank Replacement project.

Once the new tank is built and placed into service, the existing tank will be removed from service and demolished. By keeping the existing tank in service during construction, service to the supply areas is expected to remain uninterrupted. From a long-term perspective, a concrete tank does not require the same level of maintenance as a welded steel tank, and a concrete tank can remain in service for most regular maintenance tasks. This project will also improve water quality by increasing mixing within the new tank and tank turnover.

When the existing tank was originally designed, a future second tank was also sited on the parcel. While having two tanks provides greater operational flexibility, recent improvements in the affected service areas have provided a greater redundancy of supply and some flexibility of operations. The site will remain configured for the addition of a second tank; however, it is not the most effective and efficient use of customer dollars from a cost vs. benefit perspective at this time.

This application will provide a description of the project, a detailed explanation of why the project is necessary, a discussion of the alternatives considered, and the estimated cost of the construction.

2. Description of the Proposed Action

This project will include a new prestressed concrete ground storage tank, paved access driveway, 10-foot wide gravel maintenance strip around the tank, below grade valve vault containing piping, valving and appurtenances necessary to connect the new tank to the existing water main on site, as well as stormwater site improvements required for compliance with existing regulations. Additionally, the existing tank will be demolished following the construction of the new tank.

The proposed water storage tank will be 81-feet in diameter with a capacity of 1.76 MG. It will be located on the same property as the existing 3.3 MG steel storage tank at 25-45 West Pond Road in North Branford, Connecticut. The new tank will be constructed to the north of the existing tank and connected to the existing water main on the west side of the property. The existing tank will remain in service during the construction of the new tank.

Specifically, the work consists of:

- Site
  - Installation of Sedimentation and Erosion Controls
  - Clearing and grading of the site in preparation for tank construction.
  - Backfilling around the tank and landscaping when the tank construction is complete.
  - Installing new drainage and stormwater management systems to control site runoff.
  - Extending the existing driveway around the new tank and repaving the existing driveway.
  - Expanding the existing fence perimeter to include the new tank.
- Structural/Mechanical
  - Constructing a new 1.76 MG prestressed concrete storage tank with access hatches, exterior staircase, and dome railing.
  - Installing a trihalomethane (THM) removal system for the tank, including a mixer, power vent, surface aerator, and controls.
  - Constructing a new valve vault including access stairway, heater, dehumidifier, and exhaust fan to control the environment within the vault; tank level instrumentation; altitude valve, a check valve, and associated isolation valves for this tank as well as valving to allow for future connection of a second tank if necessary.
  - Installing yard piping and valving necessary to tie the new tank into the existing water main.
- Electrical
  - Providing a new electrical service from West Pond Road to the site.
  - Installing new electrical equipment to provide power to the new valve vault, process equipment and site lighting.
  - Installing new communications equipment to connect the new infrastructure to SCCRWA's existing SCADA system.

3. Need for the Proposed Action

The North Branford Water Storage Tank is an integral piece of infrastructure in SCCRWA's water distribution system. It provides treated water and fire protection to customers in the North Branford, Cherry

Hill, and Stony Creek service areas. Given the structural condition of the existing tank, there is risk to the continued service and reliability of service in these areas. Constructing this replacement tank, while the existing tank is still in service will ensure uninterrupted water supply and fire protection to the affected areas and will allow the existing tank to be taken out of service permanently once the new tank is constructed and in service.

Since the construction of the existing tank, sized at 3.3 MG, there have been significant changes in the distribution system infrastructure and customer demands. Some of these changes include the 2019 Brushy Plains Improvements Project, which combined the North Branford, Cherry Hill, and Stony Creek service areas. Infrastructure improvements consisted of upgrading the pumps/motors/VFDs, piping and valving, generator and transfer switch at the Cherry Hill Pump Station to operate more effectively and efficiently, the demolition of the Brushy Plains Tank and installation of approximately 12,000 linear feet (LF) of piping. It is well known that customer demands have been declining at a rate of 1% per year for many years due to low-flow fixtures and conservation. Given these differences, from the time the tank was originally designed in the late 1970's, it was critical to analyze the current and projected future hydraulic conditions when sizing the new tank. As mentioned previously, a detailed hydraulic evaluation was completed by Tighe & Bond and is included in Appendix B. This evaluation assessed multiple scenarios of the infrastructure capable of providing water in the service area (North Branford and Cherry Hill Pump Stations, North Branford Tank) and reasonably concluded that a 1.76 MG Tank would not only meet the required equalization storage and emergency/fire protection storage, as specified by regulatory guidelines, but would also provide an additional contingency to address a reasonable level of additional demand associated with emergencies.

The current tank capacity of 3.3 MG is no longer necessary to meet the current need. A smaller tank will also improve water quality and water age. Current issues with low chlorine with associated flushing are expected to be minimal following the construction of the proposed tank. Additionally, water age at the tank will reduce from an estimated 4.8 days with the existing tank to 2.5 days with the proposed tank under average day demand conditions.

More specifically, it has been determined that this project is necessary based on the following reasons:

- Reliability: Structural issues have been identified at the existing water storage tank that need to be addressed in a timely manner to prevent failure. The existing tank is critical to providing water storage to meet domestic demands and fire flow demands in the North Branford, Cherry Hill and Stony Creek service areas. Taking the tank out of service for repairs adds a significant risk to SCCRWA's operations ability to provide consistent, reliable service due to the necessity of the tank being used for water storage in the community. The construction of a new tank, while the existing tank remains in service, will ensure that supply to the service areas is not interrupted and adequate capacity will be available for emergency events such as a large fire or main break.

- Safety: Safety is a concern due to the structural issues with the existing tank and possible failure. Not only would the actual failure pose a safety risk, but it would also deplete a necessary water supply for the community without any backup equalization or emergency storage.

- Water Quality: Water age and quality will be greatly improved with the execution of this project.

4. Analysis of the Alternatives to the Proposed Action

In determining the best course of action for how to address the need for reliable storage in the North Branford, Cherry Hill, and Stony Creek service areas, SCCRWA evaluated several alternatives. The alternatives included the no action approach, repair of the existing tank, or construction of a new tank on the same site as the existing tank.

Alternative 1 – No Action/Status Quo: If no action is taken to provide a new storage tank or repair the existing storage tank, the risk of failure of the existing tank will remain unresolved and continue to increase. A failure of the existing tank would risk system reliability by rendering the service areas without water storage. It also poses a safety risk to SCCRWA personnel and the public, and a risk to SCCRWA property and private property in the area. Due to these risks, this alternative was dismissed.

Alternative 2 – Repair Existing 3.3 Million Gallon Tank: The existing tank is nearly 50 years old, and has been in service for over 2/3 of its expected useful life. As mentioned previously in this application, structural issues were identified on the interior roof during the tank painting project in 2016. At that time, short-term repairs, addressing missing bolts and some corrosion, were made due to the risk associated with keeping the tank offline and the higher summertime demands. These repairs have maintained structural stability longer than expected; however, based on recent inspections, a permanent solution must be executed in the next few years in order to continue providing a reliable supply for the affected service areas (Refer to Appendix A for the detailed 2024 inspection).

Repairing the existing tank would address the structural concerns and arguably extend the useful life of the tank. In the long term this tank will still need to be recoated, may require additional extensive steel repairs in the future, and/or reach the end of its useful life much sooner than expected. Steel tanks generally require painting touch-ups every 10 years and a full recoat approximately every 20 years, which would require the tank to be taken offline and increase risk to SCCRWA operations. With no other storage in the service area, temporary storage would likely need to be provided at an estimated cost of over $1.0 million. The upfront repairs would cost less than the other alternatives reviewed, however the future capital costs associated with tank painting every 20 years will increase the life-cycle costs significantly (Refer to Appendix D for the Business Case Evaluation).

Additionally, there have been concerns in recent years that water quality is a concern, due to the tank capacity being in excess of the service area requirements. Decreases in demand and improvements in the service areas, resulting from the Brushy Plains Improvements project, have reduced the supply requirements. Low levels of chlorine have been experienced frequently and flushing has increased, which would initiate investigation of a chlorine booster station should this alternative be selected. If deemed necessary, the construction of a booster station would add a significant cost to this alternative, estimated at $750,000. Repairing the tank would not address these issues.

Given the future maintenance requirements, the associated risk of taking the tank offline, improper sizing of this tank to meet current and future needs, water quality concerns, and high life-cycle costs, this alternative was not selected.

Alternative 3 – Construct a New 3.3 Million Gallon Water Storage Tank: A new in-kind water storage tank could be built adjacent to the existing water storage with the existing tank in service. As discussed in Alternative 2, this tank would be oversized and exacerbate concerns with excess storage capacity for the service area and water quality is a concern. Additionally, water quality concerns would remain and consideration for a chlorine booster station would be required. Finally, the cost associated with this alternative would be the highest and not efficient use of customers dollars. For these reasons, this alternative was dismissed.

Alternative 4 – Construct a New 1.76 Million Gallon Water Storage Tank: A new water storage tank could be built adjacent to the existing water storage tank to supply equalization volume and emergency storage to the service area. Following the construction of the new tank, the existing tank could be taken offline for replacement. This would ensure the service area has a reliable source of storage while work is completed on the existing tank. Utilizing prestressed concrete to build the tank will minimize the need to take the tank offline for normal maintenance tasks over the lifespan of the asset. Sizing the tank conservatively and for reasonable emergencies is a prudent balance of customer dollars spent on this project and the needs of the overall SCCRWA system. Options for tank material and size that were considered as part of the design process are described below (Refer to Appendix B for further details on this Alternative, North Branford, Cherry Hill, and Stony Creek Service Area Storage Capacity Analysis, September 2024).

Tank Material – Both welded steel and prestressed concrete tanks were reviewed as options for the new tank. Concrete tanks require less frequent maintenance and, due to business case comparisons associated with recent new tanks, SCCRWA has selected concrete tanks for its most recent tanks. Both concrete and welded steel tanks require regular inspections, per CTDPH regulations, internal inspections can be completed with ROV equipment which allows the tank to remain in service. The main difference in maintenance is that the welded steel tanks require painting, requiring the tank to be taken offline. This adds risk to the system, particularly since this is a single storage tank. Given the reduced maintenance cost and the reduced likelihood of having to take the tank offline to conduct normal maintenance, a concrete tank is preferred to a welded steel tank.

Tank Size – To select the size of a new storage tank, the required equalization storage and emergency/fire protection storage was calculated. Appendix B provides details on the methodology used and results of the storage capacity analysis. In summary, the analysis reviewed several pumping scenarios to determine the amount of storage needed when demand is greater than the pumping scenario. SCCRWA selected the pumping scenario of two pumps available at Cherry Hill Pump Station with the North Branford Pump Station out of service (no pumps available) that requires a storage tank volume of 1.76 MG, as recommended by Tighe & Bond. This scenario balances the need to provide storage during high demand periods and emergencies with an additional level of contingency to account for any future changes in demands or infrastructure in the system and timeframe before a second tank becomes necessary.

4.1 Business Case Evaluation

A Business Case Evaluation (BCE) on 3 alternatives was performed by RWA to further compare and evaluate Alternatives 2, 3 and 4, and is included in Appendix D, 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 (75 years) show a significant decrease in the present value of annual operating and maintenance costs for both alternatives (over the Status Quo). Overall, an estimated $4 million over the tank’s lifecycle is anticipated to be saved by implementation of this alternative through reduction of maintenance costs from the Status Quo and reduction of flushing activities.
2. Risk Reduction: The Risk Reduction Effectiveness Factor is the highest for Alternative 4. All of the alternatives were evaluated to reduce the Risk Cost from the Status Quo, with the new tank alternatives being the most impactful. The Risk Cost (annual basis) of the Status Quo is about $2.2 million. The overall Residual Risk Cost (annual basis) is about $907,000 for Alternatives 3 and 4.
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 12.26; followed by Alternative 3, with a much lower result of 6.89.

Based on the results of the BCE, Alternative 4, Construct a New 1.76 Million Gallon Water Storage Tank 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.

SCCRWA concluded based on the storage capacity analysis and Business Case Evaluation and their experience that Alternative 4, construction of a new 1.76 MG prestressed concrete storage tank, was the most favorable in terms of reliability and safety.

5. Statement of the Cost to Be Incurred and/or Saved

5.1 Capital Cost

This project will result in a capital expenditure of approximately $10.2 million. 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 90% complete design drawings, prepared in June of 2025 and include demolition of the existing 3.3 MG tank, accounting for a projected scrap metal credit for the tank material.

TABLE 1
Estimated Project Capital Cost

Description	Capital Cost
Previous Expenditures (through May 2025)	$364,828
Remaining Consultant Engineering Fees	
Design	$103,773
Construction Administration	$300,000
Construction Observation	$350,000
Construction	$7,606,623
10% Construction Contingency	$760,662
Inflation – 3% per year to midpoint of construction	$411,990
RWA Costs - Project Management, Permitting, SCADA Programming, Department Coordination	$280,000
Total Project Costs	$10,177,876
Rounded Total	$10,200,000

In accordance with cost estimating principles, the project costs have been adjusted for inflation forward 12 months from the date of this application, to the mid-point of construction, which is anticipated to be June 2026.

For the construction cost estimate, a 10% 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 F. In a Class 1 estimate, the design of the project is expected to be between 65% to 100% complete and accurate within -10% to +15%. The AACE defines contingency as a specific provision for unforeseeable elements of cost within the defined project scope, particularly where experience has shown that unforeseeable costs are likely to occur. Also, the 10% contingency allowance is included at this design stage for uncertainty in bid prices due to escalation of prices and to reduce the risk of possible cost overruns.

5.2 Operation and Maintenance Cost

Operation and maintenance (O&M) expenditures is expected to remain similar to the existing site. This includes periodic maintenance of valves and monitoring equipment in the valve chamber, electricity for the chamber, power mixer and site lighting, water quality sampling, police patrols, and site maintenance. Additionally, the site will still need to be maintained with mowing, snowplowing, etc. There may be less frequency in the power washing (with less condensation on the outside of the tank) and less compliance flushing due to reduced water age, which may result in a slight decrease. Painting of the steel tank is a capital expense, which will only affect the lifecycle costs, not the O&M.

5.3 Bonds or Other Obligations the SCCRWA Intends to Issue

The annual cost of this project to a typical residential customer using 5 ccf's a month, assuming a conservative financing assumption of RWA Bonds, would be approximately $2.64, based on the project cost of $10.2 million. For a residential customer using 8 ccf's a month, the annual cost of this project would be approximately $3.58.

However, we expect this project to be funded by a combination of funding sources. This project has the potential for funding under the Connecticut Department of Public Health's (CTDPH) Drinking Water State Revolving Fund (DWSRF) and appears on the comprehensive listing in CTDPH DWSRF Annual Intended Use Plan SFY 2025. By utilizing these funding sources, the total financing costs associated with this project will be reduced. Internally generated funds may also be used.

6. Preliminary Project Schedule and Permitting

6.1 Schedule

The project schedule is presented below.

1.	Preliminary Design:	December 2023
2.	90% Design	June 2025
3.	DPH Permitting	July 2025 – October 2025
4.	RPB Submission & Approval	July 2025 – October 2025
5.	Final Design	October - November 2025
6.	Bidding	October - November 2025
7.	Award	December 2025 – January 2026
8.	Active Construction	February 2026 - June 2027
9.	Start-up, Optimization, and Completion	July 2027

Active construction on this project is expected to occur from February 2026 through June 2027, with the new storage tank operational by August 2027. The tank site is within a known habitat for two species of endangered bats, the northern long-eared bat and the Indiana bat. To minimize the impact to the species, tree clearing will occur during the inactive period for the bats; November 1 through April 15.

6.2 Permitting

This project involves the addition of a new water storage tank and associated water main/piping extension. The project will require the following permit approvals from the Connecticut Department of Public Health:

- Public Water System General Application for Approval or Permit
- Storage Tank Project Application

Other permitting efforts for this project include:

- North Branford Local Permitting: Local permitting efforts included the submission of a variance, zoning permit, special use permit and inland wetlands permit to the Town of North Branford. After the Town completed their review, they granted an approval of a Special Use Permit for the project.
- Wetlands Delineation: Tighe & Bond performed a wetlands delineation at the site and found no direct impacts to the wetlands areas.
- Natural Diversity Database Filing: A Natural Diversity Database (NDDB) filing to the Connecticut Department of Energy & Environmental Protection was submitted. The NDDB Determination confirmed the presence of two state listed species of bats that may occur within the vicinity of the site: Northern long-eared bat (*Myotis septentrionalis*) and Tri-colored bat (*Perimyotis subflavus*). The determination included a time of year restriction for tree cutting that prohibits cutting between April 15 and October 31. Other construction activities are allowed during this time.
- Project Notification Submission: Project Notifications were submitted to the CT State Historic Preservation Office (SHPO) and Tribal Historic Preservation Office (THPO), to the following tribes:
    - Mohegan Tribe of Indians of Connecticut
    - Mashantucket Pequot Tribal Nation
    - Narragansett Indian Tribe
    - Wampanoag Tribe of Gay Head (Aquinnah)
- US Fish and Wildlife Service (USF&WS) Determination: A USF&WS determination was submitted for the project and identified three federally listed species that may occur within the vicinity of the site: Northern long-eared bat, Tri-colored bat, and Indiana bat (*Myotis sodalis*). For all species we received a determination of “may affect, not likely to adversely affect” based on the tree clearing prohibitions noted above.

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

- Provides the most efficient solution to the structural concerns and system operations of the existing North Branford Tank.
- Maintains the necessary capacity to supply the North Branford, Cherry Hill, and Stony Creek service areas to meet the current and future needs.
- Improves water quality by reducing water age and in turn helps to ensure that chlorine residuals are maintained.

8. Explanation of Unusual Circumstances Involved in the Application

There were no unusual circumstances involved in this application.

9. Conclusion

The existing 3.3 MG North Branford Tank is a critical asset for the SCCRWA. The tank has structural issues that continue to degrade over time, putting the ability for the SCCRWA to provide water for consumption, fire protection and emergency response to the North Branford, Cherry Hill, and Stony Creek service area at risk. Additionally, as the tank condition continues to deteriorate, the risk of failure increases, causing additional liability and safety concerns. The proposed project, as presented in this application, will address the needs of the existing structural issues, provide the right amount of storage, and improve water age and quality to help to ensure a continuous reliable, high-quality water supply to our customers for many years to come.

Detailed studies have been conducted to research repairing or replacing the tank, considering tank useful life, sizing and material. Storage requirements for current and future needs have been confirmed within the affected service areas, taking into consideration recent distribution system changes and improvements. This proposed project is the most effective plan for addressing the issues with the North Branford Tank. Further delays to the project will likely result in higher future costs and increase the likelihood of failure.

The SCCRWA staff has therefore concluded that, at $10.2 million, the proposed action is in the best interests of our customers and is consistent with the policies and advances the goals of the South Central Connecticut Regional Water Authority.

Appendix A

North Branford Tank Interior Roof 2024 Inspection,

February 6, 2025

- CAUTION -

THE DISCLOSURE OF CERTAIN INFORMATION ON PAGES, MAPS OR OTHER MATERIALS STAMPED HEREIN MAY POSE A SAFETY AND SECURITY RISK TO PERSONS AND/OR PROPERTY. THE DETERMINATION TO DISCLOSE THIS INFORMATION SHALL ONLY BE MADE PURSUANT TO C.G.S. SECTION 1-210. PLEASE CONTACT THE SOUTH CENTRAL CONNECTICUT REGIONAL WATER AUTHORITY WITH ANY QUESTIONS.

Appendix B

North Branford, Cherry Hill, and Stony Creek Service Area Storage Capacity Analysis, Rev. June 2025

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Appendix C

North Branford Water Storage Tank Replacement 90% Design Drawings

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Appendix D

North Branford Tank Business Case Evaluation, June 2025, prepared by RWA

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Appendix E

Engineer's Opinion of Probable Cost for the North Branford Water Storage Tank Replacement

ENGINEER'S OPINION OF PROBABLE PROJECT COST Tighe&Bond

Project: **North Branford Water Storage Tank Replacement Project**
Location: **North Branford, CT**

Prepared By: JR, AW, SC, TV, CL

Estimate Type: ☐ Conceptual ☐ Preliminary Design ☐ Design Development ☑ Construction ☐ Change Order 90 % Complete

Date Prepared: 6/12/2025

T&B Project No.: S1889-A51

Spec. Section	Item No.	Description	Qty	Units	Material/Installed Cost $/Unit	Material/Installed Cost Total	Installation $/Unit	Installation Total	Total
DIVISION 1 - GENERAL REQUIREMENTS			(Costs included in unit prices in other Divisions)						
	1	10% of Construction Subtotal	1	LS	$601,320	$601,320		$0	$601,320
SUBTOTAL - DIVISION 1						**$601,320**		**$0**	**$601,320**
DIVISION 2 - SITE CONSTRUCTION									
02075	1	Geosynthetics							
	a	Filter Fabric for Stone Swale	650	SY	$7	$4,550		$0	$4,550
02200	2	Clearing and Grubbing	1	LS	$50,000	$50,000		$0	$50,000
02220	3	Demolition							
	a	3.3 MG Steel Water Storage Tank and Appurtenances	1	LS	$200,000	$200,000		$0	$200,000
	b	Disposal of Contaminated Soils Below Tank - Oil	400	Ton	$100	$40,000		$0	$40,000
	c	Disposal of Contaminated Soils Around Tank - Lead	81	Ton	$170	$13,767		$0	$13,767
02315	4	Excavation, Backfill, Compaction and Dewatering							
	a	Earth Excavation	5,000	CY	$30	$150,000		$0	$150,000
	b	Rock Excavation	100	CY	$150	$15,000		$0	$15,000
	c	Reuse Stockpiled Fill	2,500	CY	$30	$75,000		$0	$75,000
02320	5	Borrow Material							
	a	Process Aggregate Base	400	CY	$60	$24,000		$0	$24,000
	b	Gravel Access around Tank	90	CY	$45	$4,038		$0	$4,038
	c	Tank Leveling Base (12" Thick)	260	CY	$50	$13,000		$0	$13,000
	d	Modified Rip Rap (18" Thick)	325	CY	$125	$40,625		$0	$40,625
02370	6	Erosion Control Measures							
	a	Sediment Control Filter Straw Wattle Fence System	1,300	LF	$15	$19,500		$0	$19,500
	b	Sediment Control Filter Fabric Fence System	1,500	LF	$6	$9,000		$0	$9,000
	c	Sediment Control System at Catch Basin	5	EA	$160	$800		$0	$800
	d	Erosion Control Blanket	4,660	SY	$5	$23,300		$0	$23,300
	e	Construction Entrance	245	SY	$25	$6,125		$0	$6,125
	f	Stone Check Dam	8	EA	$500	$4,000		$0	$4,000
	g	Temporary Sediment Trap	1	LS	$15,000	$15,000		$0	$15,000
02514	7	Ductile Iron Pipe and Fittings							
	a	Restrained 8" Ductile Iron Pipe	86	LF	$250	$21,500		$0	$21,500
	b	Restrained 16" Ductile Iron Pipe	275	LF	$400	$110,000		$0	$110,000
	c	Restrained 20" Ductile Iron Pipe	60	LF	$500	$30,000		$0	$30,000
02516	8	High Density Polyethylene Pipe and Fittings							
	a	8" HDPE Pipe	85	LF	$80	$6,800		$0	$6,800
	b	12" HDPE Pipe	858	LF	$100	$85,800		$0	$85,800
	c	2" Sump Pump Discharge	12	LF	$40	$480		$0	$480
	d	Flared End Section	0	EA	$2,000	$0		$0	$0

ENGINEER'S OPINION OF PROBABLE PROJECT COST

Tighe&Bond

Project: North Branford Water Storage Tank Replacement Project
Location: North Branford, CT

Prepared By: JR, AW, SC, TV, CL

Estimate Type: ☐ Conceptual ☐ Preliminary Design ☐ Design Development ☑ Construction ☐ Change Order 90 % Complete

Date Prepared: 6/12/2025

T&B Project No.: S1889-A51

Spec. Section	Item No.	Description	Qty	Units	Material/Installed Cost $/Unit	Material/Installed Cost Total	Installation $/Unit	Installation Total	Total
02518	9	Valves and Hydrants							
	a	Hydrant Assemby	1	EA	$12,000	$12,000		$0	$12,000
	b	8" Gate Valve	1	EA	$4,000	$4,000		$0	$4,000
	c	16" Gate Valves	4	EA	$16,000	$64,000		$0	$64,000
	d	20" Gate Valve	3	EA	$20,000	$60,000		$0	$60,000
02533	10	Stormwater Management System	1	LS	$250,000	$250,000		$0	$250,000
02740	11	Bituminous Concrete Pavement							
	a	HMA Surface Course	200	Ton	$150	$30,000		$0	$30,000
	b	HMA Binder Course	200	Ton	$150	$30,000		$0	$30,000
	c	Bituminous Concrete Curb	250	LF	$15	$3,750		$0	$3,750
02820	12	Chain Link Fences and Gates							
	a	6' High Chain Link Fence	1,080	LF	$75	$81,000		$0	$81,000
	b	6' High Double Swing Gate	1	EA	$2,000	$2,000		$0	$2,000
	c	10' High Chain Link Fence (Around Tank Stair Only)	40	LF	$95	$3,800		$0	$3,800
	d	10' High Man Gate	1	EA	$1,000	$1,000		$0	$1,000
02900	13	Landscaping	1	LS	$15,000	$15,000		$0	$15,000
	a	Black Spruce	9	EA	$800	$7,200		$0	$7,200
	b	White Cedar	10	EA	$800	$8,000		$0	$8,000
02920	14	Lawns and Grasses	6,300	SY	$10	$63,000		$0	$63,000
SUBTOTAL - DIVISION 2						**$1,592,485**		**$0**	**$1,597,035**
DIVISION 3 - CONCRETE									
03300	1	Misc Equipment Pad, Stair Landing and Bollard	1	LS	$8,000	$8,000		$0	$8,000
03485	2	Cast in Place Concrete							
	a	Precast Concrete Structures - Valve Vault	1	LS	$653,000	$653,000		$0	$653,000
	b	Type "C" Catch Basin - 0' - 10' Deep	4	EA	$5,000	$20,000		$0	$20,000
	c	48" Manhole - 0' - 10' Deep	4	EA	$6,000	$24,000		$0	$24,000
	d	72" Manhole - 0' - 10' Deep	1	EA	$8,000	$8,000		$0	$8,000
	e	Water Quality Structure	1	EA	$16,000	$16,000		$0	$16,000
	f	Outlet Control Structure	1	EA	$15,000	$15,000		$0	$15,000
	g	Remove Drainage Structure (Headwalls)	1	EA	$2,500	$2,500		$0	$2,500
	h	Dechlorination Chamber	1	EA	$6,000	$6,000		$0	$6,000
SUBTOTAL - DIVISION 3						**$752,500**		**$0**	**$752,500**
DIVISION 5 - METALS									
05500	1	Miscellaneous Metals - Tank Staircase	1	LS	$100,000	$100,000		$0	$100,000
SUBTOTAL - DIVISION 5						**$100,000**		**$0**	**$100,000**
DIVISION 11 - EQUIPMENT									
11232	1	THM Removal System	1	LS	$225,000	$225,000		$0	$225,000
SUBTOTAL - DIVISION 11						**$225,000**		**$0**	**$225,000**

ENGINEER'S OPINION OF PROBABLE PROJECT COST Tighe&Bond

Project: **North Branford Water Storage Tank Replacement Project**
Location: **North Branford, CT**

Prepared By: JR, AW, SC, TV, CL

Estimate Type: ☐ Conceptual ☑ Construction
☐ Preliminary Design ☐ Change Order
☐ Design Development 90 % Complete

Date Prepared: 6/12/2025
T&B Project No.: S1889-A51

Spec. Section	Item No.	Description	Qty	Units	Material/Installed Cost $/Unit	Material/Installed Cost Total	Installation $/Unit	Installation Total	Total
DIVISION 13 - SPECIAL CONSTRUCTION									
13204	1	Prestressed Concrete Tank							
	a	1.76 MG Prestressed Concrete Water Storage Tank	1	LS	$2,150,000	$2,150,000		$0	$2,150,000
	b	Tank Appurtenances	1	LS	$450,000	$450,000		$0	$450,000
13420	2	Instrumentation	1	LS	$30,000	$30,000		$0	$30,000
SUBTOTAL - DIVISION 13						**$2,630,000**		**$0**	**$2,630,000**
DIVISION 16 - ELECTRICAL									
16000	1	General Electrical - Utility, Demolition, Etc	1	LS	$54,000	$54,000		$0	$54,000
16050	2	Electrical Equipment	1	LS	$101,000	$101,000		$0	$101,000
16120	3	Conduit and Wire	1	LS	$493,000	$493,000		$0	$493,000
16140	4	Devices and Boxes etc	1	LS	$15,000	$15,000		$0	$15,000
16500	5	Luminaires	1	LS	$28,000	$28,000		$0	$28,000
	6	Misc Electrical	1	LS	$17,600	$17,600		$0	$17,600
SUBTOTAL - DIVISION 16						**$708,600**		**$0**	**$708,600**
SUB-TOTAL									$6,614,455
CONTRACTOR OH&P			@	15%					$992,168
SUB-TOTAL WITH OH&P									**$7,606,623**
CONTINGENCY			@	10%					$760,662
CONSTRUCTION SUBTOTAL									**$8,367,286**
Escalation to Mid Point of Construction (Anticipated June 2026)			@	3%					$411,990
CONSTRUCTION SUB TOTAL WITH ESCALATION									**$8,779,276**
								SAY	**$8,780,000**
ENGINEERING - DESIGN PHASE									$303,600
ENGINEERING - CONSTRUCTION ADMIN									$300,000
ENGINEERING - CONSTRUCTION OBSERVATION									$450,000
PROJECT TOTAL									**$9,832,876**
								SAY	**$9,900,000**

Appendix F

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

aace International

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

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

Figure 3b. – Comparison of Classification Practices

INCREASING PROJECT DEFINITION

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

[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

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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.**