**City of Portland Low-Embodied Carbon Concrete Threshold Committee**
**Background on the Development of the Concrete Embodied Carbon Thresholds and Implementation Recommendations for the City of Portland**

**March 4, 2022**

The City of Portland Low-Embodied Carbon Concrete Threshold Committee was established by the City's Sustainable Procurement Program in December 2020 to develop recommendations for concrete embodied carbon thresholds and corresponding implementation strategies to reduce the carbon intensity of the concrete used on City projects. This document provides background information regarding the Committee composition and highlights from the Committee's discussions that defined the resulting recommendations dated March 4, 2022.

**2020-2022 Committee Composition**

The composition of the committee was developed to ensure representation from key stakeholders involved on City-owned or solicited construction projects and who specify, supply, and work with concrete, or otherwise have expertise related to shifting concrete use to lower-carbon mixes. The Sustainable Procurement Program staff sought to keep the committee to about 20 individuals, to enable engaging (online) meetings where all stakeholders had a reasonable opportunity to contribute. The following are the key stakeholder types (and number of representatives) making up the Committee: City bureaus (4), Oregon Department of Environmental Quality - Materials Management Division (1), concrete producers (5), engineers (3), contractors who frequently work on City projects (4), architects (1), and Oregon Concrete and Aggregate Producers Association (1). The Sustainable Procurement Program staff also sought diverse representation within the stakeholder types in terms of company size, project portfolios (small/large, buildings/infrastructure), and business ownership.

The 2020-22 Committee comprised of the following individuals:
**(bold indicates regular attendance/contributions)**

| Name | Representing | Stakeholder Type |
|---|---|---|
| **Stacey Foreman** | City of Portland – Sustainable Procurement Program | City Bureau/Committee Convener |
| **Joe Broberg** | City of Portland – Water Bureau | City Bureau |
| **Todd Liles** | City of Portland – Bureau of Transportation | City Bureau |
| **Andrew Weiher** | City of Portland – Bureau of Environmental Services - Materials Testing Lab | City Bureau |
| **Jordan Palmeri** | Oregon Department of Environmental Quality | Subject Matter Expert – Low Carbon Concrete |
| **Dave Germer** | CalPortland | Concrete Producer |
| **Greg Wong** | Knife River | Concrete Producer |
| **Robert Raynes** | Cadman | Concrete Producer |
| **Michael Bernert** | Wilsonville Concrete | Concrete Producer |
| Brian Moran (alt: Mike Anderson) | Troutdale Sand and Gravel | Concrete Producer |
| **Eric McDonnell** | Holmes Structures | Engineer |
| **Matthew Perkins** | Stantec | Engineer |
| **Josh Richards** | KPFF Engineers | Engineer |
| **Steve Clem** | Skanska | Contractor |

| | | |
|---|---|---|
| **Bill Mariucci** | Kiewit Corporation | Contractor |
| Cary Bubenik | Hoffman Construction Company | Contractor |
| **Webster (Web) Moreland** | Raimore Construction | Contractor |
| **Baha Sadreddin** | ZGF Architects / Jacobs | Architect |
| Rich Angstrom | Oregon Concrete and Aggregate Producers Association | Subject Matter Expert |

The full committee met four times over the course of 13 months. Additional meetings were held with subsets of the committee – either by stakeholder group or by topic. There was a significant delay between the first three and the fourth of the committee meetings due to the committee's decision to tie the thresholds to the PNW NRMCA Benchmarks, *AND* to wait for the update to those Benchmarks following the release of new cement industry LCA data in March 2021. This waiting period also accommodated the time needed for LCA software tools that produce EPDs to be updated with the new cement LCA data.

**Committee Goals**

The Committee's work was based on the following overarching goal:

- Develop recommendations to the City on low-embodied carbon thresholds to be used in concrete specifications. Include key implementation recommendations, such as how to calculate and reasonable exemptions
    - These thresholds shall be:
        - ✓ Meaningful = will result in a reduction in embodied carbon compared to baseline
        - ✓ Feasible = can meet thresholds with current technologies/know-how while still meeting concrete performance needs for all kinds of applications
        - ✓ Equitable = recommendations do not result in excluding any key stakeholders; impacts of thresholds on all types of operations are considered; implementation strategies developed accordingly

    The Committee will strive for consensus on the recommendations.

**Key Committee Discussion Points and Rationale for Proposed Recommendations**

The following table highlights key discussion points and rationale for the proposed recommendations to document (in a succinct manner) what factored into the Committee's decisions.

Acronyms Used In this Table

EPD = Environmental Product Declaration
GHG = Greenhouse Gas
GWP = Global Warming Potential
HPC = High Performance Concrete
ODOT = Oregon Department of Transportation
PNW NRMCA Benchmarks = concrete mix lifecycle analysis benchmarks (industry averages) for the Pacific Northwest Region of the National Ready Mix Concrete Association [1]
SCM = Supplemental Cementitious Material

[1] https://www.nrmca.org/wp-content/uploads/2020/02/NRMCA_LCA_ReportV3_20200416.pdf

| Issue/Decision Point | Discussion/Rationale |
|---|---|
| GWP threshold vs cement limits | ▪ Use GWP threshold to focus on GHG reduction objective and allow concrete producers to determine how to achieve it rather than prescribing cement limits. |
| GWP thresholds by key strength class with interpolation for in-between strengths vs. having one GWP threshold apply to strength range. | ▪ Cement levels increase with strength, thus GWP thresholds need to reflect this<br>▪ Example: There is too much difference between a 3300psi mix vs 3800psi mix for a single GWP threshold to be feasible. Thus, it is more workable to apply interpolation between defined GWP-strength bookends (3000, 4000, 5000, etc.) |
| GWP thresholds tied to PNW NRMCA Benchmarks to start | ▪ Committee reviewed multiple data sets on historical mix use GWPs (City-specific and Portland Metro) vs. PNW NRMCA Benchmarks. In general, the historical data showed baseline GWPs higher than the PNW NRMCA Benchmarks – particularly for City projects.<br>▪ Committee agreed that given historical baseline and the current mix portfolios that starting at PNW NRMCA Benchmarks would result in meaningful GHG reductions while acknowledging that doing so also maintains competitiveness and near-term implementation feasibility.<br>▪ There are certain concrete mix applications where the City's standard construction specifications limit SCM. For example, the current structural pavement maximum water/cement ratio is considerably low. And, for HPC there are limits on the percent SCM replacement (limiting anything higher than 30% SCM). HPC mixes with higher SCM replacement may be approved, but must undergo significant testing as part of the approval process. From an implementation perspective, the committee was trying to avoid the additional testing requirements for high SCM HPC mixes. Overall, the City's HPC SCM limits showed that many 30% SCM mixes were well aligned with the PNW NRMCA, further supporting it as a starting point.<br>▪ A review of the locally available EPDs showed that across strength classes the PNW NRMCA Benchmarks would exclude roughly 75% of the mixes on the market that had EPDs. The committee felt it was important to leave a large enough portion (at least 25%) of established mixes with historical testing data on the market during the transition to a broader array of low carbon mix availability. Generally, robust historical testing data is an important element to avoid overdesign and excess carbon on projects.<br>▪ Starting at the PNW NRMCA Benchmarks suits the diversity of City concrete applications (sidewalks to |

| | |
|---|---|
| | large drinking water filtration plants) – doing so effectively brings the City's whole supply chain of stakeholders to a reasonable and meaningful starting point for carbon reductions. |
| Committee reconvene annually for the next few years to review and potentially lower GWP thresholds | ▪ While PNW NRMCA Benchmarks are a good starting point, there is the know-how today (as well as new approaches in development) to achieve further GHG reductions over time. |
| Defer incentives for GHG reductions beyond thresholds | ▪ Concerns that incentives could lead to focusing on GWP over performance when higher SCM mixes (above 30%) are still fairly untested in many applications.<br>▪ Deferring allows more time to test and evaluate mixes that would achieve really low GWP levels as compared to the benchmarks.<br>▪ Concerns over lack of funding sources for financial incentives. |
| Allow for project-averaging GWP threshold approach in addition to per-mix approach | ▪ Recognition that some flexibility is needed on large projects with unique concrete applications and/or challenging/high-early-strength applications that present challenges for lowering cement content and/or utilizing high % of SCMs. A project average approach allows for some mixes on a project to exceed the GWP threshold to satisfy challenging performance requirements while pushing beyond GWP thresholds on other mixes used on the project.<br>▪ The committee chose not to set exemptions for high early strength mixes and instead use the project average approach combined with a reasonable starting point for GWP limits to strive for net reductions among projects and avoid a potentially complicated set of exemptions. |
| GWP thresholds only apply to mixes used in volume greater than 50yd3 on a project | ▪ It is a disproportional cost burden to require EPDs for mixes made by mobile mix concrete producers. Mobile mixers do not typically do more than 50yd3 on a project.<br>▪ 50yd3 aligns with ODOT's Small Quantity Schedule for commercial grade concrete (Section 4(b) of ODOT's Manual Field Test Procedures).<br>▪ In light of this, provide other program-based support for mobile mixers to reduce the embodied carbon of their concrete mixes<br>▪ Review <50yd3 exemption during annual threshold review process to see if it should be lowered |
| Exclude shotcrete at first; review for inclusion at later date | ▪ Deferred inclusion of shotcrete until some panel testing and direct input from nozzlepersons could be documented regarding lower-carbon shotcrete mixes. |

| | |
|---|---|
| | ▪ Some concerns over how lower-carbon mixes would affect the upfront strength and thus the application of shotcrete.<br>▪ Also, concerns related to the fact that there is no NRMCA benchmark for shotcrete. |
| Allow for supply constraint exemption on a case-by-case basis | ▪ Recognition of the potential for supply chain interruptions for key low-carbon mix components (e.g. SCMs) that may temporarily prevent the concrete producer selected for a project to produce a compliant mix as planned. |

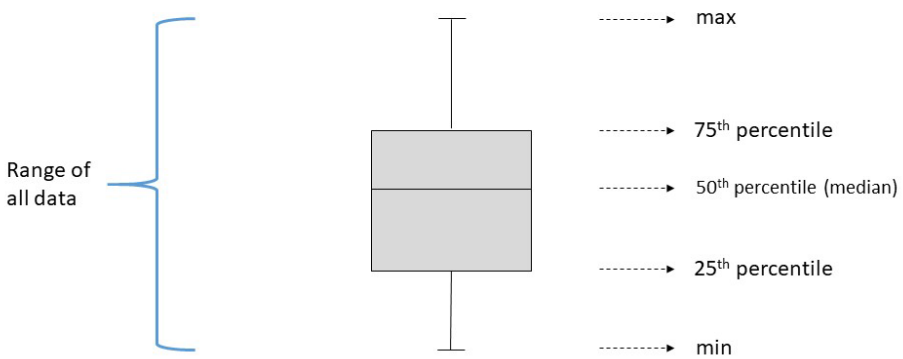
**Considerations When Applying the City's Concrete Embodied Carbon Thresholds to Non-City Projects**
The Low Carbon Concrete Initiative data collection effort was very specific to the concrete produced and consumed in the Portland metro area. Material properties change from region to region resulting in varying ratios of materials needed to achieve comparable performance. For example, the quality (density, porosity, gradation, shape) of one's aggregate can greatly influence the amount of cement (binder) used in a mix, resulting in GWP fluctuations from region to region. Thus, other agencies should take caution is using or applying these carbon thresholds outside of the Portland metro area.

It's important to emphasize that the City's Low-Embodied Carbon Concrete Thresholds were developed with City projects in mind. The City's consumption of concrete includes a wide variety of commercial and structural applications. Large volume projects include special applications like drinking water reservoirs and filtration plants, which all include very specific performance requirements. As mentioned above, the diversity of applications was an additional reason aligning the initial thresholds with the PNW NRMCA Benchmarks.

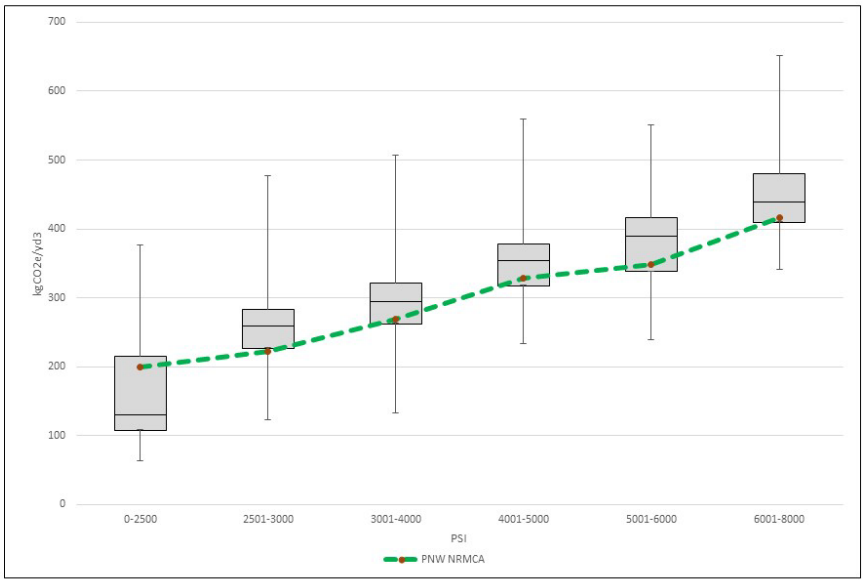
If seeking to apply concrete embodied carbon thresholds to projects outside the City's portfolio, use your project team's past experience to specify reasonable thresholds. Within the Portland metro area, this could be at or below the City's Low-Embodied Carbon Concrete Thresholds. For most commercial building projects, for example, the data collected through the Structural Engineer's Association of Oregon, show the vast majority of specified mixes do fall at or below the PNW NRMCA thresholds. However, SEAO's data collection was limited to mix designs and not total volumes consumed, making it hard to tell how well a whole project achieved reductions below average. If a commercial building has large volumes of concrete used in the foundation system, then a project target 15-20% below the City's thresholds could be warranted. However, if the building project is tall, and large volumes of concrete are used in elevated post tensioned slabs, smaller reductions from the City's thresholds may warranted given the high early strength needs of that particular application.

**Key Data Used to Inform Committee Decisions (developed 2020/2021)**
The following charts show key data used to help inform committee decision making. Please note that the PNW NRMCA Benchmarks referenced in these charts are based on the November 2019 (Updated February 20, 2020) published Benchmarks.

# How to read a “box and whisker” plot




# Published EPDs in Portland area

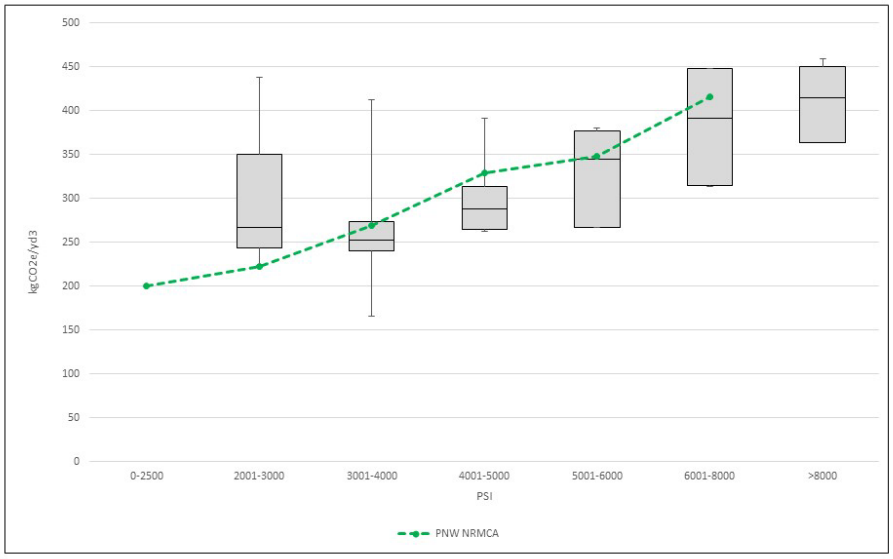



Data description:

- GWP range of the 1100 published EPDs in Portland, OR region
- 17 plants; 4 producers represented
  - Cadman
  - CalPortland
  - Knife River
  - Wilsonville

All data obtained from the free publicly available EPD database called buildingtransparency.org. A custom download of all Oregon EPDs was requested and delivered for this project.

# Local Engineer specified mix range w/ benchmarks

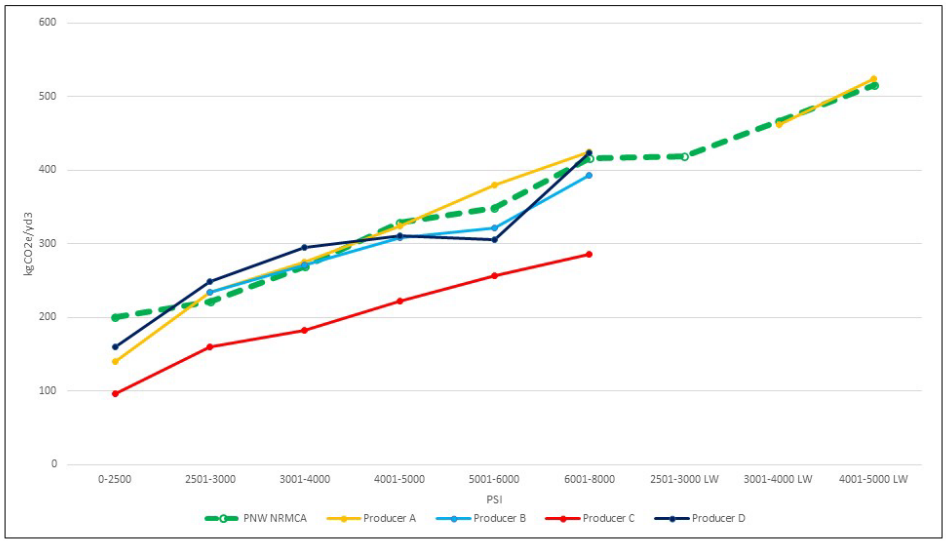



Data description:

- Collected through Structural Engineer's Association of Oregon (SEAO)
- 115 mixes total
- 40 projects
- 1 project:
  - 2017
- 39 projects:
  - 2018-2020
- 95% if projects in Portland area. 1 in Newport and 1 in Salem.
- 71% of all mixes in 3001-5000 range. Other classes have small sample size

The Structural Engineers Association of Oregon (SEAO) formed a "Resiliency" committee to help collect past specified mix design in the commercial construction market. Members of the committee pulled mix submittals from past projects and entered them into a survey form. The mixes were then passed through the Athena EPD calculator to determine GWP for each mix. Volumes consumed were not collected. These mixes represent a range of what was specified on approximately 40 projects in the Portland Metro area.

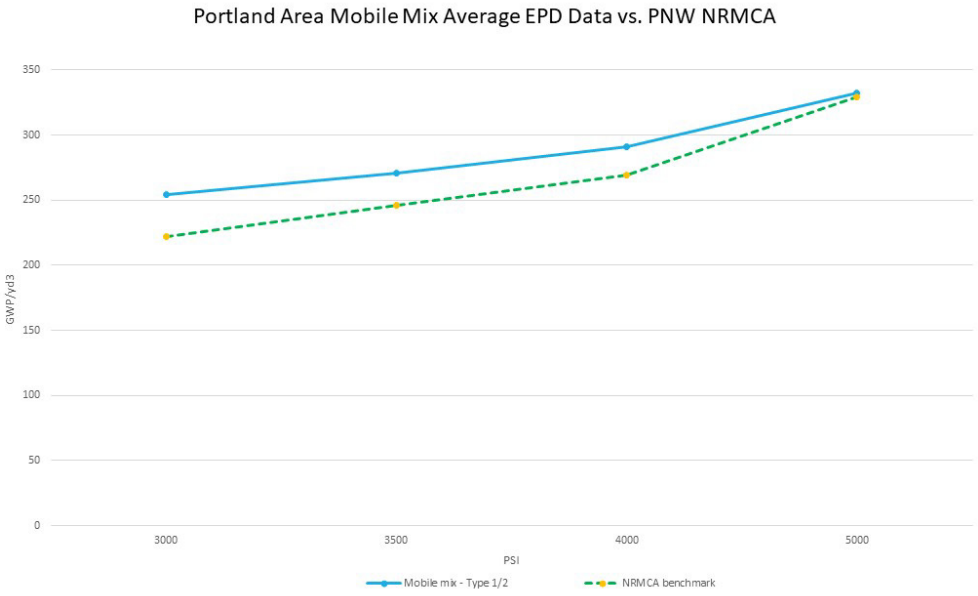
# Portland Area Concrete Production + PNW benchmarks




Data description:

- 17 plants
- Production weighted average mixes / strength class
- Oct 2019 – Sept 2020

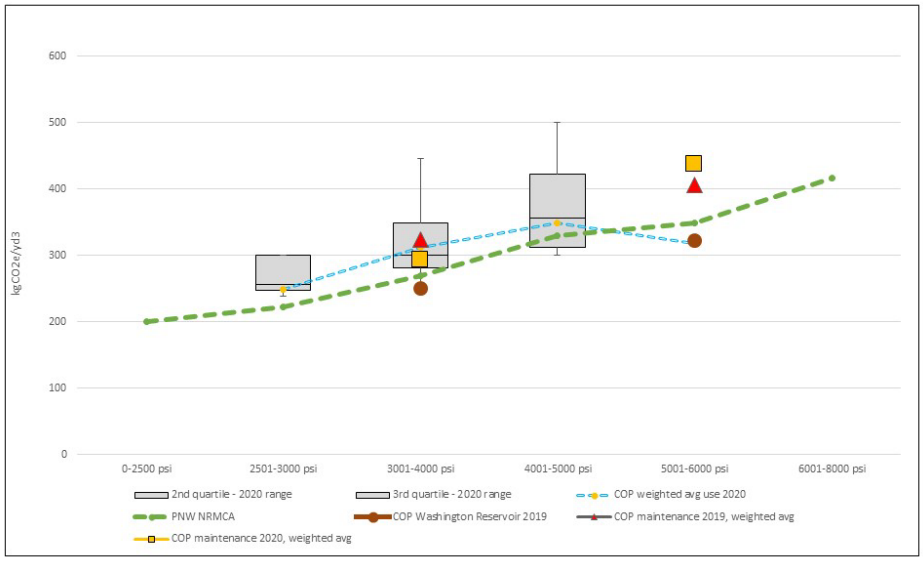
Four local concrete producers supplied Oregon DEQ with the production weighted average material quantities per strength class over a 12 month period. Oregon DEQ ran these material quantities through Athena's EPD calculator to determine the production weighted average GWP per strength class. This is a good representation of the GWP per strength class that the broader Portland Metro area is consuming.




Portland Area Mobile Mix Average EPD published 3/2021.
https://www.astm.org/CERTIFICATION/DOCS/628.EPD_for_City_of_Portland_report.pdf

# City of Portland (COP) concrete use:

## approved list + select project 2019-2020




**Data description:**

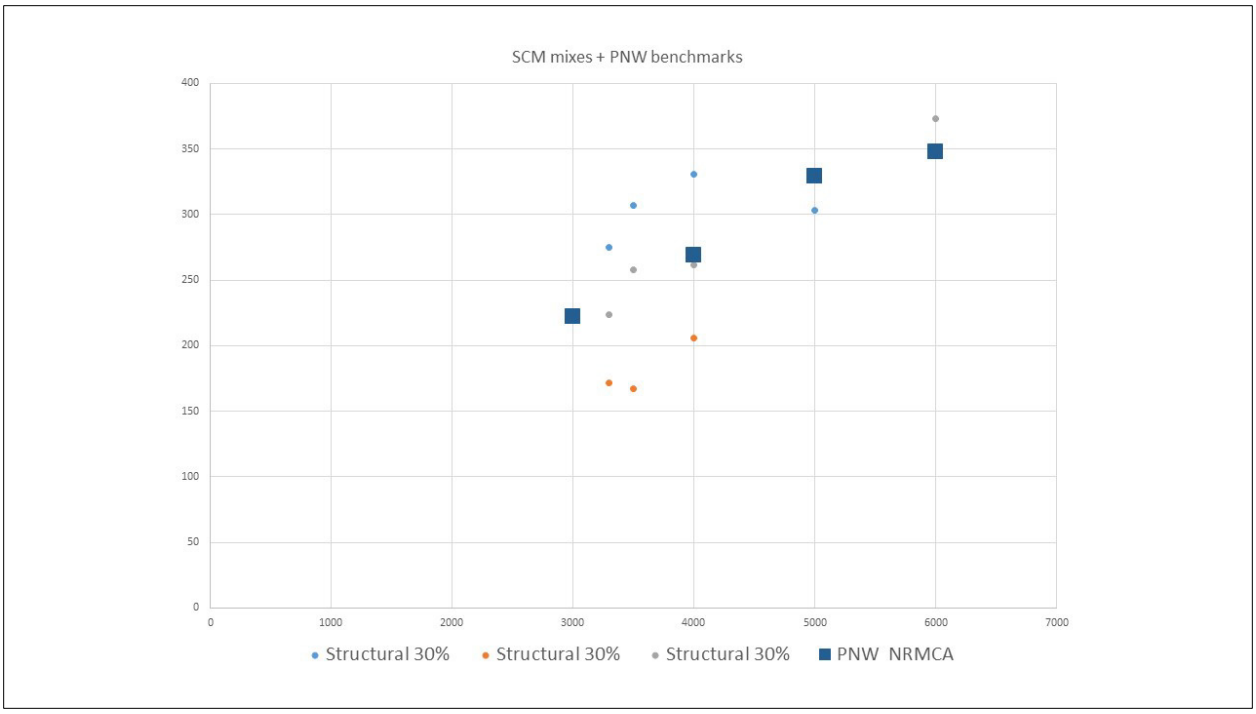
- Box + whisker plot represents range of mixes used in 2020
- Weighted average 2020 is GWP average weighted by approximate volumes (based on cylinder sets) weighted (~9000yd3 total)
- Washington Park Reservoir was approx. 21,000 yd3 in 2019
- Maintenance contracts are GWP averages weighted volumes from a single concrete producer (approx. 4000yd3 per year)

Box and whisker plot is the range of utilized mixes on City projects throughout 2020. The vast majority of these mixes were selected directly from the City's Approved concrete list. Some were approved on project by project basis.

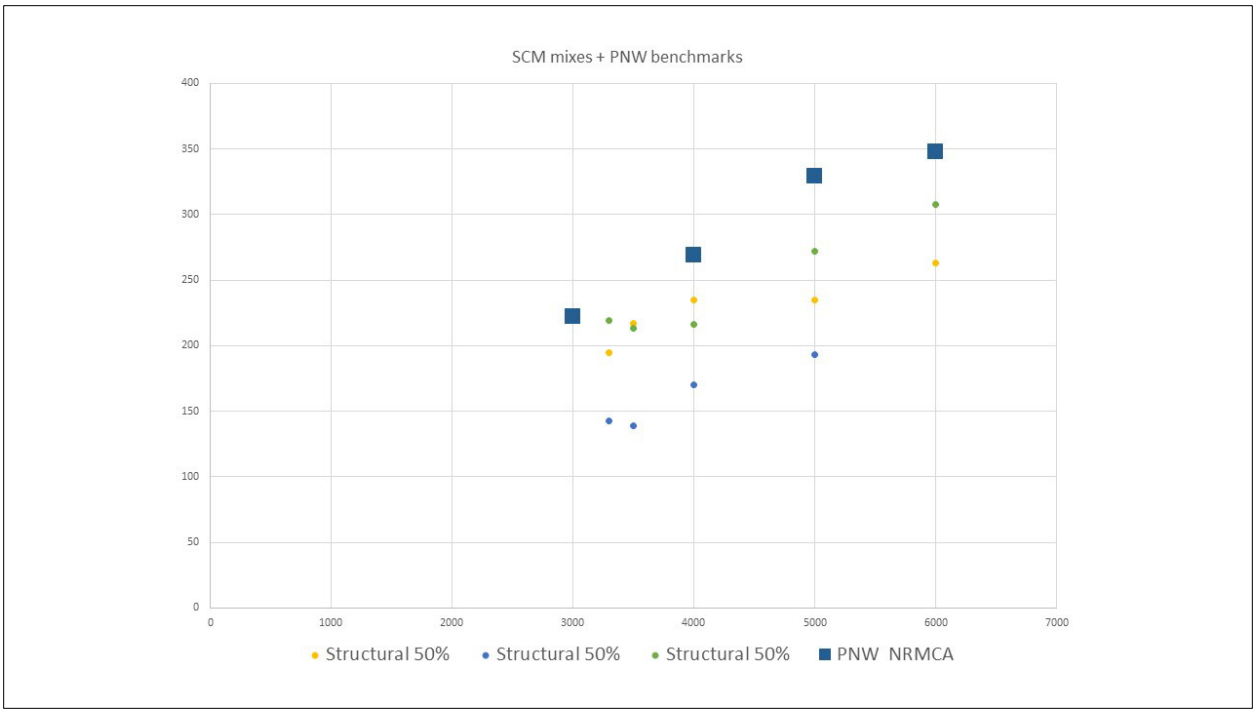
Weighted average of 2020 mixes combines the box and whisker range data with approximate volumes consumed. Volumes were estimated based on number of cylinder sets tested by the City's concrete lab and best professional judgement.

Washington park exact mixes and volumes were charted based on collected project data

Maintenance contracts are based on actual mixes and volumes consumed on a maintenance contract held by one local producer.




This chart shows the GWPs of mixes that meet the City of Portland's structural concrete specifications for mixes between 3000 and 6000 PSI (section 02001 of City Specifications). Mix GWPs were requested from concrete producers that were as close to 30% cement replacement as possible. Replacement between 30-50% requires special testing for "alternate" mix designs, which adds time, cost, and would ideally be avoided during the initial transition to lower carbon mixes. Thus, this data collection exercise was aimed at seeing how closely the existing 30% cement replacement mixes on the market aligned with the NRMCA benchmark mixes. Please note that the mixes with highest GWP were about 18-19% fly ash mixes that were as close to the 30% cement replacement that one producer had available. Thus, this snapshot of available mixes on the market represents the mixes from 3 concrete producers that stay within City structural specifications without requiring additional testing for "alternate" mix designs.




This chart shows how existing 50% replacement mixes on the market compare to NRMCA benchmark mixes. 50% is the max cement replacement rate allowed in City Specifications – although additional testing is required for any cement replacement over 30%. Therefore, this chart provided a snapshot of what the lowest potential GWP threshold could be based on available mixes in the market. Overall, we see that there is still a wide range of GWPs for similar performing mixes. As material sourcing improves, we could expect to see lower GWPs across the entire market.