

Green Line Light Rail Project Before-and-After Study (2014)

Portland, Oregon



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Green Line Light Rail Project; Portland, Oregon

The Green Line project added a new line to the light rail system in Portland, Oregon. The Green Line connects Clackamas Town Center in the southeastern suburbs to downtown Portland via new light rail construction along I-205 South, shared tracks with the existing Banfield light rail line, and a new light rail alignment through downtown to Portland State University (PSU).

The figure provides a map of the project and the corridor that it serves. The total length of the project is 14.5 miles comprising 6.5 miles along I-205 South, 6.2 miles on the Banfield segment, and 1.8 miles on the downtown Transit Mall.

The project was developed, built, and is now operated by TriMet, as part of the Metropolitan Area Express (MAX) light rail system that is 52 miles in length, serves 87 stations, and attracts 120,000 passenger boardings per day. TriMet also provides the bus, commuter rail, and paratransit services in metro Portland. Total ridership on all services averages 320,000 passenger boardings per weekday.

The project was initially identified in 1994 as part of planning for north-south expansion of the light rail system in the I-5 and I-205 corridors. Subsequent decisions prioritized three extensions: Interstate MAX, which opened in 2004 as the Yellow Line; I-205 South, which opened in 2009 as part of the Green Line; and Milwaukie, which is under construction and scheduled to open in 2015.

These planning efforts also identified the need for an additional light-rail route through downtown to add capacity and expand geographic coverage. Subsequent decisions identified the reconstruction of the downtown Bus Mall for bus and rail operations as part of the Green Line project.

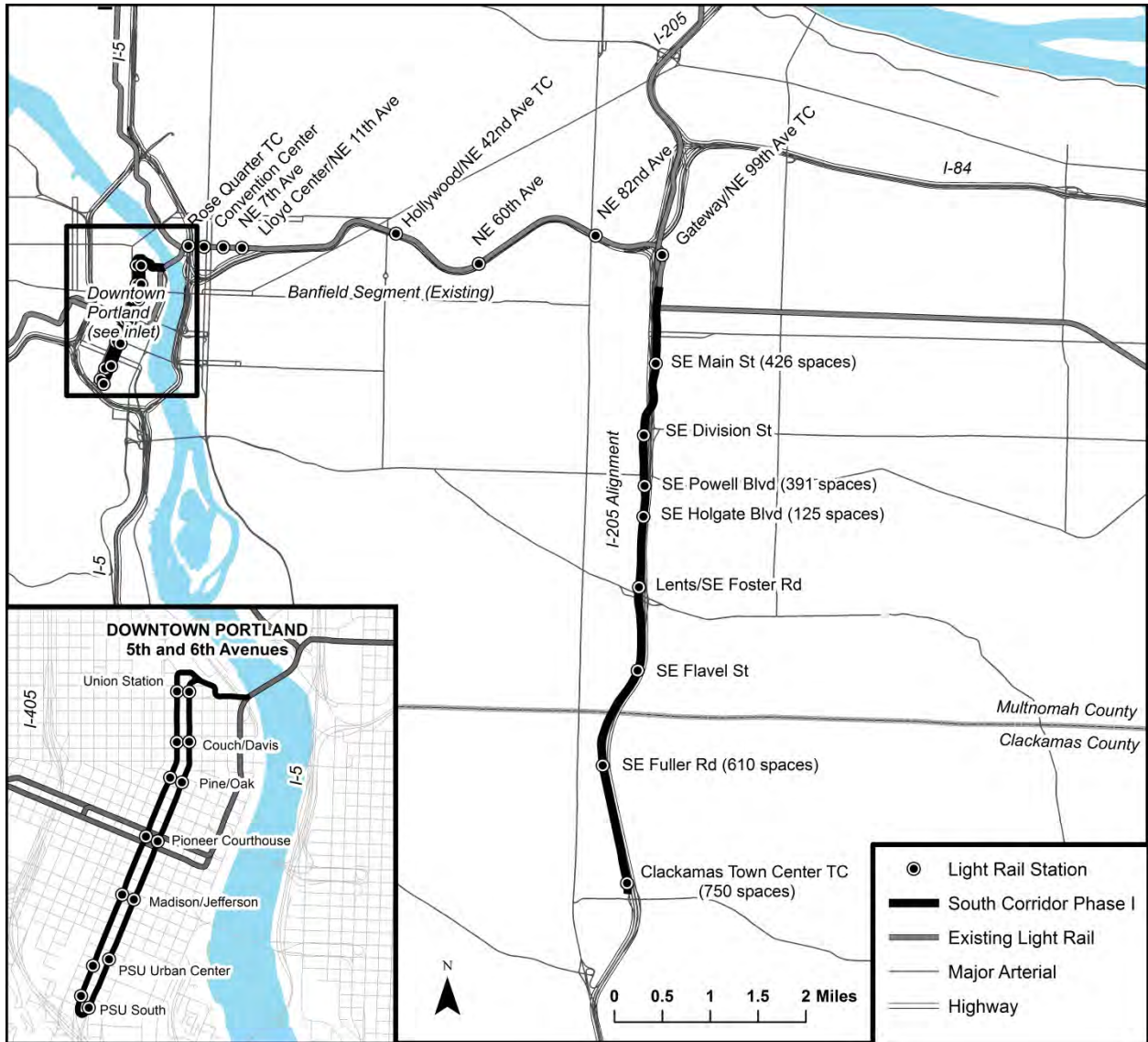
The project entered into preliminary engineering (PE) in 2004, entered into final design (FD) in 2005, received a Full Funding Grant Agreement (FFGA) in 2007, and opened to service in 2009.

Physical scope of the project

The Green Line employs conventional light-rail components with overhead electrification, cab signaling, articulated vehicles, and level-boarding at stations. The project has three segments:

1. New construction along I-205 South;
2. Minor upgrades of the existing light rail facility along the Banfield freeway; and
3. New construction in downtown Portland to convert the existing bus mall into a transit mall for both buses and light rail.

The 6.5-mile segment along I-205 South is entirely new double-tracked construction. In this segment, the alignment is largely at grade, immediately adjacent to the I-205 highway, and within an alignment prepared for light rail as part of the construction of I-205 in the 1970s. Design features built as part of highway construction included a wider right of way and longer overpasses to accommodate both the highway and a transit-way, and an underpass where the transit-way alignment transitions from the west side to the east side of the highway. The light rail project added two new street underpasses totaling 180 linear feet and seven aerial structures totaling 2,700 feet that carry the alignment over highway ramps and arterial streets. The result is an alignment that is exclusive to light rail with only one at-grade crossing – on an arterial street. The I-205 South segment has eight stations that are 200 feet long to accommodate two-car trains.



The Green Line
 In Downtown Portland, on the Existing Banfield Light Rail Segment,
 and along the New I-205 Alignment

Five of these stations have park-ride facilities, four with surface lots totaling 1,550 spaces and the terminal station at Clackamas Town Center with 750 spaces in a parking garage.

The 6.2-mile Banfield segment was built in the 1980s as part of the initial light rail project in Portland. Most of this segment is located immediately adjacent to I-84, the Banfield Expressway, in an alignment exclusive to light rail. As it proceeds west, the rail alignment transitions from the highway onto arterial streets through the dense activity concentrations in Lloyd Center and the Rose Quarter, and across the Willamette River into downtown Portland. The Green Line now shares this segment with the MAX Blue and Red Lines. All three lines serve the eight stations on the segment. For this segment, the scope of the Green Line project included only the addition of one power substation and an upgrade to the signaling system – both needed to expand the capacity of the segment from 20 to 30 trains per hour.

The downtown Portland segment consists chiefly of the reconstructed Transit Mall that traverses 1.4 miles of downtown on both 5th and 6th Avenues from Union Station at the north end to Portland State University at the southern edge of downtown. The project reconstructed 5th and 6th Avenues from property line to property line, transforming the former bus mall into a shared facility that accommodates both trains and buses and includes 14 rail stations, 31 bus stations, pedestrian amenities, benches, public art, covered bicycle parking, and landscaping. The Green Line operates as a single-track one-way couplet, southbound on 5th Avenue and northbound on 6th Avenue, sharing the track with the Yellow line that was rerouted to the Transit Mall as part of the Green line project. With turn-around tracks and the two-track connection between the Transit Mall and the Banfield line, the downtown segment of the Green line comprises 3.6 one-way track miles.

The project included 22 low-floor light rail vehicles that provide accessible seating and level boarding at all doors. The vehicles carry automated on-board bridge plates at every door to overcome the two-inch vertical difference between the platform and the vehicle-floor heights. The project also included minor modifications to two existing vehicle-maintenance facilities to expand their maintenance and storage capacity.

Overall, the physical scope of the project anticipated at the project development milestones was consistent with the as-built project. Minor differences included:

- At entry into PE, a new ramp structure providing access from the Steel Bridge to the Transit Mall that was dropped in favor of modifications to the existing ramp in the as-built project; and two at-grade crossings in the I-205 South segment that were actually grade-separated in the as-built project;
- Variations at entry into PE and entry into FD in the locations and individual capacities of parking facilities at stations in the I-205 South – but with no difference in the total number of park-ride spaces in this segment;
- At entry into FD, an underestimate of the scope of streetscape improvements for the downtown Transit Mall, subsequently upgraded in response to the downtown business community; and
- A change from 24 vehicles in the FFGA scope to 22 in the as-built project – to accommodate anticipated ridership in 2018 rather than in the 2025 horizon year and to help control project costs.

Overall, the actual as-built scope of the project was well anticipated at the milestones – reflecting the long-planned nature of the project, the transit right-of-way prepared as part of the I-205

South highway construction, and TriMet's long experience in the development and construction of light rail projects.

Capital cost

The actual capital cost was \$576 million in year-of-expenditure (YOE) dollars. Excluding the 6.2 miles of the existing Banfield segment and counting separately the 5th and 6th Avenue components of the Transit Mall, the aggregate unit cost of the transit project was \$69.4 million/mile, \$59.7 million/mile excluding vehicles. Some 77 percent of project costs were for physical elements of the project: guideway construction, vehicles, and systems.

The predicted capital cost at entry into PE was low by 14 percent, almost entirely because of unanticipated inflation effects. The predicted inflation effect assumed a historic annual rate of 3.0 percent over a 3.5 year period of design and construction – an 11 percent increase caused by inflation. However, the actual annual rate of inflation over the period averaged 6.5 percent – driven by national and international conditions that increased labor and commodity prices. These conditions, together with an additional year needed in the project schedule, produced a 33 percent increase in project costs because of inflation. Expressed in constant dollars – with inflation effects removed – the capital cost predicted at entry into PE was only two percent lower than the actual cost.

The predicted costs at entry into FD and at the FFGA were within three percent of the actual cost in both YOE dollars and constant dollars. The accuracy of these predictions resulted from recognition at these milestones of both continuing period of higher inflation and the longer schedule needed for construction.

Transit service

The Green Line operates on weekdays with 15 minutes between trains all day except evenings, when trains are 35 minutes apart. Service on weekend days operates with trains 17 minutes apart all day and 35 minutes apart in the evenings.

End-to-end running time averages 48 minutes, including stops at stations and traffic intersections, equivalent to an average speed 18.1 mph. This relative high average speed for a light rail line reflects the line's almost complete separation from traffic in the I-205 South segment and much of the Banfield segment.

Almost no changes were made to the bus system because of the introduction of the Green Line. This outcome reflects three characteristics:

- The Green Line replaces no pre-existing bus service because no bus routes followed a routing similar to that of the Green Line.
- East-west bus routes in the I-205 South segment provide connections to Green Line stations, obviating the need to establish feeder-bus services.
- Bus services in the Banfield segment were already configured with respect to the existing Blue and Red Lines.
- The downtown Transit Mall accommodates the same regional bus services that used the Bus Mall prior to its reconstruction to include light rail service.

The principal impacts of the Green Line on transit service are (1) the extension of light rail service to PSU, a substantial attractor of transit trips; (2) the expanded light rail coverage within

downtown Portland, also a substantial transit attractor; (3) the introduction of light rail service and new park-ride opportunities in the I-205 South corridor, and (4) the somewhat more frequent light rail service at stations in the Banfield segment. The new connection to PSU occurred both for the Green Line and the Yellow Line after its rerouting in downtown Portland onto the reconstructed Transit Mall.

Predicted Green Line service frequencies through all project-development milestones anticipated 10 minutes between trains during weekday peak periods and 15 minutes during other times. The project opened with 15-minute intervals throughout the day and 35-minute intervals in the evenings because of a drop in tax revenues associated with the national recession in 2008. The same financial challenges also led to reductions in service on existing light rail lines and bus routes that were not anticipated during the development of the project. Between 2009 and 2011, rail and bus service was reduced by 11 percent system-wide. As revenues expand with the economic recovery, TriMet is now restoring service.

Operating and maintenance (O&M) costs

Per vehicle-hour of service, Green Line O&M costs are consistent with the cost experience of the TriMet light rail system. Consequently, total O&M costs have increased in direct proportion to the increase in light rail service associated with the Green Line. Because bus service levels were effectively unchanged by the Green Line opening, bus O&M costs did not change because of the project.

Predictions of O&M costs for the project itself and its direct impact on the bus system accurately anticipated these outcomes. Those predictions anticipated higher system-wide costs compared to current actual costs because they did not foresee a severe national recession and subsequent service reductions.

Ridership

Actual ridership on the Green Line averages 24,000 trips on weekdays. The largest ridership market is the 63 percent of Green Line trips that travel to and from work or other activities in the core of the region: downtown Portland, PSU, and the Lloyd Center. The other ends of these trips to/from the core are located along the I-205 South segment (35 percent), within the core itself (24 percent), along the Banfield segment (19 percent), and in outlying areas (the remaining 22 percent). The purposes of these trips include travel between home and work (41 percent), school (27 percent, overwhelmingly to PSU), and other activities (17 percent). The remaining 15 percent of Green Line trips involving the regional core occur between non-home locations, particularly within the core where workers use transit services to travel to lunch, meetings, and other activities in the mid-day and evening.

The second largest ridership market is the 16 percent of Green Line trips that travel to/from jobs and other activities along the I-205 South segment. These trips are produced in roughly equal proportions elsewhere along the Green Line and throughout the Portland metro area. They are marginally less oriented towards work and school, and are more oriented towards shopping and other non-work activities.

Some 72 percent of trips on the Green Line access the transit system by either walking or transferring from buses or other light rail lines. The remaining 28 percent of all trips rely on an automobile to access a Green Line station (primarily park-ride but also drop-offs). Auto access

is particularly prominent for residents of the I-205 South segment where 33 percent of trips to all other locations arrive at Green Line stations by automobile. For Green Line trips from the I-205 South corridor that travel to the core of the region, auto access has its largest share at 48 percent. Nearly all auto-access trips on the Green Line – 95 percent – travel to activities in the regional core in downtown Portland, PSU, and Lloyd Center – effectively the areas where parking charges or parking restrictions (residential parking permits) are found.

Households with incomes under \$40,000 produce 58 percent of trips on the Green Line. Households without cars produce 20 percent of trips on the Green Line.

The predicted number of opening-year weekday trips on the Green Line was 30,400 at entry into PE and was revised to 25,250 during PE. The revision apparently resulted from work to update the regional travel model as year-2000 Census data became available, including the preparation of new estimates of land use, population, and employment distributions – plus the recalibration of the travel model against then-current ridership patterns. The revised prediction remained in place at entry into FD and at the FFGA. Thus, the predicted opening-year ridership at those two milestones was within four percent of the actual 24,000 average weekday trips.

Two differences between predicted and actual ridership exist within this close match on total Green Line ridership.

First, predicted ridership significantly understated the importance of the regional core in both generating and attracting Green Line trips. At the “after” milestone in 2011, 63 percent of trips on the Green Line had one or both ends within the core compared to 33 percent in the ridership prediction. Just over half (57 percent) of this under-prediction occurred for trips to/from locations outside the core and the remainder occurred for trips within the core.

Some of the difference for trips to the core occurred because operating speeds were over-estimated for bus routes between the I-205 South corridor and the regional core. Consequently, some trips that actually use the Green Line were shifted in the ridership predictions to the artificially fast bus services. Some of the difference for intra-core trips is likely to be caused by a change in fare policy. The ridership predictions assumed the continuation of “Fareless Square” that let trips within the core use bus and rail services without paying any fare. In 2011, however, TriMet had changed the policy to “Free Rail Zone” in which bus travel required a fare payment. That change in fare policy is likely to have shifted some former bus trips onto the rail system, including the Green Line within the core.

Second, while the predictions of the total number of Green Line trips using auto access were within 12 percent of the actual total, the predicted pattern of these trips was substantially different from the actual outcome. Nearly all Green Line trips – 93 percent – that use park-ride access actually go to work or other attractions in the core – downtown Portland, PSU, and Lloyd Center. In contrast, the forecasts anticipated that park-ride trips would go to locations throughout the metro area and only 51 percent to the core. The pattern of actual park-ride trips suggests that travelers with ready availability of a car are likely to drive to transit only when they are traveling to locations with charges for, or restrictions on, daily parking.

Recent updates of the regional travel model for the Portland area have corrected the difficulties in prediction of overall transit travel to the regional core and the orientation of park-ride trips to the core.